J&J Institute

Essential Contact Lens Practice

A comprehensive guide to the foundations of contact lens practice, brought to you by the Johnson & Johnson Institute.

The Johnson & Johnson Institute provides education, coaching, development, and advocacy for those on the frontlines of health – focused on advancing the safe and effective use of our products. Together with healthcare professionals around the world, we share the same goal: to deliver the best and most compassionate care to people everywhere.

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A practical guide

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About this book

Just as the world around us continues to evolve, so too does the contact lens world, and the technologies available to us as practitioners to help us to better serve our patients' changing needs. With over 10 years having elapsed since the publication of the last edition of the Essential Contact Lens Series, by Jane Veys, John Meyler and Ian Davies, an update was necessary. Whilst many of the fundamentals of contact lens practice remain unchanged, significant advances in technology, contact lens materials and designs offer new opportunities to practitioners. Research continues to shape our understanding of vision, the ocular surface and contact lens practice, therefore references have been updated throughout. Numerous authors with a wide breath of experience from high street practice, through to academia and industry, were involved in bringing this text up to date.

Contact lenses offer patients the freedom to experience life without glasses. They can bolster confidence and allow patients to experience the world in a new way. Eye care professionals are in a unique position to be able to enhance patients' lives daily, which is something which should not be underestimated.

As practitioners, we have a duty of care to ensure our patients are fully informed about all the options available to them. As such, we must ensure that we not only possess the core skills necessary to fit and manage contact lens wearers, but that we also keep up to date with the latest introductions to market.

This book aims to provide readers with a strong foundation of contact lens knowledge, which they are able to build upon through continuous learning and development available through The Johnson & Johnson Institute, as well as other sources.

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This book is a revised and updated text based on the 'Essential Contact Lens Practice' series, originally authored by Jane Veys, John Meyler and Ian Davies. This book was produced without further input or review from the original authors.

All chapters of this book were originally printed in Optician. Many thanks to Bill Harvey for his support in bringing this text back to life.

Contents

Insights into the UK Contact Lens Market

Author: Clair Bulpin

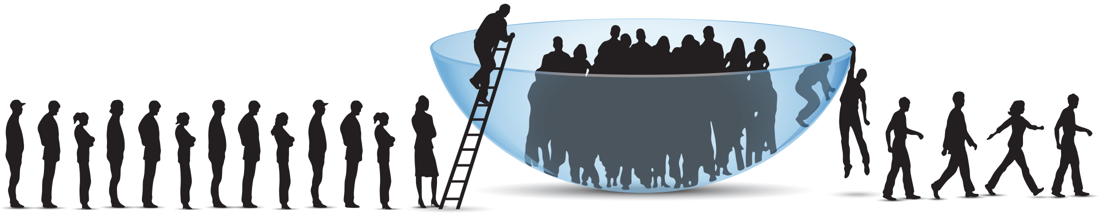
The contact lens market is full of potential. We arguably have the widest range of soft lens materials, modalities and parameters available than ever before. With this vast soft contact lens availability to support the smaller rigid gas permeable market, more patients than ever can find a contact lens which best meets their individual needs. Alongside availability, high profile marketing campaigns and public relations activity have served to increase public awareness.

Yet, despite these advances, contact lens penetration remains low, for example, within the UK it remains at approximately 15%, a figure which is just under two thirds that of the US.[1]

The availability of better contact lens products, brought about by advances in technology is most certainly creating an impact, but, the UK contact lens market, like many others, grows only slowly year on year indicating that there is still a significant opportunity for growth.

Focusing on the UK market as an example, research suggests that there are somewhere in the region of 19 million spectacle wearers, but only 4.8 million contact lens wearers. More interestingly, there are around 9 million patients who would be open to trying contact lenses.[1] It is staggering to think that there are more people considering contact lenses than there are actual wearers. These market figures would appear to indicate that we are not identifying these millions of potential contact lens wearers in our midst, suggesting we must pay closer attention to our patients' visual correction needs.

Equally, whilst marketing campaigns strive to recruit new wearers, the contact lens market is a known 'leaky bucket' and research suggests that for every new wearer we recruit, just as many drop out of contact lens wear.[1] The key to a healthy contact lens market lies not only in the successful identification of all potential contact lens considerers, but also in the early detection and appropriate management of the patients at risk of leaving contact lens wear behind.



Glasses only wearers	Open to Contact Lenses	New starters	Contact Lens wearers	Contact Lens drop-outs
19.3	9.2	0.6	4.8	0.5
Million	Million	Million	Million	Million

Figure 1. The UK contact lens market in 2023.[1]

Identifying Patient Needs

In 2016 the UK optical regulator, the General Optical Council launched their Standards of Practice replacing the previous Code of Conduct defining the levels of expected behaviour and performance for registrants. The 19 listed standards begin with 2 key elements:

- Listen to patients and ensure they are at the heart of the decisions made about their care
- Communicate effectively with your patients

Eye care professionals are encouraged to fully listen to patients and to take account of their individual views, preferences and concerns, with an emphasis on allowing sufficient time to deal properly with patient needs. Great communication lies at the heart of any consultation and these standards reiterate the importance of clear and honest discussions, ensuring the patient is always welcome to ask questions where appropriate.

Now, more than ever, the expectation of the profession is to provide support, expertise, and a chance to ensure that any patients' unmet needs are identified and addressed.

Communication extends much further than words alone, and whilst an eye care practitioner may not intentionally set out to do a 'bad job', research repeatedly indicates that we are not doing as well as we might suspect, particularly where the field of contact lenses is considered.[2] In fact, 66% of patients who are considering contact lenses do not feel well informed, and over half (59%) wish that their eye care professional would talk to them more on the topic.[2] Listening to the patient and putting them at the heart of the decisions made about their care can only seek to rectify the disparity within these statistics. Sufficient time should be spent with each patient to create the rapport needed to successfully ascertain their specific visual correction requirements.

Understanding what drives someone to consider contact lenses requires identification of their specific patient needs. Keeping a patient as a successful contact lens wearer requires an understanding of changing needs or identification of situations whereby those needs are no longer being met.

Benefits of Contact Lens Wear

Contact lenses are fundamentally a form of vision correction, so the simple benefit of clear vision cannot be overlooked. However, vision is most often defined by what can be resolved on an acuity chart assessment, but in reality, 'good vision' is so much more than that. For example, there is an improvement in field of view with contact lenses over spectacles in many cases. Patients with high powered spectacle prescriptions are often recommended smaller frames to achieve a good cosmetic outcome – but this can impede peripheral vision. It's also worthwhile remembering that spectacle minification occurs in high minus powers, often rendering a patient with 'better' vision in contact lenses. Contact lenses are a recognised excellent alternative for anisometropic patients who could struggle with the differential image sizes that their prescription creates. Research has also shown that contact lenses may reduce amplitude and frequency of nystagmus in some patients[3] and it has been suggested that a contact lens may be the preferred corrective option here as a contact lens will move with the eye,[4] potentially creating visual stability.

Alongside the visual benefits, there are many reasons why a contact lens recommendation may be appropriate, and there are many recognisable 'flags' which may prompt a discussion.

A desire or need to wear contact lenses for sports or hobbies can provide important motivation and create an obvious and clear benefit, giving an easy way to begin a contact lens conversation. Certain occupations may generate discussion about contact lens suitability, as will many other lifestyle requirements. Most practitioners would feel that these recognisable lifestyle and recreational activities should generate, at the very least, a suggestion of a contact lens option.

Other more subtle clues may also highlight a patient as a considerer. A patient who openly admits that they don't like spectacles, or 'only uses them when they absolutely have to' may also be sending out a signal for an alternative option. An increase in reliance on the spectacles or a change in wearing habit may also elicit a contact lens need.

Contact Lens Considerers

It would be much easier if each person considering contact lenses simply asked for them, but we know that this has never been, and is unlikely to ever be the case. There is often so much information to discuss at the end of an eye examination that a contact lens recommendation may not be top of mind. Sadly, the situation will often arise whereby the professional assumes that if the patient wanted contact lenses – they would ask about them. Conversely, the patient assumes that if they were a suitable option, the professional would have mentioned them. It is however a vicious cycle, as the eye care professional not mentioning contact lenses is cited by consumers as one of the main reasons for not taking any steps towards getting them.[5] The vast majority of considerers would simply appear to be waiting for us to recommend contact lenses as an option.

Top Tips for Introducing Contact Lenses to Your Patients

- Offer contact lenses to patients as an aid to spectacle dispensing
- Present contact lenses and spectacles as complementary correction options
- Link contact lens recommendations to patient hobbies so they can immediately see when they would offer benefits over spectacles
- Increase the visibility of contact lenses in your practice to engage with prospective wearers
- Educate and motivate the whole team on the benefits of contact lenses, ensuring everyone is kept up to date with the latest developments
- Use positive and encouraging language e.g. ‘You’re an excellent candidate for contact lenses’.

With the significant improvements in contact lens parameters and materials, considerers will lie at both ends of the population demographic, and practitioners may find they need to rethink ‘who’ they really listen for these clues from. Improvements in parameters and materials also re-opens the door to previous contact lens wearers, who now may be satisfied with new products. This highlights the need for eye care practitioners to keep up to date with new additions to the contact lens market.

There is often a disconnect between how practitioners feel about fitting contact lenses, and the actual contact lens wearing population. For example, in the UK, ECPs’ feel that, on average, the minimum age they would be happy to recommend contact lenses for is 9 years old, yet less than 4% of current contact lens wearers tell us they started under 15 years of age.[6,7] These numbers would suggest that whilst practitioners may be happy to fit 9-year olds with contact lenses, they may not be actively recommending to this age group. The key to converting these considerers, and any others, may simply lie in an open conversation.

The benefit of contact lenses in children expands to include a social benefit. The Adolescent and Child Health Initiative to Encourage Vision Empowerment (ACHIEVE) study considered the quality-of-life improvements associated with contact lens wear in children. In a study of 8- to 11-year-old myopic children their physical appearance, athletic competence and social acceptance self-perceptions were shown to improve with contact lens wear.[8]

At the opposite end of the potential wearer demographic are presbyopes. Nearly half of contact lens considerers are presbyopic, even though this may not appear to fit the mould of a new contact lens wearer.[1] Statistics demonstrate that whilst the percentage of spectacle wearers in the 45+ age group steadily rises with age, the contact lens wearing percentage reflects a corresponding decline (Figure 2).[7] Yet, in a study where presbyopic patients were

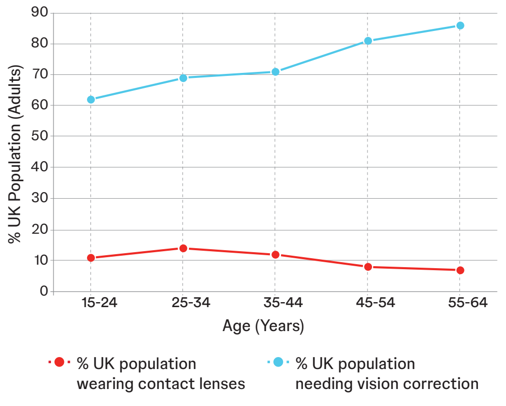


Figure 2. Contact lens penetration compared to the percentage of the population who require vision correction versus age.[7]

given the choice between contact lenses and spectacles, 78% of patients said they would prefer a combination of the two.[9] It is therefore not surprising that there are 6.2 million patients over the age of 45 who are open to and interested in contact lenses.[7]

Identifying contact lens considerers goes above and beyond the simple identification of an appropriate hobby or lifestyle requirement.

Whilst just 15% of the UK vision correction users wear contact lenses,[1] research indicates that there are deeper drivers to contact lens wear than simple vision correction alone.[10] Motivation comes in many forms and whilst rational benefits such as clear vision and convenience may be the presenting need, these elements can be considered ‘surface drivers’ or rational drivers, and only represent a relatively small proportion of the motivation. A more significant proportion (two thirds), of the motivational drivers have been shown to be emotional in origin, promoting self-confidence and a sense of belonging.[10] This is where great communication skills become invaluable as a patient is less likely to share these deeper emotional needs with a practitioner if there is not a comfortable rapport.

When considering these emotional drivers, it can be useful to consider how life simply ‘changes’ over time. As people change, so do the things that they want or need. An awareness of designer high fashion sunglasses may suddenly appear overnight and become the only thing a patient wants to be seen in. Their faithful prescription sunglasses may simply no longer suffice. A change in personal circumstance may promote the desire for a 'new look', or an increased reliance on spectacles may provide frustrations in certain circumstances. It would be a happy coincidence if any change to a patient's life happened at the same time that their next routine appointment was due, but we know that this isn't going to be the case. Ironically, it may also be emotional reasons holding the patient back from starting the conversation. There are deeper emotional elements here too – some patients may fear being judged as vain or shallow for initiating a conversation around simply changing their look. They may present stating one need, such as a desire to use them for sport, to avoid the conversation around a deeper more emotional need.

Initial patient interactions during history and symptoms are essential to a successful examination but will often identify only the 'top line' needs. The real skill in identifying a potential contact lens wearer comes from really understanding what would motivate an individual to wear them, and this goes above and beyond the instantly obvious 'practical' reasons which are so easy to identify from basic questioning. Building a relationship which encourages open and honest discussion about contact lens possibilities, both currently and into the future, is what will help ensure that we really understand our patient's needs.

Keeping the contact lens wearer happy

Much of the promotion of contact lenses in the practice environment targets the potential new wearer and whilst we must strive to build this further by identifying the millions of considerers, the issue of contact lens drop-out must also be addressed. As much as a life changing event may trigger an interest in contact lenses, the same can be said for the reverse. When the contact lens ceases to meet the patient needs, motivation to continue wear reduces. The identification of changing wants and needs not only applies to the new wearer but maintaining our existing contact lens wearers too. Life is not static in its demands, and a contact lens wearer may need several adaptations to their lenses to address their changing requirements. In the same way that a patient may assume that if they were suitable for contact lenses, the practitioner would mention them, an existing contact lens wearer may assume there are no alternative options available if these are not discussed.

> Patients can initially be very accepting of subtle inconsistencies in their needs being met, maybe assuming that end of day discomfort is part and parcel of contact lens wear – or that it is normal to need to blink hard to see clearly.

Whilst these issues might initially be infrequent and not too bothersome, they

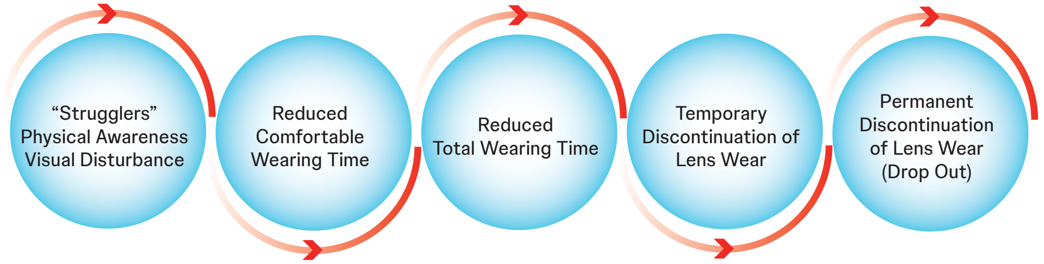


Figure 3. Progression of contact lens discomfort. Adapted from TFOS.[12]

may build and impact the patient more often. Wearing hours may reduce, followed by less days in contact lenses, ultimately the cessation of contact lens wear altogether may occur. The Tear Film and Ocular Surface (TFOS) International Workshop on Contact Lens Discomfort[11] proposed a progression for the stages of discomfort, starting with 'strugglers' experiencing early symptoms and concluding ultimately with permanent dropout (Figure 3).

> These vanishing contact lens wearers can slip under the radar as those that cease contact lens wear will rarely make an appointment just to share this news with you; they simply disappear.

So, what leads to the discontinuation of contact lens wear? Put bluntly, for a myriad of potential reasons, the contact lens may no longer meet the needs of the patient. When the perceived benefit of the contact lens reduces – maybe due to increasing comfort issues, or the 'hassle' of the care regime, or if the wearer's motivation alters and changes - it doesn't matter if the wearer is new to contact lenses, or an established wearer – the end point is the same. When the benefit of the contact lenses are no longer obvious to the wearer, they will reduce lens wear and could ultimately drop out of lens wear altogether.

With this in mind, it is useful to consider why patients at different stages in their contact lens journey may cease to see the benefits of contact lens wear, or lose sight of the motivation that attracted them to contact lenses initially. Studies looking at retention of the new contact lens wearer provide some interesting insight.[12,13] When patients in their first year of contact lens wear are considered, 26% ceased lens wear within this period (Figure 4). More significantly, of those that do drop out, nearly half did so in the first 2 months. It is often assumed that handling problems contribute to new wearer drop out, and this was cited as the most common reason for spherical lens wearers. However, poor vision was cited as the most common reason for early drop out amongst toric and multifocal new lens wearers.

Within these studies,[12,13] only a small amount (29%) of patients had an additional trial fitting with a changed power or lens type prior to dropping out of contact lens wear altogether. Providing patients with a better understanding as to what to expect in the early stages of contact lens wear could do much to address these issues.

Today it is possible to purchase pretty much anything, at any time of day, with a simple click of a button from wherever you happen to be. The path to successful contact lens wear is more complex than clicking a button and it somewhat lacks the quick fix of so many of life's commodities. It is essential that a patient understands why this is so and appreciates that this is a product recommended specifically for them and their individual needs, and not something that is simply picked off a shelf. The early stages of the contact lens journey are key to successful contact lens wear and support provided during these initial stages is vital to success.

An established contact lens wearer, conversely, is more likely to leave contact lens wear because of comfort concerns. Maintaining comfort is key to long term successful contact lens wear.[14] Introducing the notion that a specific type of contact lens may not be a lifelong partner could prove valuable in prompting patient discussion when the world around them changes. A patient needs to feel secure, not only in the knowledge that there will be alternatives should their needs evolve or change, but that their chosen professional can provide the knowledge and support to make these adjustments if they become necessary.

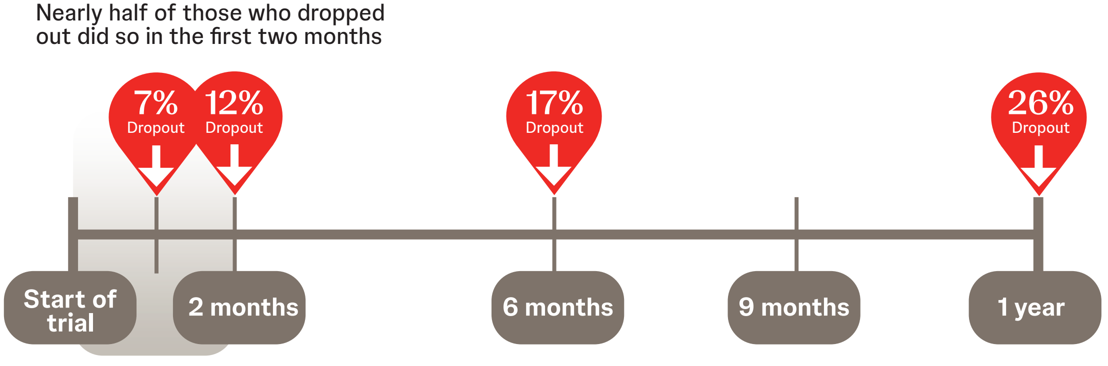


Figure 4. Proportion of new wearers who discontinued lens wear by number of days since dispensing (n=510, for 14 patients time discontinued unknown).[13.]

Recommendations

Whilst the need to maintain clinical skills and knowledge clearly forms an essential element of the practitioner-patient interaction, insights tell us that our recommendations are more valuable than we realise. There is a certain expectation from a patient that the clinician will be technically competent to perform the required clinical examinations or have access to the scientific background data supporting the products we choose to use. When considering what drives a patient to make a vision correction purchase, more patients will prioritise ECP expertise over everything else.[15] But alongside this is an expectation that the recommendation will be tailored to their individual needs and requirements.

In the world of contact lens fitting, this personalised recommendation is a sum of several parts. The practitioner must firstly strive to fully understand the benefits that contact lens wear can bring to the patient and really understand their motivations. This should combine with the clinical skills to evaluate an eye and understand how it's individual physiology will impact contact lens wear. A firm understanding of material properties and optical design, and how these can influence the potential drop out risk factors of handling, vision and comfort, complements the preliminary investigations and ensures that each recommendation made, is a recommendation truly tailored to the individual patient's needs. But this approach should not be reserved for the new wearer. The motivation for an established wearer will change over time and if this isn't identified and addressed, we risk losing this patient from contact lens wear.

Whilst the default recommendation at the conclusion of an eye examination would seem to be discussion about spectacle correction, it could be argued that complete communication of the visual correction options for a large number of patients should also include a contact lens suggestion too.

Increasing the amount of contact lens wearers will simply – yet importantly – mean that we are meeting the currently unidentified needs of more of our patients. Creating a successful contact lens wearer is not simply about removing barriers to wear but understanding potential motivations and the specific benefits that contact lens wear will bring.

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Initial Patient Discussion

Author: Theresa Cox

Success with contact lenses begins with finding the best match for each individual patient and ensuring that we review that match regularly as patients' lifestyles and ocular health needs change.

Contact lens retention research indicates that 26% of new wearers cease lens wear within the first year, with nearly half of those dropping out in the first two months.[1,2]

It's evident that a deep understanding of the patient's needs alongside meaningful clinical evaluations, are key to success. Significant advancements in technology now mean we have a large range of materials, modalities and designs available to best match up with each individual's specific requirements. Beyond the initial investigation and fitting, viewing each encounter as an opportunity to update this information ensures that the patient has every chance of remaining a successful contact lens wearer.

Patient discussion 'History and symptoms'

The initial conversations within a contact lens assessment are key to gaining a comprehensive evaluation of the patient. Determining any contraindications to contact lens wear alongside the initial clinical assessment will provide you with the information needed to help recommend the most appropriate lens for the patient. If we can select the best lens the first time, it helps not only to reduce the need to trial alternatives, and hence use more chair time, but also serves to reduce drop out in those first few months or thereafter.

A comprehensive evaluation should include discussion around:

- Motivation
- Occupation
- Lifestyle
- Ocular History
- General Health

In addition to providing you with an understanding of the patient's vision requirements and expectations, this initial conversation is key to building rapport with your patient. Not only does this make them feel more comfortable, but it helps you determine the personality type of your patient and adapt your communication accordingly. For example, the anxious patient may need more reassurance, whereas someone who likes to just get things done may only want the key points highlighting and less in-depth discussion.

As per the General Optical Council (GOC) Standards of Practice, we need to treat our patients as individuals, taking into account their views, preferences and concerns.

Patients need to be involved in decisions about their care, so by giving them recommendations specific to their own requirements, you are very much involving them in the lens selection process.[3]

Remember, effective communication relies on responsive listening and appropriate body language from you as a practitioner (Figure 1). You need to look interested in what patients are saying and maintain eye contact wherever possible. It is critical that you make note of any information gathered from the history taking in order to manage the patient

Figure 1. Body language is an important part of effective communication.

effectively throughout their contact lens journey. It is also worth considering what your body language is saying, for example, facing away from a patient to record notes, especially with computer-based systems, may change the dynamic of the interaction. Accurate notes are essential, but building a rapport is equally as important.

Before you start - what do you need?

Before you begin a contact lens fitting appointment, the patient **must** have a valid spectacle prescription – most commonly this is dated within the last two years, but it may need to be more recent if a different recall is specified on their prescription. If the patient hasn't been to your practice previously, they need to bring a copy of their results to the fitting appointment.[4] For those wanting zero powered (cosmetic) contact lenses they **should** have had a recent sight test.

Within this chapter we will consider each aspect of the history taking in turn, highlighting the key things you should learn about your patient, and more importantly, why (Table 1). A history is commonly taken in a pre-defined order and can be a remarkably similar list of questions from one patient to the next. Understanding why each question should be asked - and beyond that, when and how to explore an answer further - provides the practitioner with the additional understanding needed to make any recommendations truly specific to that individual.

Motivation	Establish ***why*** the patient has decided to try contact lenses
Occupation	Gather information about task requirements and environment
Lifestyle	Discover what hobbies/interests patients have
Ocular Health	Establish full ocular history from the patient including any previous contact lens wear
General Health & Medication	Establish general health issues, current medication and any allergies they have
Age	Consider maturity level and dexterity
Prescription	Consider what lens type is needed to provide the best visual outcome to meet the patient's needs
Previous Contact Lens Wearer	Establish reasons for previous lens drop out
Financial Considerations	Work with the patient to find a suitable lens to meet any budget requirements they may have. Ensure this is balanced with the perceived value of having contact lenses.

Table 1. Aspects of a thorough history & symptoms.

Motivation

When a patient arrives for a contact lens fitting, they have already made the decision that they want to try contact lenses. However, it is still essential to establish **why** someone has decided to try contact lenses. Is it due to practical reasons such as frustration with reading glasses, to help with sports as spectacles aren't a practical solution, or is the decision a deeper, more emotional based reason, such as confidence and self-esteem? Finding the true motivation is easier with some patients than others which is why building rapport is key. Open questions like 'what has prompted you to come in to discuss the option of contact lenses with me today?' or 'how do you see contact lenses fitting in to your lifestyle?' may provide insight. It is important to remember that patients may be less forthcoming with emotional reasons and may provide a practical explanation as an alternative. Non-verbal clues may also provide insight, for example a patient with a significant prescription coming in without their glasses on. Understanding their motivation will help you establish what type of wearing schedule they will want and in turn consider what material properties will be needed. It is important to be mindful when asking questions about potential wearing schedules at this stage, especially if you are using this information in your decision-making process. Your patient is new to contact lenses, and whilst they may initially think they only want them for a specific task, they could later decide that they want to wear them far more often!

Occupation

Finding out what the patient does for work is critical in understanding what they will be doing when wearing their contact lenses and the specific requirements they will have. A simple job title however, does not always suffice.

Again, open questions such as 'what does a typical day at work look like?' gathers far more useful information than a job title.

The following are key things to discover;

- **Screen use?**

  If so, what type. Is it a desktop, laptop or even a tablet or phone, as this will affect working distance considerations; something which is particularly important for presbyopic patients. The number of hours spent on these devices is also useful to note as screen use is known to reduce blink rate,[5] which may lead to corneal desiccation (Figure 2) and ultimately affect the comfort of the lenses, especially if coupled with an air-conditioned environment. Knowledge of screen work requirements can help when considering an appropriate lens material. If they want lenses for work which involves a lot of screen use, lenses with reduced pervaporation and low co-efficient of friction should be considered.

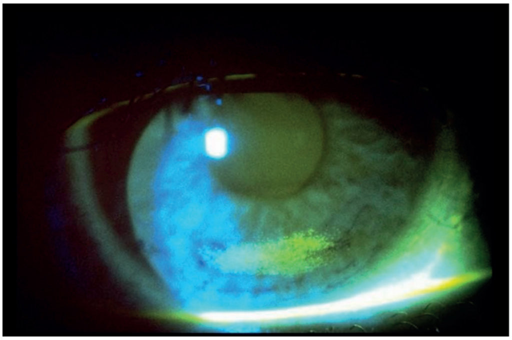

Figure 2. Corneal desiccation staining secondary to incomplete blinking.

- **Driver?**
  Blink rate can also reduce when driving and differing environments within the car such as heating or air-conditioning could affect lens comfort. When driving, patients will regularly change gaze directions, meaning rotational stability is a key consideration for toric wearers.

- **Environment?**
  It is important to consider if the environment is suitable for contact lens wear. Dusty environments may present a contraindication to contact lens wear, as will environments where toxic fumes are present.

Depending on the work environment, contact lenses may not be suitable for work purposes but could still be an option for outside of work. For example, pilots are only allowed to wear distance only contact lenses, with monovision and multifocal options not permitted, so it may be that a presbyopic pilot requires different contact lenses for work than for social purposes.[6] Dual wear of glasses and contact lenses is a key opportunity, enabling your patient to make the most of both correction options. Honest conversations about what contact lenses can and cannot deliver is key at this stage.

Lifestyle

In addition to any occupational information, it is useful to know what hobbies or interests people have, particularly if contact lenses are to be used for specific activities. The best way to start this discussion is with an open question such as, 'what do you like to do in your spare time?' or 'do you have any particular hobbies or interests?'. Further questions will then often be required to provide further clarification. For example, if the answer is 'sports or exercise' further details are needed to establish the type of sport or activity to ensure appropriate advice is given. Soft contact lenses, as opposed to RGPs, are more advisable for sports in general, particularly for contact sports, due to safety implications.

Swimming is always an important thing to discuss with potential contact lens wearers because of the increased risk of serious infections such as microbial keratitis and acanthamoeba keratitis due to accumulation of microbial organisms on or in the contact lens.[7] If a patient wants contact lenses for swimming, then a frank and open discussion around the increased risk must be had. General advice is that contact lenses should not be worn for swimming or participating in water sports without wearing tight-fitting goggles over the top. Research has shown fewer bacterial colonies were found on goggled contact lenses, therefore if a patient wants them for swimming we should encourage them to wear tight fitting goggles. This, in conjunction with a daily disposable option which can be removed and discarded immediately after swimming – or indeed any other activity where there will be contact with water – will minimise the risk.[8]

If the lenses are to be worn outdoors for significant periods of time, then UV protection is worth discussing with your patients as they can provide protection to the cornea, lens and retina. Many patients are unaware that contact lenses can also provide this health benefit. It is important that wrap-around sunglasses and wide-brimmed headgear are still recommended in addition for activities which involve high concentrations of UV light, such as skiing or sailing, in order to fully protect the eye and surrounding tissue.

Ocular History

A full and detailed ocular history is invaluable for successful contact lens fitting.

In general, it is good to establish if patients have had any previous infections, surgery, trips to hospital for their eyes or any ocular conditions that have previously been mentioned..

Perhaps most importantly, it must be established if they have worn contact lenses previously. A detailed history into previous lens wear and specifically, why they ceased lens wear, can provide valuable and necessary insight.

Contraindications to contact lens wear would include any acute or sub-acute inflammation of the anterior segment, or acute or chronic eye infection.[9] Certain ocular conditions may be a contraindication to contact lens wear or may mean you decide to still fit the patient but do so with caution and may need to limit wear times accordingly. Ocular conditions that may be relevant include corneal dystrophies and patients with pterygium or pinguecula. Patients with dry eye or blepharitis will necessitate additional advice or investigations prior to fitting, whilst patients with a history of previous microbial keratitis may affect your advice on contact lens replacement frequency. Ocular conditions requiring frequent drop use such as glaucoma, or even the regular use of anti-histamine eye drops will require specific recommendations. It is worth noting that fitting contact lenses in the presence of active pathology should not be undertaken without the prior approval of the treating ophthalmologist.

Dry eye is worth a specific mention here as discomfort is often a key reason for patients dropping out of contact lens wear. Table 2 summarises some of the risk factors which were categorised as consistent, probable and inconclusive in terms of risk of developing dry eye disease from the Dry Eye Workshop (DEWS) II report.[10] If a patient has any of these risk factors, discussion about dry eye symptoms is useful at this stage. Key words to listen out for include: gritty, burning, watery or stingy, all of which would indicate a potential eye dryness issue. The use of a specific dry eye questionnaire such as Dry Eye Questionnaire-5 (DEQ-5) or the Ocular Surface Disease Index (OSDI) can be used to indicate if the patient suffers from dry eye disease.[11] This topic will be discussed in more detail in a later chapter of this series.

Consistent	Probable	Inconclusive (But with some basis for rationale)
Age	Diabetes	Hispanic ethnicity
Female Sex	Rosacea	Menopause
Meibomian Gland Dysfunction	Viral infection	Acne
Connective tissue disease	Thyroid disease	Sarcoidosis
Sjogren syndrome	Psychiatric conditions	Smoking
Androgen deficiency	Pterygium	Pregnancy
Computer use	Low fatty acid intake	Demodex infestation
Oestrogen replacement therapy	Refractive surgery	Botulinum toxin injections
Environmental conditions (i.e. pollution, low humidity, sick building syndrome)	Allergic conjunctivitis	Multivitamins
Medication use (i.e. antihistamines, antidepressants, anxiolytics and isotretinoin)	Additional medications (anti-cholinergic, diuretics and B-blockers)	Oral contraceptives
Race		Alcohol

Table 2. Risk Factors for Dry Eye (Table generated using information from the DEWs II Executive Summary[10]).

General Health

This is another area where specific lists of questions are routinely asked. It is important to consider how you ask a question, and whether it adds any value to your consultation. Open questions are needed initially but take care in the way they are asked. If you ask a well-controlled, diet managed diabetic 'how is your general health?' they would probably reply by saying 'fine' as they are well controlled. Many practitioners will follow up this type of question by asking if they take any medication. In this instance – the patient would truthfully answer 'no' and you may completely miss the fact they are diabetic. Instead, try 'tell me about your general health' or 'tell me about any general health issues currently being managed by your GP or other healthcare professional'. You may then need to use closed questioning to ask about medication, allergies or certain conditions you feel may be relevant.

Gaining an impression of the patient's general health is important as certain general health issues may affect suitability for wearing contact lenses or affect the type of lenses that should be worn.

- **Diabetes**
  It is estimated that the cornea is adversely affected in up to 70% of all patients with diabetes.[11] Clinical manifestations are variable and may include corneal epithelial issues such as slow and incomplete wound healing and neuropathy meaning loss of corneal sensitivity.[12] Patients with diabetes are also at increased risk of microbial keratitis,[11] so daily disposable lenses maybe indicated. Further questioning around duration of diabetes, level of glycaemic control and presence of retinopathy may be important considerations.

- **Arthritis**
  These patients may suffer with associated dry eye issues, but also the arthritis may affect their manual dexterity. This may affect their ability to handle contact lenses and as such a lens with a higher modulus may be of benefit here.

- **Skin conditions such as eczema**
  These patients may be vulnerable to excessive deposits, lid irritations, punctate keratitis and blepharitis and therefore careful consideration of lens material and modality is necessary.

- **Thyroid dysfunction**
  Patients with thyroid dysfunction can suffer with associated thyroid eye disease (TED). The major concern here is exposure keratitis, however only 5-10% of patients have orbitopathy.[13] Dry eye is the most common cause of ocular discomfort in these patients so questioning around this is key to see if they are symptomatic. Research has shown incomplete blinking and meibomian gland structural loss of the upper eyelid are more prominent in patients with TED than those with dry eye so this again highlights the need for a comprehensive anterior eye assessment.[13]

- **Mental health conditions**

It is also important to note any history of mental health issues, as patient's taking antipsychotic medications may be more vulnerable to dry eye issues (see Table 2). The College of Optometrists guidance states: 'You must not fit a patient with contact lenses if they are not able to use them safely', so this should always be considered during the initial consultation.[4]

- **Allergies**

Approximately 25 per cent of the population suffer from allergies at some point in their life time.[14] It is important to establish an atopic history for the patient as this may influence which type of lens you prescribe. Atopic patients are more likely to have papillae present under their lids initially, or could be more vulnerable to contact lens induced papillary conjunctivitis. Patients prone to allergy may also be more susceptible to contact lens solution reactions or be adversely affected by deposits that form on a contact lens surface. Daily disposable lenses have been shown to be an effective strategy for managing allergy suffering contact lens wearers[14]

- **Medications**

A significant number of commonly prescribed medications list dry eye as a potential side effect (Table 2). Whilst not every patient taking this medication will experience this side effect, it is important to consider as this may influence contact lens comfort. An accurate record of current medication is therefore crucial in all patient assessments.

- **Smoking**

When assessing patients for suitability for contact lens wear asking them if they smoke is very important as research suggests smoking is associated with a 3.7x increased risk of moderate and severe microbial keratitis.[15]

When eye care practitioners were asked what standard questions they ask on initial fitting only 59% asked if the patient smokes.[16] This is something that we may need to get more comfortable asking our patients about, especially as our role as professionals extends into preventative health care.

Top Tip

Asking patients to bring in a copy of their current medication list can be very useful, rather than relying on a patient's memory!

Other Considerations

Age of Patient

1. Children

Often parents will ask ‘how old do children need to be to wear contact lenses?’. A survey conducted by the College of Optometrists highlighted that the maturity of the child is of much greater importance than the age when deciding on suitability.[17] A practitioner must also be able to satisfy themselves that a patient will be able to use them safely.[4] The decision to wear contact lenses should come from the child, and not just a parent. Directing conversation and questions around contact lens wear to the child specifically, rather than the adult can, in some cases, provide invaluable insight into who truly wants them to wear contact lenses.

2. Presbyopes

It is important to be aware of the natural changes to the eye that occur with age (Table 3), as well as potential changes in manual dexterity, all of which may affect the potential success of the contact lenses. It is important to know and understand the patient’s specific visual needs, alongside discussing the different correction options. Newer generation multifocal lenses provide functional distance, intermediate and near vision, whilst maintaining the patient’s binocular vision and stereoacuity. It is important to set realistic expectations during this discussion stage, before you move onto the fitting section. Over-promising and under-delivering is a recipe for failure, whereas time spent managing and setting realistic expectations will help drive success. We are fortunate to now have a range of options to suit the presbyopic

Ocular Changes	Visual Performance Changes
Decreased tonus of upper & lower eyelids	Decrease in visual acuity (reduction greater for low contrast and low luminance)
Reduced palpebral aperture	Reduction in contrast sensitivity for higher spatial and temporal frequencies
Decreased lacrimal secretion	Potential reduction in stereoacuity
Reduced tear stability	Increased glare sensitivity
Decreased corneal sensitivity	
Increased corneal fragility	
Decreased ocular media transparency	
Decreased pupil diameter	
Increased incidence of corneal age-related disorders	

Table 3. The effects of ageing on the eye (Adapted from Woods[18,19]).

patient, so presbyopia should no longer be a barrier to successful contact lens fitting.

Prescription Considerations

The range of prescriptions available for contact lens wear is extensive, and many of the recommendations made will focus on the best material and modality options for the patient. Vision is often accepted as a 'given'. However, an awareness of prescription availability is always handy before you launch into making your specific recommendation! Discussing with patients the benefits of contact lenses in terms of loss of spectacle magnification and increased field of view is worthwhile at this stage as it gives them further motivation to trial the lenses. Binocular status needs to be considered, and whilst binocular function can be improved compared to spectacles in the anisometropic patient, soft contact lenses are unable to correct any prism prescribed within the spectacle prescription. High ametropia, or large astigmatic corrections may lend themselves to different lens types or forms.

Previous Contact Lens Wear

If patients have worn lenses previously it is important to determine what type of lenses they wore and reasons for ceasing wear.

You also want to be aware of any complications they had when wearing contact lenses previously as this may influence your choice of contact lens this time round. Studies continue to show that handling and comfort are commonly cited performance-related reasons for drop out, but visual problems, especially in toric and multifocal wearers, are more of a factor in drop out than previously thought.[20] With the newer technologies available, alongside increased prescription ranges, we can often overcome these issues with appropriate contact lens selection.

Financial Considerations

In an ideal world, every patient would choose to wear the best product for them. On occasions, financial considerations may necessitate a change in recommendation. It is however important not to pre-judge a patient's financial status or indeed feel protective of their finances. Our role is to listen to their requirements, assess their suitability and from that, make the most appropriate recommendation for them. At this point they need to be informed of the cost and if it isn't suitable, then you can work together to see if a more cost-effective option is available and advise them of the loss of benefit – if any – that this option delivers. It is often useful to break cost down to price per wear as this often helps them see it is an affordable option for them. Crucially, although cost is a constant between patients, value can be very different between patients, and as health care providers it's important not to judge what value patients attach to the change in lifestyle contact lenses may provide on the basis of cost.

Summary

A great contact lens recommendation comes from a combination of understanding the patient's individual needs and evaluating the eye health.

A comprehensive history can help a practitioner enormously with the first element. The information gathered in an initial discussion which will help aid decisions around which material properties are important to consider for the individual patient. With so many areas to cover and often with limited time available, effective communication is key to enable you to extract the information needed from your patient in a timely manner. Whilst it is good to follow a systematic approach to use the time effectively and ensure information is not missed, it is important to maintain a conversational style and good rapport with the patient. In many ways this improves time efficiency as selecting the right lens for the patient's needs and managing their expectations will reduce follow-up appointments and remedial actions.

Before making any final decisions on which lens to recommend, a comprehensive anterior eye examination and tear film assessment will need to be performed. Using the detailed history alongside the health examination results, means that a recommendation which is truly specific to the patient can be comfortably made.

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Initial Examination Part 1 – Refraction & Corneal Assessment

Authors: Clair Bulpin & Rachel Hiscox

The process of contact lens fitting requires comprehensive clinical assessment of the patient, including evaluation of refractive requirements along with a series of additional anterior eye measurements, together with assessment of corneal contour. This information, in conjunction with consideration of the patient needs and an anterior eye health assessment, will contribute to determining the ideal lens choice for each individual patient.

Refraction

As discussed in the last article, a valid refraction is a pre-requisite for a contact lens fitting and if the patient is new to you, they should provide a copy of their results.[1] Practitioners may opt to check this result prior to commencing a fitting, especially if some time has passed since their last eye examination. This can provide additional insight for finer details, such as astigmatic axis, spherical refinement, and multifocal contact lens fitting, for those patients sitting 'between' available contact lens parameters, or for those that require a best vision sphere lens where cylindrical correction is not available. Small checks at this stage here may save future additional 'tweaks' to prescriptions. There are several key elements to consider when evaluating a refraction.

A Back Vertex Distance (BVD) measurement is required to be recorded on the prescription for refractions with a power of >±5.00 dioptres along either axis.[2]

However, it should be noted that dependent on BVD, adjustments may need to be made on powers of >±4.00.

For those that prefer to do the calculations themselves, the formula shown in Figure 1 can be utilised. However, there are many online calculators available and these, alongside BVD conversion tables, often serve as a quicker alternative. It is worth mentioning at this stage that BVD calculations must also be considered in the presence of an astigmatic refraction result. A prescription reading -3.75DS / -1.50DC x 180, may not at first glance look like it necessitates a BVD adjustment, however, it is important that each meridian is considered independently as this may influence the cylindrical power needed (Figure 2). As a rule of thumb, when a prescription is written in negative cyl form, a myopic patient will need the cylindrical power reduced whereas a hyperopic patient will require a cylindrical power increase.

The presence of binocular vision anomalies will need to be considered when fitting a patient with contact lenses. Any prismatic correction provided in spectacles cannot be given in contact lenses so a discussion establishing expectations is

$$Fc = \frac{F}{(1 - xF)}$$

Fc is the focal length of the new lens in dioptres,
F is the focal length of the original lens in dioptres,
x is the distance that the lens was moved in m.

E.g.: Spectacle Rx is -5.50DS, BVD is 12mm

$$Fc = \frac{-5.50}{1 - (0.012 \text{ x } - 5.50)}$$

$$Fc = \frac{-5.50}{1 - (-0.066)}$$

$$Fc = \frac{-5.50}{1.066}$$

Fc = -5.16 DSDS

E.g.: Spectacle Rx is +5.50DS, BVD is 12mm

$$Fc = \frac{5.50}{1 - (0.012 \text{ x } 5.50)}$$

$$Fc = \frac{5.50}{1 - (0.066)}$$

$$Fc = \frac{5.50}{0.934}$$

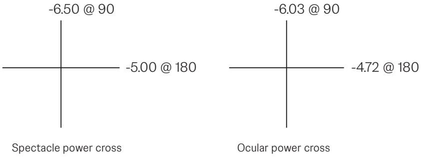
Fc = 5.89 DS

Figure 1. Calculation of contact lens power from spectacle refraction.

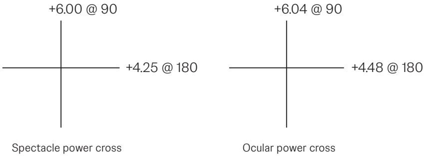
critical here. Prism incorporated to assist a decompensating phoria may not be a contraindication depending on the needs of the patient and the tasks they wish to wear contact lenses for; prism incorporated to alleviate constant diplopia however, will be.

Details of visual acuity are not required on a spectacle prescription[2] so thorough questioning becomes invaluable in identifying amblyopia if you do not have access to eye examination records. Recording achievable visual acuity in the current spectacles can provide additional useful information and provide a target acuity for contact lens wear. Amblyopia and binocular status become even more relevant when looking to fit multifocal contact lenses as many lens designs rely on near equal input from both eyes to allow for binocular summation and achieve maximum success. Understanding and explaining the concept of spectacle magnification can be beneficial at this stage too, especially in high hyperopic prescriptions. Some patients benefit from 'better' acuity in spectacles due to the magnification provided by a plus lens. They may 'lose' a line on a letter chart but will of course gain the field of view restricted by spectacle frames. Myopic patients nearing presbyopia may need additional information about near expectations as the accommodative demand for close tasks is higher in contact lenses than that in spectacles.[3] Conversely, hypermetropic patients will benefit from having to accommodate less and delay the need for a presbyopic correction.

Myopic calculation
Spectacle Rx: -5.00DS / -1.50DC x 180 BVD 12mm
This equates to: -5.00DS power along 180 and -6.50DS power along 90
BVD adjustments: -4.72DS x 180 and -6.03DS at 90
Ocular refraction: -4.72DS / -1.31DC x 180
Starting trial lens power: -4.75DS / -1.25DC x 180



Hypermetropic calculation
Spectacle Rx: +6.00DS / -1.75DC x 90 BVD 12mm
This equates to: +6.00DS x 90 and +4.25DS x 180
BVD adjustments: +6.47DS x 90 and +4.48DS x 180
Ocular refraction: +6.47DS / -1.99DC x 90
Starting trial lens power: +6.50DS / -2.00DC x 90



*Remember axis and power meridians are perpendicular to each other, therefore a cyl at 90 will generate its power at 180 degrees.

Figure 2. Calculation of contact lens prescription with a toric spectacle prescription, taking into account BVD.

Attention to detail at this stage, considering how the spectacle prescription will translate into contact lens wear, provides a real opportunity to fully discuss and manage expectations.

Measurements

It has long been a topic of debate as to the relevance of certain ocular measurements, particularly in reference to soft lens fitting. The advent of 'one-fit' soft lenses meant that many practitioners adopted the 'try it and see' approach rather than considering in detail the measured values of various ocular parameters. Whilst arguably, these measurements are more important in rigid gas permeable (RGP) and more complex lens fittings, understanding the impact to comfort from a poorly fitting contact lens, can highlight areas for improvement.

Horizontal Visible Iris Diameter

Horizontal visible iris diameter (HVID) can be measured in a number of ways from the highly precise use of instrumentation such as topographers or use of slit lamp graticules, to simply measuring by eye with a conventional ruler. It is important to note that it can be difficult to be highly accurate whilst measuring a curved surface with a flat tool and traditional ruler-based methods may underestimate the horizontal cornea by nearly 1mm. The value of this measurement potentially lies in initial lens diameter selection and provides an indication as to whether a soft lens diameter is sufficient to maintain full corneal coverage. Typically, an average HVID measurement is 11.8mm[4] and manufacturers of soft lenses will produce diameters designed to overlap the limbus by approximately 1mm each side for most patients. A patient falling outside of these 'average' parameters may experience difficulties with lens fit and this might, in turn, affect comfort or vision stability.

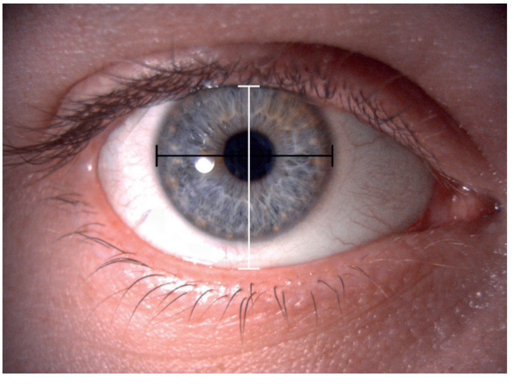


Figure 3. Measurement of HVID (black line) and VPA (white line).

Vertical Palpebral Aperture

Measurement of vertical palpebral aperture (VPA), is of questionable value in modern contact lens fitting. However, it may provide useful information for RGP and bifocal lens fitting if the position of the lids relative to the limbus is also considered. Assessing lid tension alongside VPA may provide valuable information about ease of lens application and removal.

Pupil Size

Measurement of pupil size becomes relevant when looking to understand the influence of lens geometry on visual outcomes, particularly when it comes to RGP lenses or in presbyopic lens fitting. In these situations, both average pupil size in ambient lighting and maximum pupil size, measured with a burton lamp in a darkened room should be considered. The back optic zone diameter (BOZD) of a contact lens should be considered alongside pupil measurements, as there is an increased potential for visual problems, such as glare and haloes, if the pupil is larger than the BOZD. Whilst a BOZD may be specified in RGP and more complex lens types, it will not be adjustable in most soft contact lens designs.

Assessment of Corneal Contour

Advancing technologies provide an increasing understanding of the relevance of corneal contour in contact lens fitting. These measurements can provide valuable data in the preliminary stages of fitting, but perhaps more importantly, they provide information for the ongoing monitoring of the effects of contact lens wear on the eye. Subtle changes in corneal contour induced by contact lenses or pathology can have a substantial impact on clarity of vision and may be indicators of problems to come. Significant changes in visual acuity or refractive correction can be induced by relatively small changes to corneal shape, hence the importance of using a sensitive and accurate method of measurement.

Keratometry

Use of keratometry, which typically measures the central 2-4mm of cornea, to select the initial soft contact lens base curve is based upon the assumption that central corneal curvature is directly related to sagittal height, however, it is also related to other factors, including corneal diameter, corneoscleral profile and corneal shape factor.[5,6] It also assumes that the cornea is spherical, where it is typically a prolate ellipse, flattening gradually towards its periphery. It is therefore perhaps no surprise that several studies show no correlation between central or peripheral k-readings and the best fitting soft contact lens.[5,6,7] However, the baseline data obtained by keratometry provides useful reference information and remains a common method of measurement in many practices. Assessment of mire clarity during assessment can provide valuable insight into tear film stability or corneal regularity and should be recorded alongside keratometry readings (Table 1, Figure 4).

Grade 0	Clear mire image
Grade 1	Slight distortion of mires
Grade 2	Mild distortion: reading possible with some difficulty
Grade 3	Moderate distortion: reading difficult to assess
Grade 4	Gross distortion: reading impossible

Table 1. Grading of mire distortion.

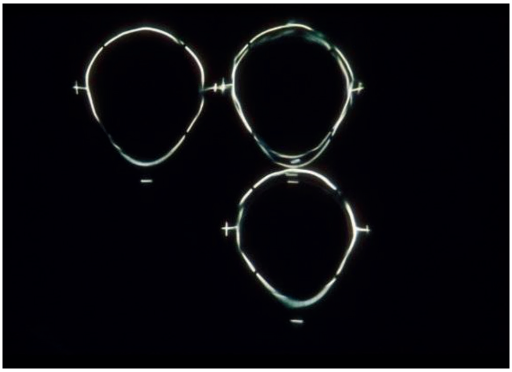


Figure 4. Bausch & Lomb one-position keratometer showing mire distortion.

Keratometry works on the principle of recording the image size reflected from a known-sized object. Given the object size and distance from image to object, the radius of curvature of the cornea can be calculated. In manual keratometry, measurement of corneal curvature is achieved using an optical doubling system where the observer aligns images of mires reflected from the cornea. This doubling may be ‘fixed’ as in the Javal-Schiotz instruments, or variable as in the Bausch & Lomb style instrumentation. Often referred to as ‘one-position’ (variable doubling) or ‘two-position’ (fixed doubling) instruments, there are advantages and disadvantages to both. In a one-position instrument such as the Bausch and Lomb Keratometer, readings from 2 principle meridians can be taken at the same time so it may be quicker (Figure 5). However, it does assume that these 2 meridians are perpendicular to each other. The two-position, fixed doubling instruments have a longer working distance so can be more accurate and can also identify and measure irregular meridians. Using these instruments requires correct eye-piece focusing as errors in this leads to incorrect measurements of corneal curvature. Calibration is also necessary and this is achieved using calibration steel ball bearings of known curvature that are accurate to +/- 0.001mm.

Keratometry may also be obtained electronically, typically in conjunction with refraction. These systems are usually two position instruments which utilise servomotors (a motor coupled with a sensor for position feedback) to drive the doubling device until alignment can be assessed optically using light emitting and detecting diodes. These devices typically provide a mean of three measurements and may provide an estimate of the corneal shape by measuring the corneal radius peripherally as well as centrally.

Obtaining results from any method is only part of the process; interpreting the measurements accurately is what can facilitate contact lens fitting. Table 2

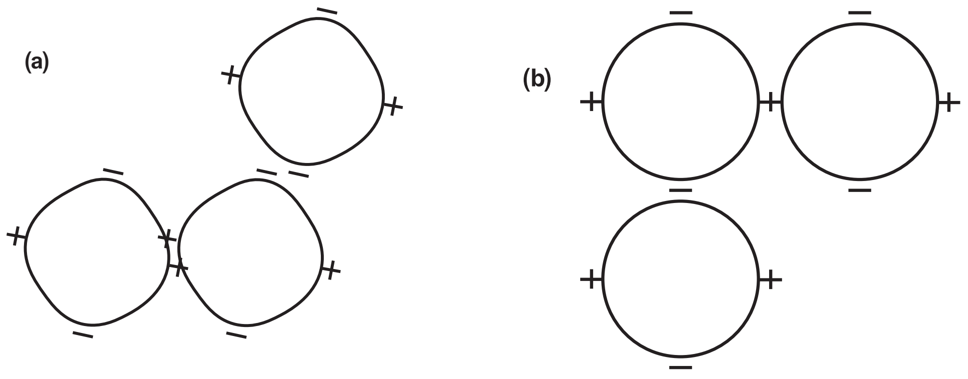


Figure 5. Bausch & Lomb one-position keratometer mires: (a) mire and axis misalignment, (b) mire alignment.

Authors	Eyes	Ethnicity	Horizontal (mm)		Vertical (mm)	
			Mean ± SD	Range	Mean ± SD	Range
Kiely et al 1984[16]	196	Caucasian	7.79 ± 0.26	7.10 to 8.75	7.69 ± 0.28	7.06 to 8.66
Guillon et al 1986[17]	220	Caucasian	7.87 ± 0.25	7.14 to 8.54	7.7 ± 0.27	7.03 to 8.46
Lam & Loran 1991[18]	63	Caucasian	7.98 ± 0.21	7.10 to 8.36	8.03 ± 0.20	7.29 to 8.43
Lam & Loran 1991[18]	64	Chinese	7.74 ± 0.24	7.21 to 8.31	7.9 ± 0.23	7.46 to 8.48

Table 2. Range of K-readings in normal population.

shows the range of K-readings in a normal population, with averages around 7.70-7.90mm, or 43 to 44D. Falling outside of these parameters would indicate a steeper or flatter than average central cornea. Typically, a myope will have steeper keratometry readings than a hyperope.[8] Keratometry measurements are useful in evaluating astigmatism and can provide valuable information as to whether astigmatism is corneal or lenticular. With the rule astigmatism is when the steepest axis is vertical (or within 30 degrees) creating a negative cylinder axis at 180. In against the rule astigmatism, the steepest axis is horizontal leaving a negative cylinder axis at 90 degrees. When the two meridional measurements are compared, this can indicate the amount of corneal astigmatism, with 0.1mm difference equating to approximately 0.50DC of astigmatism. This information can be used to help select the best design and type of lens to correct astigmatism, particularly when it comes to RGP contact lenses.

Corneal Topography

When more information about the shape and curvature of the cornea is required, for example to facilitate fitting of complex RGP lenses or in orthokeratology, corneal topography will provide a more detailed description of the corneal characteristics.

Whilst a keratometer will measure the radius of curvature across the central 2-4mm of the cornea, corneal topography traditionally analyses and measures between 9 and 10mm of the cornea, generating a topographic map of the corneal shape. Topographers are now available to map the whole of the anterior surface of the eye, which can be particularly helpful in large diameter rigid lens fitting.

Gross corneal topography was first assessed by Placido in 1880 by projection of a simple concentric ring target onto the cornea.[9] Many modern day topography systems continue to use the technique of Placido disc projection to measure corneal curvature, with information captured using specialised video systems. With the use of computer-aided software and the capability to translate the information captured by the camera into useful information on corneal shape, these systems are also referred to as videokeratoscopes.

Placido disc/ring based topographers use the tear film as a convex mirror to reflect a series of concentric rings (Figure 6).[9] Corneal shape is assessed by analysing the regularity and separation of the reflected rings to give curvature and power information. Placido disc based systems do not obtain true corneal height information. This type of topography requires a good quality tear film to ensure accurate measurement, therefore it is advisable to ensure the patient had a good blink immediately before capture.

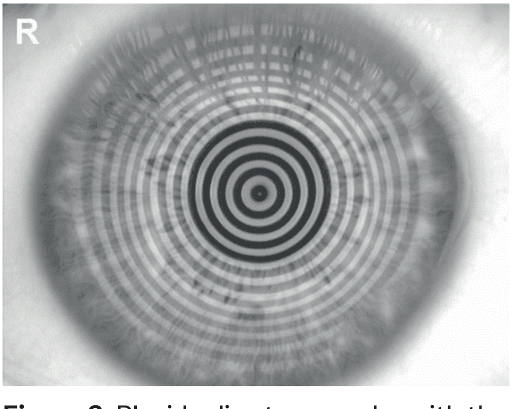


Figure 6. Placido disc topography, with the Topcon CA800.

Alternatively, ocular lubricants can be used to improve a poor quality tear film.

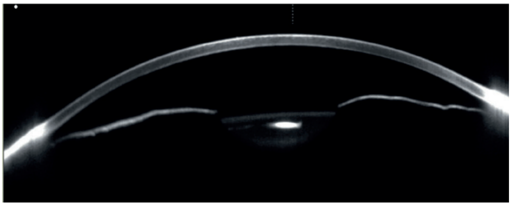


Figure 7. Slit projection, Scheimpflug tomography with the Oculus Pentacam.

Corneal Tomography

Whilst corneal topography can only gather information about the anterior corneal curvature, corneal tomography can also gather posterior corneal information, by examining cross sections of the cornea. The Oculus Pentacam combines a slit projection system with a scheimpflug camera, which rotates around the eye (Figure 7).[10,11] The cornea is illuminated with a slit of light, causing back scatter of light which is captured by a camera, oriented according to the Scheimpflug principle, thus creating a perfectly sharp image. A series of radial images are captured around the eye, then combined to create a three-dimensional model of the entire anterior portion of the eye from the anterior lens to the anterior corneal surface. The rotating measurement principle used in scheimpflug imaging avoids measurement errors that would result from horizontal scanning. Captured images are mathematically analysed to generate data on elevation, curvature and pachymetry.[10]

Topography & Tomography Interpretation

As with any technique, the real skill lies in interpreting the information gathered. Corneal topographers, using sophisticated software, are able to present results in a range of different forms including colour coded maps, 3D images and corneal cross sections. The most commonly used maps are the curvature and elevation (height) maps, each of which will be briefly described below.

Curvature maps display the cornea's radii of curvature and can be expressed in either mm or diopters. Colours are used to represent the curvature and dioptric value across the cornea, with hotter colours (reds and oranges) representing steeper areas, and cooler colours (blues and greens) representing flatter areas. It is worth noting whether an absolute or normalised scale is being used to display results as this will have an impact on the pattern observed. The absolute scale uses large, fixed intervals to cover the whole scale of possible curvature values, with the same scale and colours used for all eyes. While the absolute scale can mask fine details, it should always be used to facilitate comparisons over time. The normalised scale is not fixed and varies for each eye and image. The range for the normalised scale is determined by the flattest and steepest values of the cornea it is examining. While this scale reveals fine corneal detail, care should be taken when using it as small details can appear to be magnified by an inappropriately narrow scale (Figure 8).[12]

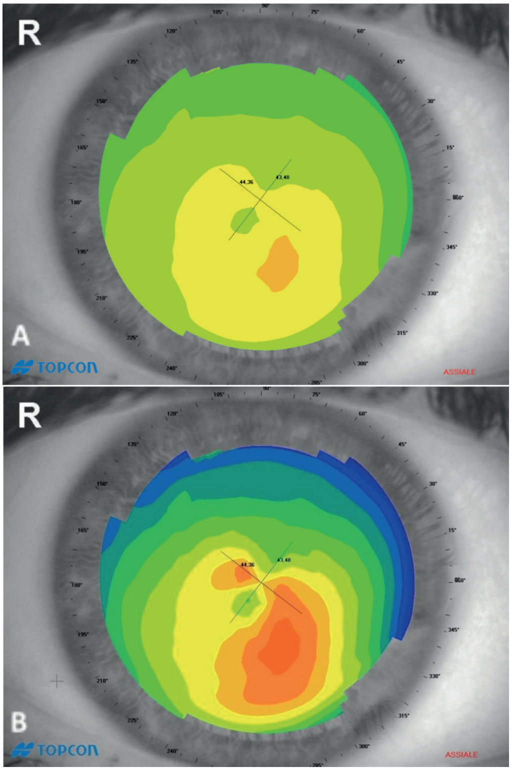


Figure 8. Axial curvature maps showing irregular astigmatism, which is revealed in the normalized scale (B), but masked in the absolute scale (A).

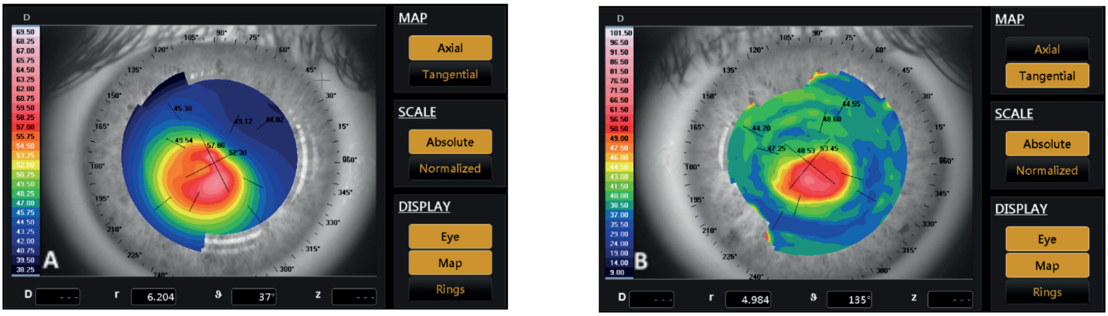


Figure 9. Curvature maps of a keratoconic eye. Whilst the cone can be seen in the axial map (A), the tangential map (B) allows better localization and more detail.

Corneal curvature can be calculated, and thus displayed in two ways; axial and tangential. Axial (global/saggital) radius of curvature measures the curvature of each section of the cornea in relation to the optical axis (Figure 9A). This results in measurements having a spherical bias and being inaccurate in the periphery and in irregular corneas.[13,14] However, as these maps produce large, diffuse patterns they are better for visualising regular corneal astigmatism, for contact lens fitting and for estimating the general corneal curvature. Axial curvature maps of normal corneal topography can be classified into five groups: round, oval, symmetrical bow tie, asymmetric bow tie and irregular (Figure 10).[15] Tangential (local/instantaneous) radius of curvature measures the curvature of each point on the cornea with respect to its neighbouring points (Figure 9B). Therefore, tangential mapping is more accurate for local irregularities and for mapping the peripheral cornea curvature.[12,14] Tangential maps should always be used over axial maps in detection and monitoring of keratoconus as they allow more accurate assessment of the cone location.

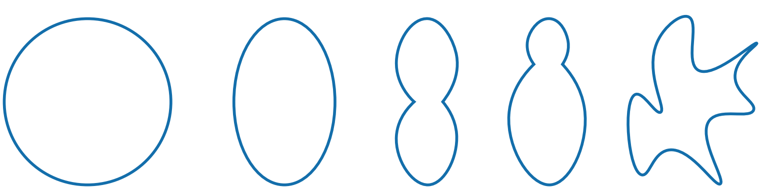


Figure 10. Classification of corneal topography map showing (from left to right) round (spherical cornea), oval, symmetrical bow tie (regular astigmatism), asymmetric bow tie (irregular astigmatism) and irregular patterns, as described by Brogan et al[15]

Height maps can be approximately generated from Placido-based topographers, but can only truly be created from a projection-based system. Rather than displaying the raw data, it is typically illustrated in reference to a known sphere shape.[15] In elevation maps, hot colours represent elevation above the reference sphere (i.e. flatter curvature), whilst cool colours represent areas lower than the reference steeper (i.e steeper curvature) (Figures 11 and 12). Elevation maps can be useful for RGP fitting. When the reference sphere is set to the BOZR of the contact lens, warm colours would show where the fluorescein would be displaced, whilst the cool colours demonstrate where fluorescein would be expected to pool.

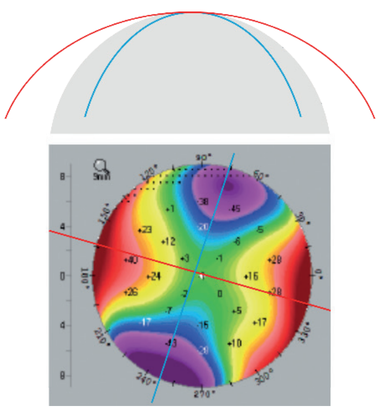


Figure 11. Elevation maps. (Top) A diagrammatic depiction of elevation maps, described in relation to a best-fit-sphere. The steep meridian (blue) is below the best-fit-sphere, and the flatter meridian (red) falls above the best-fit-sphere. In the elevation map (Bottom), the flatter meridian is seen as elevated above the best-fit-sphere (warm colours), whilst the steeper meridian is seen as below the best-fit-sphere (cool colours).

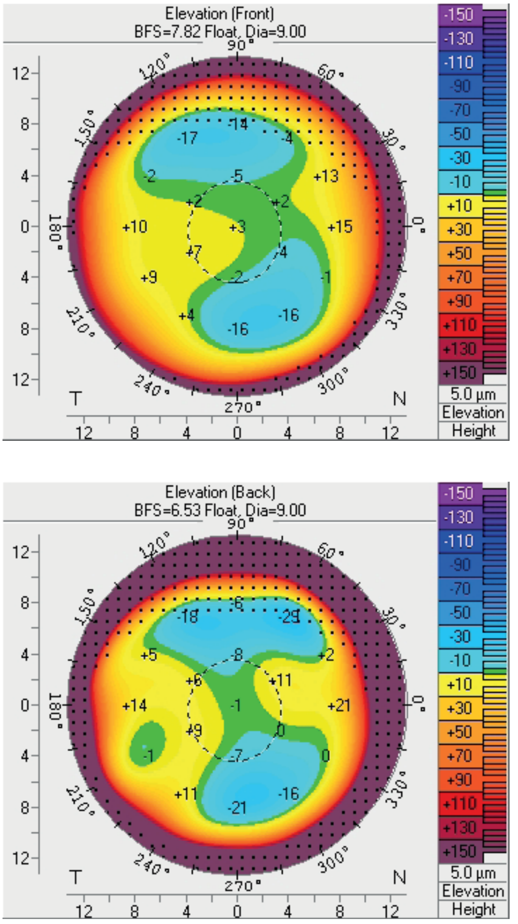


Figure 12. Elevation maps for a normal astigmatic cornea, where warm colours represent elevation above the reference sphere, i.e. flatter curvature, and cool colours represent areas lower than the reference sphere, i.e. steeper curvature. The front surface (top) and back surface (bottom) elevation maps show elevation above the reference sphere across 10°.

Summary

When commencing a contact lens fit, refractive information must be carefully assessed to ensure the correct contact lens power is selected, with BVD calculations applied for each meridian once the spectacle refraction is over +/- 4.00DS. Whilst assessment of corneal curvature using keratometry is now thought to offer little help with selection of an appropriate soft contact lens, The College of Optometrists guidance suggests keratometry or topography should be completed during a fitting assessment. Despite its potential limitations within the fitting process of soft contact lenses, understanding and monitoring corneal curvature is vital in contact lens practice to monitor for corneal changes and keratometry continues to provide accurate and reliable results for many practitioners. Where more specialist contact lens fitting is required, corneal topography or tomography can provide a wealth of information which is often vital to achieve a successful outcome for the patient.

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J&J Institute

Initial Examination Part 2 – Slit Lamp Examination

Author: Amanda Davidson

Careful slit lamp examination of the anterior eye is an essential part of contact lens practice. Guidelines from professional bodies, such as the College of Optometrists specify that contact lens practitioners must have a slit lamp microscope.[1] The guidance further specifies that the practitioner must carry out a detailed assessment of the anterior eye which might be affected by wearing contact lenses– for example, the cornea, conjunctiva, limbus, lids and tear film. This article will consider how the slit lamp examination should be performed during contact lens fitting in a systematic manner to ensure all relevant information is captured and used to inform contact lens selection.

Technique and Set up

Correct set up of both the slit lamp and the patient is essential for accurate observations.

Instrument Focusing - It is essential to focus the slit lamp prior to commencing examination as a slightly out of focus image at low magnification will become indistinguishable once the magnification is increased. The aim is for the microscope to be focused at the same plane as the illumination system, which typically has a fixed focus and cannot be altered. Accurate focusing can be achieved using the focusing rod placed in the pivot hole of the slit lamp, together with a high magnification and a medium width beam. Eyepieces should be rotated fully anti-clockwise, producing maximum plus, before each eyepiece is focused individually by rotating the eyepiece clockwise, decreasing the plus, until the grainy appearance of the slit beam on the focusing rod is clear. Care should be taken not to rotate the eyepieces further than this point as this will induce accommodation in younger users. When both eyepieces have been focused their separation should be adjusted to allow a comfortable and clear binocular view of the focusing rod surface.

Patient Position - Before you position your patient, don't forget to clean the slit lamp. The College of Optometrist's Guidance for Professional Practice emphasises the importance of clear and effective communication with our patients[2] so it is important to explain to the patient the nature of the examination including what they should expect. It is also advisable to make sure that they are seated comfortably; the examination becomes significantly more difficult it the patient becomes uncomfortable and continually shifts position. Optimal position is achieved when the patient's head is central on the chin rest, with the outer canthus aligned with the guide on the head rest.

Slit lamp routine

A slit lamp routine is something that a practitioner develops over time and can vary according to the patient and their presenting symptoms and history. Whilst the exact order of the examination will vary between practitioners, typically the examination will start with low magnification and diffuse illumination for general observation, with the magnification increasing and more specific illumination techniques employed to view structures in greater detail. Throughout the routine different magnification and illumination

Illumination	Magnification	Filters	Slit Width	Structures Examined	Conditions Evaluated
Direct	Low	No	Wide/diffuse	Lashes	Blepharitis
				Bulbar conjunctiva	Hyperaemia Pterygium Pingueculae
				Palpebral conjunctiva	Follicles Papillae Hyperaemia
	Medium/high	No	Wide	Lid margins	Meibomian glands Patency of tear ducts
		Blue, if using NaFl	Wide/diffuse	Lid wiper area	Lid Wiper Epitheliopathy (LWE)
		No	Wide/diffuse	Bulbar conjunctiva	Lid Parallel Conjunctival Folds (LIPCOF)
			Medium	Cornea	Opacities
				Iris	Naevus
		Red free		Limbus	Vascularisation
	High	No	Narrow	Cornea	Epithelial dystrophies Dellen Striae Folds Endothelial morphology
				Tear Film	Quality e.g. debris
	Medium / high	Blue	Medium	Cornea	Staining
				Conjunctiva	Staining
Indirect	Low	No	Medium	Cornea	Corneal Opacities Central corneal clouding
	High	No	Narrow	Limbus	Vascularisation

Table 1. Summary of structures and conditions viewed at each stage of the slit lamp examination

techniques are used in order to carefully view different structures of the anterior segment (Table 1). These techniques are described in detail by various authors.[3,4,5] With practice, practitioners will be able to utilise a combination of viewing techniques to systematically examine the anterior eye to detect abnormalities or issues which may affect contact lens fitting (Table 2). A wider or diffuse beam with a low magnification will enable the practitioner a general overview at the same time as providing a greater depth of focus, while narrowing the beam and increasing magnification allows a more detailed observation but with significantly less depth of focus. By continually varying magnification, beam widths and observation techniques different structures can be assessed with accuracy and efficiency.

Structure	Variation from the norm	Management Options
Eyelashes	Blepharitis	Consider managing alongside fitting unless severe
	Stye	Usually self-limiting. Wait until resolved before fitting
Eyelid margin	Meibomian gland dysfunction	Consider managing alongside fitting unless severe
Palpebral conjunctiva	Hyperaemia	Ascertain cause prior to fitting
	Follicles and/or papillae	Ascertain cause and consider appropriate management. Consider contact lens material properties
Bulbar conjunctiva	Hyperaemia	Ascertain cause prior to fitting
	Pinguecula/pterygium	Try to ensure minimal mechanical stimulus on the area
Limbus	Vascularisation	Record for baseline, carefully consider desired contact lens material properties and monitor closely
Cornea	Staining	Ascertain cause prior to fitting
	Opacities	Ascertain cause and record for baseline

Table 2. Variations from normal that need to be considered in the initial slit lamp examination

Overall view – Low magnification

It is best to begin most examinations with low magnification (6-10x) and a wide beam, preferably with diffuse illumination to allow for general observation of the ocular structures (Figure 1).

Several sweeps across the adnexa should be performed, focusing attention sequentially on different anterior structures. Starting with the lids closed, the lid margins and lashes can be examined for signs of blepharitis or styes. Instructing the patient to open their eyes will allow the upper and lower lid margins to be examined for any signs of meibomian gland dysfunction and to assess the position of the puncta. Patency of the meibomian glands should not be assessed at this stage as expressing lipid into the tear film will affect later tear film evaluations. Assessment of blink patterns can be performed at this stage if this has not already been noted.

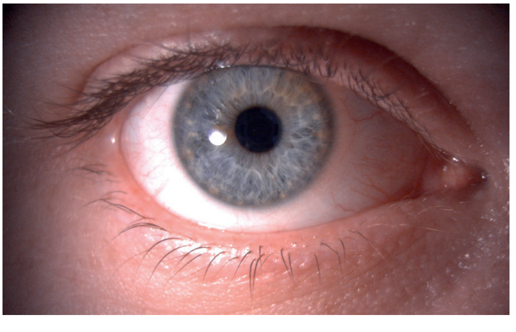

Figure 1. Overview of the ocular adnexa, lids and lashes using 6x magnification and diffuse illumination.

Once the lids have been observed, attention and focus should move to the bulbar conjunctiva to assess the level of hyperaemia and the possible presence of any irregularities of the conjunctival surface such as pingueculae or pterygium as these may potentially impact contact lens fit and comfort (Figure 2).

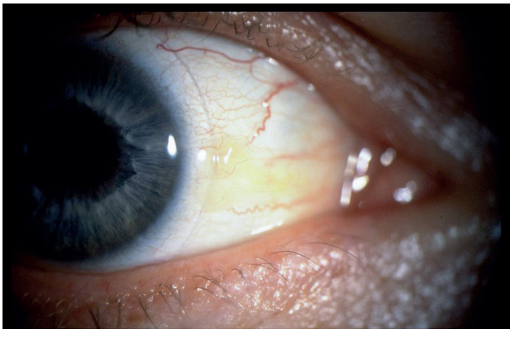

Figure 2. Grade 1 pinguecula slit lamp photograph, taken at 10x magnification with diffuse illumination.

Tear film examination – Medium to high magnification

With higher magnification (16-24x) and a thinner beam (2-3mm) tear film quality and quantity can now be assessed. It is important to examine the tear film at this early stage in the slit lamp routine as prolonged exposure to bright light may induce reflex tearing, leading to inaccurate findings. Note should be made of the tear film quality with respect to any debris, e.g. makeup, presence of any frothing and thickness of the lipid layer by observation of the interference pattern6 seen with specular reflection (Figure 3). Tear volume can be measured using a horizontal slit beam and adjusting the slit width to match the tear meniscus height centrally along the lower lid (Figure 4).

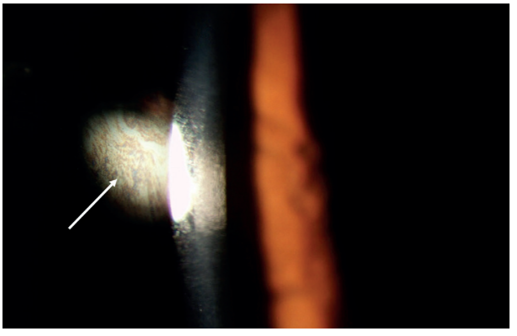

Figure 3. Observation of lipid layer coloured fringes (white arrow) using specular reflection.

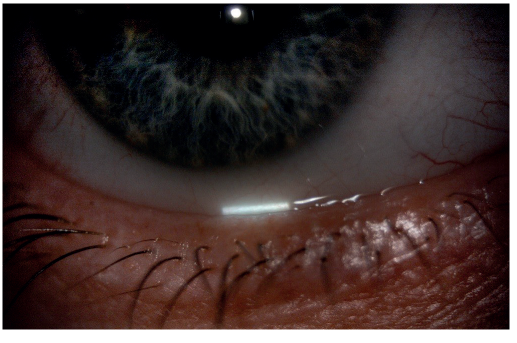

Figure 4. Measurement of tear meniscus height using the slit beam width, with the illumination rotated by 90 degrees.

Figure 5. Observation of normal limbal vasculature using medium magnification.

Corneal and limbus examination – Medium magnification

Continuing the examination, attention should now move to the cornea and limbus. Some practitioners like to use sclerotic scatter at this stage to check for any corneal opacities or localised corneal oedema. This technique involves decoupling the slit lamp and directing a slit beam of 1-2mm thickness on the temporal limbus at an angle of about 40 to 60 degrees in order to achieve total internal reflection within the cornea. Sclerotic scatter will result in a halo of light around the limbus and the objective is to detect any scatter within the cornea which - without abnormality present - should appear dark. To enhance the contrast of any light scatter, ambient room lighting should be minimised.

With the slit lamp re-coupled, a narrow beam (1-2mm) of medium brightness and approximately 10-16x magnification should be used to examine the cornea, beginning at the limbus and sweeping across the cornea to detect gross abnormalities. Physiological corneal vascularisation (blood vessels overlying clear cornea) should be differentiated from any neovascularisation (new vessels growing into clear cornea). Blood vessels are seen using both direct illumination (Figure 5), looking directly at the illuminated area of the cornea, or indirectly, looking to the side of the illuminated cornea, simultaneously. Retro-illumination may also be used whereby vascularisation is viewed by illumination resulting from diffuse scatter coming off the iris and illuminating the vessels from behind. A red-free (green) filter can aid observation of vascularisation. During observation of the limbal region, the presence or absence of peripheral infiltrates should be noted.

Corneal examination – High magnification

After gaining a gross overview of the cornea, the slit width should be reduced to its minimum to allow observation of the cornea in cross section (Figure 6). The clarity of the section is determined predominantly by the width of the slit; the thinner the slit the better the quality of the section. With high magnification and illumination, systematically sweep the cornea, taking care not to miss any part. Any opacification should be recorded, with the cross-sectional view allowing the depth to be determined. Though highly unlikely to be seen, especially in a contact lens neophyte, epithelial microcysts, a sign associated with corneal oedema typically secondary to hypoxia, can be observed at this stage by viewing the cornea with direct retro-illumination (Figure 7).

Figure 6. Optical section of the cornea, showing the epithelium, stroma and endothelium.

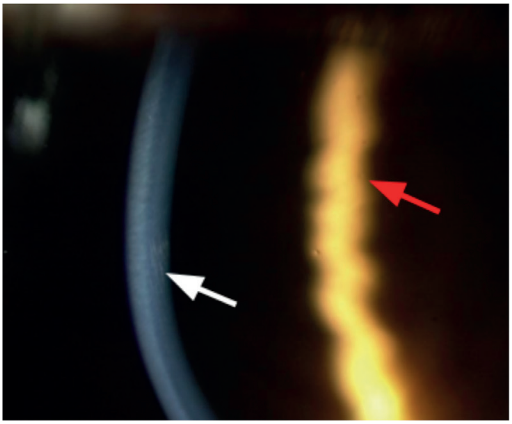

Figure 7. High magnification of the cornea showing simultaneous observation of striae in the optical section under direct illumination and a microcyst by direct, retro-illumination.

The final part of the corneal examination is to observe the endothelium using specular reflection. The endothelium will be visible monocularly as a dull patch to the side of the slit beam (Figure 8).[7] With a good slit lamp that has high resolution and magnification it is possible to view individual cells, however, in some cases it is only possible to make a gross clinical judgement. Should more detail be required, a specular microscope needs to be employed. Endothelial polymegathism describes a significant variation of apparent cell sizes; the extent of polymegathism increases throughout life, however, it is important to note any excessive changes outside of expected age-related changes which may be caused by chronic hypoxia.[8] Fortunately, endothelial changes are very rarely seen with modern contact lens materials.

Stains

The most commonly used stain in optometric practice, and critical during contact lens fitting and aftercare is sodium fluorescein.

Sodium fluorescein is often referred to as a vital stain but is actually a fluorescent pH indicator that will fluoresce more in an alkali environment. As the deeper layers of the cornea are more alkali, any breach of the epithelium will cause fluorescence or 'staining', with the intensity of fluorescence increasing with depth. The appearance of the green fluorescein may be enhanced by filtering out the blue excitation light by placing a yellow barrier filter over the observation system.

Corneal fluorescein staining should be observed using medium magnification, a narrow beam and high illumination, systematically sweeping across the cornea to detect small areas of staining with gaze directed up, down and straight ahead (Figure 9). The conjunctiva should also be assessed in this way, with any staining noted accurately graded and recorded.

As well as being useful for examination of corneal and conjunctival integrity, fluorescein can also be used to evaluate the tear film stability and puncta patency. Following instillation, the time taken in seconds after a blink for areas of tear thinning and interruption of fluorescence should be recorded (Figure 10). After instillation, sodium fluorescein will usually drain away after a few minutes. This may take a little longer with older patients due to narrowing puncta. It is useful to note if the sodium fluorescein takes longer to clear as it may indicate a blockage in the drainage mechanism.

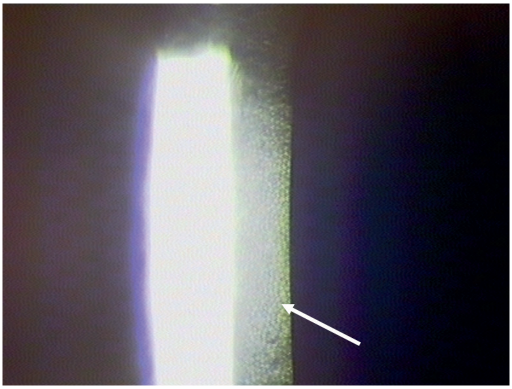

Figure 8. Observation of the endothelium with specular reflection using high magnification. Endothelial cells are seen to the right of the bright reflection, as indicated by the white arrow.

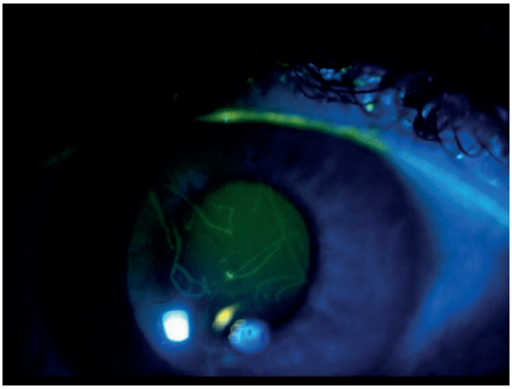

Figure 9. Foreign body stain showing light fluorescence, indicating damage has not breached the epithelium.

Invasive examination of the lids

With the tear film evaluations complete, the patency of the meibomian glands can also be evaluated by applying gentle pressure to the lid margin to observe and grade any secretions. This is best observed using a diffuse beam with low to medium magnification and using a Meibomian Gland Evaluator (Figure 11) to apply standardised pressure to the lid margin.

Using low magnification and a wider beam, lid eversion should now be performed to assess the inferior and superior palpebral conjunctiva for hyperaemia and papillae (Figure 12). Any residual fluorescein will pool around the boundary of papillae and aid their visualisation.

Recording results

The accurate and detailed recording of examination findings should not be underestimated; time should be taken to carefully record and quantify what is seen.

Where possible grading scales should be used (Figure 13). Table 3 lists structures that can be objectively measured or subjectively graded. Grading schemes may be quantitative, e.g. corneal staining (Table 4) or banded according to clinical judgement (Table 5). There are several different grading scales available to practitioners which have been validated for clinical use. Whilst each grading scale has its advantages and disadvantages, it is important the practitioner – and indeed a practice – sticks to (and notes) the use of one system.

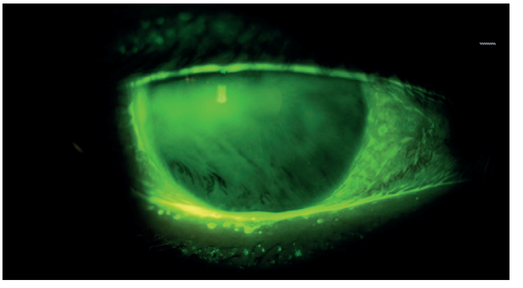

Figure 10. Examination of tear film break up using fluorescein. Break up is seen as the black 'streaks' inferiorly.

Figure 11. The Meibomian Gland Evaluator is a hand-held instrument, which provides a standardized method to apply consistent, gentle pressure to the outer skin of the lower eyelid while visualising the secretions from the Meibomian gland orifices through a slit lamp biomicroscope. Product image for illustrative purposes only.

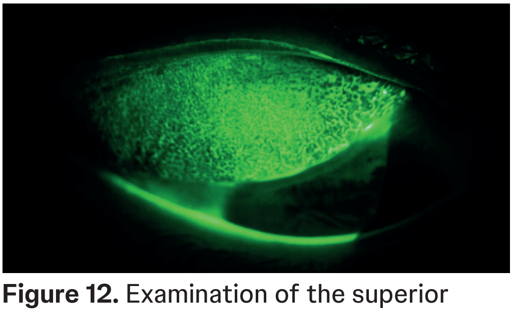

Figure 12. Examination of the superior palpebral conjunctiva using fluorescein to enhance visualisation of papillae.

Objective measurement	Subjective grading
Vascularisation (size & position)	Staining
Folds (number)	Follicles
Striae (number)	Papillae
Pingueculae/pterygium (size)	Hyperaemia
Opacities (size & position)	Tear film quality
Infiltrates (size & position)	Blepharitis
Tear meniscus height	Meibomian gland dysfunction
	LIPCOF
	LWE

Table 3. Structures and lesions requiring measurement or grading.

Type	Depth	Extent of surface involvement
0 Absent	0 Absent	0 Absent
1 Micropunctate	1 Superficial epithelial involvement	1 1% to 15%
2 Macropunctate	2 Stromal glow present within 30 secs	2 16% to 30%
3 Coalescent macropunctate	3 Immediate localised stromal glow	3 31% to 45%
4 Patch	4 Immediate diffuse stromal glow	4 46% or greater endothelium

Table 4. The CCLRU grading for corneal staining[9]

0	Normal
1	Slight or mild changes from normal that are clinically insignificant
2	Moderate changes that may require clinical intervention
3	Severe changes that usually require clinical intervention
4	Very severe changes that require intervention, often medical

Table 5. US FDA clinical grading.

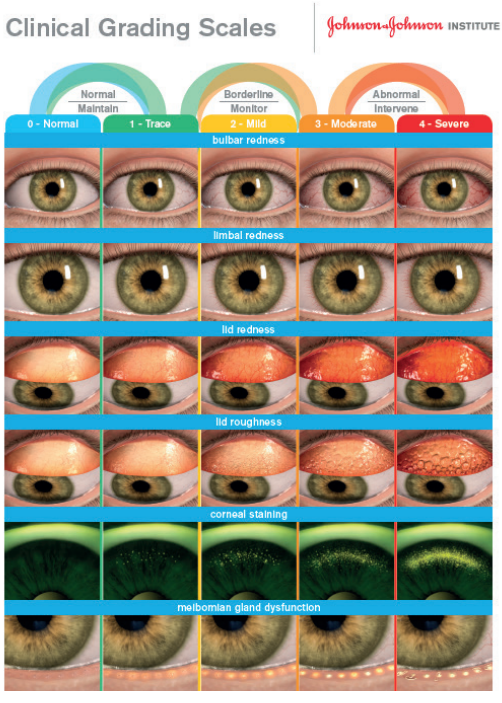

Figure 13. Example grading scale which can be used to record and monitor abnormalities.

Summary

The slit lamp examination is probably the most important aspect of contact lens practice. It is vital for assessing the potential for contact lens wear and for monitoring the established wearer. The examination must be comprehensive and objectively recorded so that when considered with the patient's history and symptoms, refraction and any other initial examinations the practitioner can give their patients the best advice and ultimately determine the best lens for the patient's individual needs thereby fulfilling the GOC Standards of Practice.[10]

Key Points

- Always remember to focus the slit lamp carefully before use
- Establish a systematic routine to ensure thorough examination of all ocular structures
- Using fluorescein is essential to examine ocular surface integrity. The use of an additional barrier filter will enhance observations
- Evaluate the tear film early in the examination, with the least invasive techniques performed first to provide the least disruption to the tear film's stability
- Grading scales are valuable in producing accurate and comprehensive records
- Careful examination of the anterior segment and tear film will aid in appropriate contact lens material selection

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J&J Institute

Assessment of the Tear Film

Author: Marie-Therese Hall

As soon as a contact lens is placed on to the eye, it is bathed in the complex structure of the tear film. The ability of the tear film to maintain its integrity in the presence of a contact lens is crucial for successful contact lens wear. Tear film instability can lead to deficiencies in the lens/tear interface, and the wearer reporting symptoms of dryness and discomfort, which are arguably the most common reasons for contact lens drop out.[1]

The importance of the tear film in maintaining comfortable contact lens wear means that the practitioner must be able to carefully and accurately assess the tears, both before and during contact lens wear.

This chapter will review the clinical examination of the tear film in contact lens practice.

The Tear Film

The tear film plays a multifunctional role in maintaining ocular surface health; it not only protects and moisturises the cornea, but also forms the first refractive surface for light entering the eye.[2] It was previously believed that the tear film comprised of three distinct layers: mucin, aqueous and lipid layers.[3] However, newer publications, such as the TFOS DEWS II Tear Film report,[2] describe the tear film as a complex blended two layer structure, comprising of a mucoaqueous layer and an outer lipid layer (Figure 1). This indicates that the mucin and aqueous layers are more of a continuum, with a higher concentration of mucin nearest to the ocular surface.[3] It is currently understood that this complex continuum contains 20 types of mucins, approximately 1800 proteins and other essential components such as inflammatory markers, ions, salts and electrolytes.[2] Each of the different components of the tear film plays an important role (Table 1); while the aqueous component provides hydration

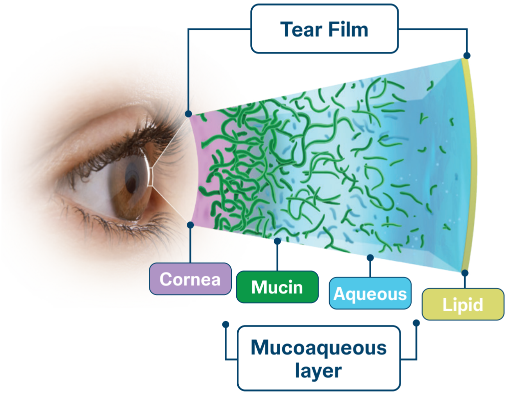

Figure 1. The structure of the tear film. Image for illustrative purposes only.

and flushes toxins, mucins bind to both lipid and water to help stabilise the tear film. The outermost lipid layer, comprising of at least 153 types of lipids, has the role of reducing evaporation and lowering surface tension of the thin film to avoid its collapse.[2]

Tear Film-Contact Lens Interactions

Modern soft contact lenses are estimated to be between 15-30 times thicker (Figure 2) than the average tear film and therefore when a contact lens is inserted on the eye and becomes bathed in the tear film, it is vital that this delicate structure is maintained.[3]

Material properties will undoubtedly play a part in the stability of the tear film, with different materials causing different interactions. For example, silicone hydrogel materials tend to deposit more lipid and less protein compared to high water content, ionic hydrogels.[4] Deposits, whether protein or lipid, can affect the wettability of the contact lens and have an impact on both comfort and vision over time,[4] therefore the presence of deposits should be noted and managed.

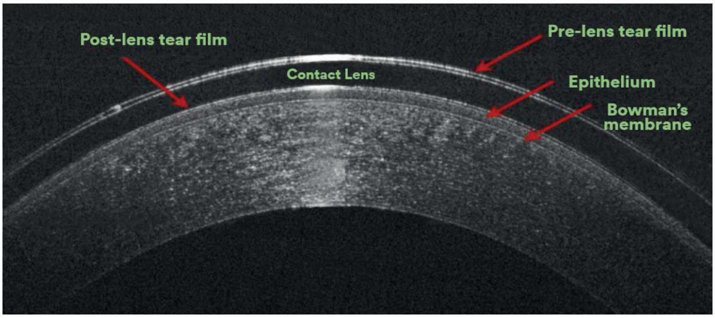

Figure 2. Anterior Optical Coherence Tomography image showing a contact lens thickness in relation to the pre- and post-lens tear film.

Structure	Origin	Major Components	Function
Lipid Layer	Meibomian Glands	Cholesterolesters Ester waxes	Retards evaporation, lowers surface tension and provides an optically smooth surface
Mucoaqueous Layer (Aqueous component)	Lacrimal Glands, Conjunctival Epithelial Cells	Water Protein Salts (electrolytes)	Bacteriostasis, debris flushing and maintenance of epithelial hydration
Mucoaqueos Layer (Mucin component)	Conjunctival Goblet Cells, Corneal & conjunctival Epithelial Cells, Glands of Moll & Krause	Glycoprotein	Renders the epithelial surface hydrophilic for aqueous to hydrate

Table 1. The origins, major components and function of each structure of the tear film

Assessing the tear film

Assessing the tear film accurately is made challenging in that it is transparent, small in volume (approximately 8μl) and relatively thin (between 2-5.5μm).[2] Additionally, the reflex nature of the tears is induced by the method of assessment which can affect results.

Assessment of the tear film in practice can be achieved through a variety of methods, however, consistent with many aspects of contact lens practice, the slit lamp remains the instrument predominantly used by practitioners. Its high magnification and excellent optics allow detailed observation of the structures and integrity of the tear film. A keratometer, if available, can also be employed to assess tear stability by observing the clarity of the mires between blinks. With advances in dry eye diagnostic and treatment technology, more sophisticated instrumentation can be found in clinical practice which can provide invaluable information on the tear film. Whilst mainly adopted for dry eye management, their use for a detailed analysis of the tear film in contact lens practice should also be considered. This article will consider techniques that can be easily fitted into routine eye examinations and contact lens appointments, whilst also considering the value of newer technology.

Tear film evaluation can be divided into two areas – assessment of tear quantity (volume) and tear quality (stability). Each shall be considered in turn.

Tear Quantity

Bearing in mind that stimulation of reflex tearing will affect any evaluations it is generally suggested to perform the least invasive techniques first.

As the bright light source from the slit lamp will inevitably provoke a degree of reflex tearing, it is advisable to perform tear quantity evaluations towards the beginning of the assessment. Measuring the inferior tear meniscus height (meniscometry) will give an indication of tear volume (Figure 3). This is simple and quick to perform and can easily form part of any anterior eye examination, but is especially important during the pre-assessment of potential contact lens wearers.

Figure 3. Measurement of tear meniscus height using the slit beam width

To measure tear prism height, an illuminated slit set horizontally in alignment with the lower lid margin can be altered until it appears to match the height of the tear prism (Figure 3). A value in millimetres can be obtained by adjusting the slit width to match the tear meniscus height centrally along the lower lid. Guillon[5] proposes a clinical routine to incorporate the measurement of the tear film prism height in these positions, enabling a more comprehensive assessment of tear volume:

- Immediately below the pupil centre
- 5mm nasally
- 5mm temporally.

It is generally accepted that a tear meniscus in normal eyes measures between 0.2 and 0.4mm.[6]

The above method of meniscometry depends on observer reliability, and therefore repeatability of results can vary. Newer instruments may allow a more accurate method of measuring the tear prism height by utilising reflective meniscometry to non-invasively measure the tear meniscus using integrated callipers, and has been shown to have accuracy of 0.1mm.[7] Optical Coherence Tomography (OCT), now widely available in optometric practice, has been recognised by the DEWS II Methodology[7] report as a quick and simple way to measure tear meniscus height (Figure 4). Although it recognises that further development of validated measurement software is needed it recognises that it has shown to have good intra- and inter-observer repeatability.

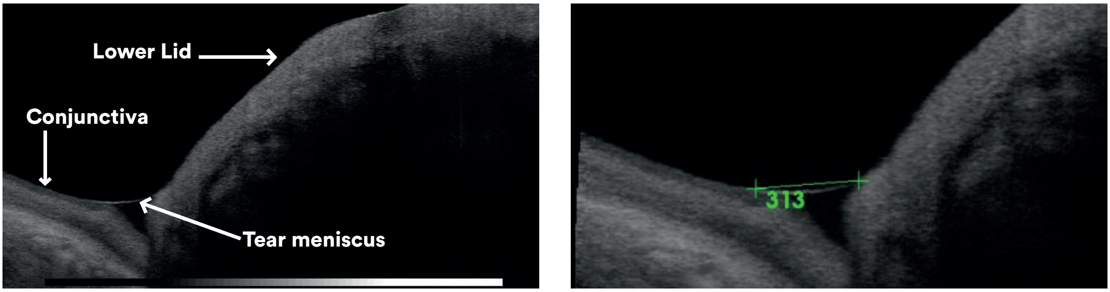

Figure 4. OCT visualisation (a) and measurement of (b) the tear meniscus height using integrated callipers

Although less commonly used in clinical practice, alternative invasive techniques for measuring tear volume include the Schirmer test and the Phenol red thread test.

The Schirmer test involves hooking an absorbent tear test strip of paper over the margin of the lower lid (Figure 5). The length of wetting from the bend is measured in millimetres after five minutes. A normal tear film should produce a wetting length of more than 10mm. Dry eye is indicated where there is less than 5mm of wetting.[7] The invasive nature of this technique results in excessive reflex tearing, limiting the value of the test in clinical practice. There appears to be a reluctance to discard this test, which is partly due to the fact that it is still the simplest, fastest and least expensive diagnostic test available for assessing tear production. DEWS II,[7] whilst recognising that the variability and invasiveness of the Schirmer test precludes it as a diagnostic test of tear quantity, recommended it as a test to confirm severe aqueous deficiency in conditions such as Sjögren's syndrome.

The Phenol red thread test (Figure 6) has the advantage of being less invasive than the Schirmer test, utilising a two-ply cotton thread impregnated with phenol red dye. Phenol red is pH sensitive and changes from yellow to red when wetted by tears, due to the alkaline nature of tears (pH 7.6).[8] The length of the colour change on the thread, indicating the length of the thread wetted by the tears, is measured in millimetres. Wetting lengths should normally be between 9mm and 20mm. Values of less than 9mm have been shown to correlate with subjective symptoms of dryness. DEWS II Methodology recognise the Phenol Red test as a realistic measurement of resting tear volume.[7]

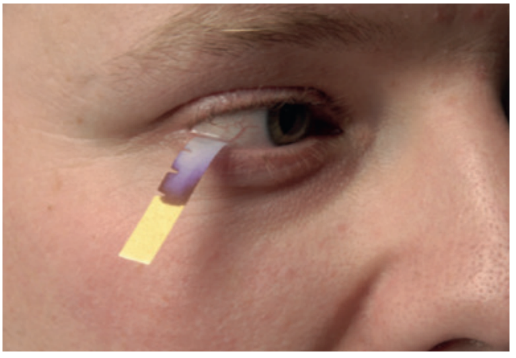

Figure 5. Schirmer Test to measure tear quantity using an absorbent strip

Figure 6. Phenol Red test to measure tear quantity using a cotton thread with phenol red dye

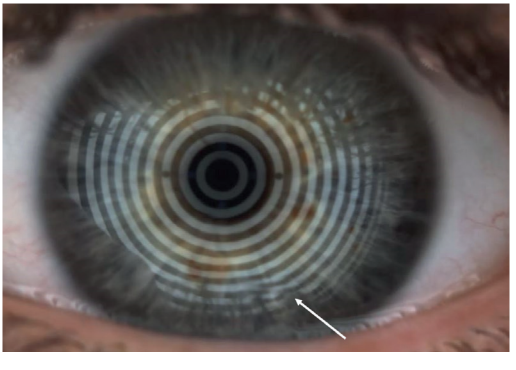

Figure 7. Assessment of NITBUT. Break-up time is automatically recorded but can also be observed as distortion of the placido rings (white arrow)

Tear Quality

Tear quality can be assessed in a variety of ways. DEWS II suggests non-invasive tear break-up time (NITBUT) as the preferred technique;[7] this is the measurement, in seconds, of the time that elapses between the last complete blink and the appearance of the first discontinuity in the tear film. The one-position keratometer is the most commonly available instrument which can be employed to measure NITBUT in clinical practice. For measurement, the practitioner observes the keratometer mires and records the time taken from a complete blink until the mires begin to distort, and/or break-up. One consideration which could affect measurement is that the keratometer is limited to assessing a small area, only providing information on tear break-up in the central cornea.

Placido disc topographers, use white illumination and placido discs to visualise the tear film. These instruments allow visibility of the majority of the corneal surface and can automatically detect and record the time of first break-up (Figure 7). The TFOS DEWS II report states that a NITBUT of less than 10 seconds is a marker for dry eye disease.[7]

Observation of the lipid layer

The lipid layer can be viewed by utilising specular reflection on a slit lamp. Viewing the first Purkinje image with a narrow-slit beam, lipid interference patterns can be observed (Figure 8). As a general rule the brighter the coloured fringes appear, the thicker the lipid layer, whereas a dull, grey appearance may indicate a thinner layer. Whilst a useful technique, the observer is limited to viewing a small area at a time, and the practitioner should be cautious that the heat of the slit lamp does not produce artificial drying.

Lipid layer interferometry can also be employed to assess the lipid layer thickness and many of the dry eye diagnostic devices include this feature. This is a more advanced examination method, giving practitioners an accurate and quantitative measurement of this delicate layer (Figure 9), with a healthy lipid layer thought to be approximately 40nm thick.[9] Considering the importance of the lipid layer in maintaining tear film stability, interferometry can be a useful tool for practitioners wanting to examine the lipid layer in greater detail.

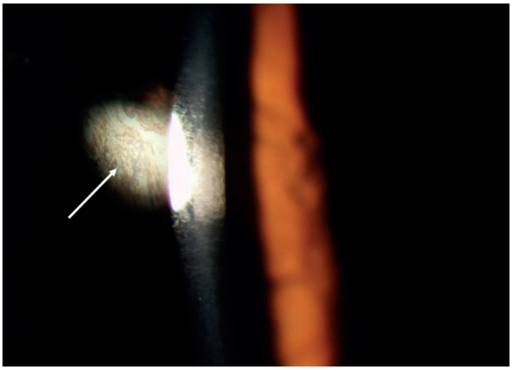

Figure 8. Observation of the lipid layer coloured fringes (white arrow) using specular reflection

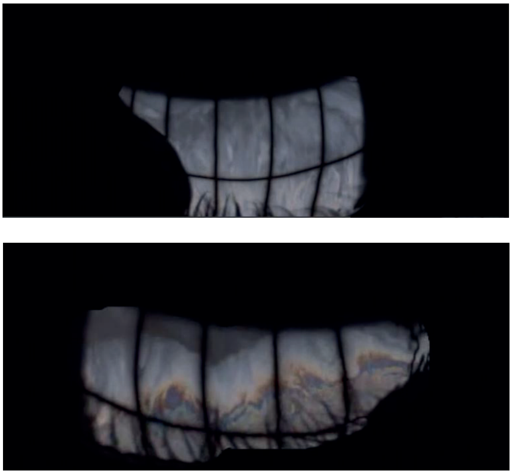

Figure 9. Examination of the lipid layer using interferometry. Few coloured fringes can be seen when the lipid layer is thin (a) compared to when it is thicker (b)

Fluorescin Tear Break Up Time

Traditionally, tear break-up time has been measured by staining the 'transparent' tears with fluorescein to assist with observing and viewing the tear film under cobalt blue light (Figure 10). Additional use of a yellow 'Wratten' filter further improves observation of fluorescence. The stain is usually applied by wetting a fluorescein-impregnated strip with saline, then shaking off any excess liquid and gently touching the conjunctiva with the strip tip. Touching the eye with the paper strip will induce a degree of reflex tearing and instilling too much fluorescein may swamp the normal 8μl tear film, destabilising it.[10] Furthermore, the addition of fluorescein to the tear film alters the physical interactions between its layers, which reduces the surface tension and, hence, affects the break-up time value.[11] It should be noted that whilst this technique is invasive, it is still widely used as a method of tear film assessment in practice. Studies have shown that when care is taken to instil a minimal amount of fluorescein, results are comparable with non-invasive techniques.[10] Using this technique, a value of less than 10 seconds is typically considered abnormal.[11]

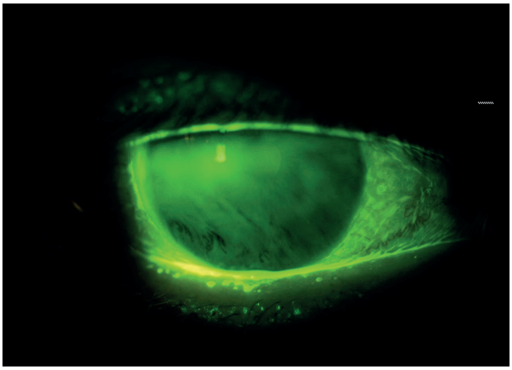

Figure 10. Fluorescein tear break-up time, observed as the time taken from a blink to the observation of the first break-up, shown here inferiorly as black streaks

Lids, lashes and blinking

The lids and blinking play an important role in the formation and maintenance of a healthy tear film,[12] therefore careful observation should be included in a full tear film assessment.

Blinking frequency can be observed during slit lamp examination with diffuse illumination, or during history & symptoms. A typical blink pattern should be approximately one blink every three to four seconds, i.e. between 15-20 blinks per minute.[13] The tear film is maintained and formed through blinking, and so a reduced blink rate or impartial blink can have a detrimental effect on tear film stability.

It is important not to forget that the lipid layer comprises of lipids produced by the meibomian glands and so once any non-invasive methods of assessing the tear film quantity and quality have been carried out, the other ocular surface structures that contribute to the stability of the tear film should also be evaluated. This slit lamp assessment should begin with diffuse illumination to achieve a general overview. Lashes, lid margins, the inner and outer canthus and meibomian glands should all be examined. Traces of make-up and blepharitis will impact tear film stability.

Whilst slit lamp examination will only allow clear observation of the meibomian gland orifices, use of infrared meibography will allow observation of the whole gland (Figure 11). As well as allowing practitioners a more detailed view of the meibomian glands, the images can be a useful tool for educating patients on the management of their tear film and/or symptoms.

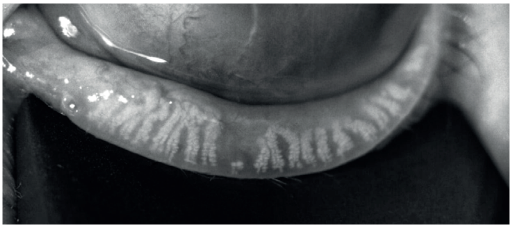

Figure 11. Observation of the inferior meibomian glands using infrared interferometry. Glands are seen as white stalks extending from the lid margin. Here the glands are shortening, with almost complete loss of a gland centrally

Conclusion

Examination of the tear film is one of the most important aspects involved in the fitting and aftercare of contact lens patients. The very nature of contact lens wear results in a tear film that is thinner and less stable than the undisturbed tear film. The transparency of the tears makes it difficult to examine, and the challenge to the practitioner is in developing skills to visualise the structure without causing disruption. Use of non-invasive, or minimally invasive techniques increases the accuracy of tear film assessment and should be employed where possible. No one test is enough, and a combination of tests to assess both tear film quality and quantity is recommended. In addition, consideration of patient symptoms is critical in the overall clinical assessment in both selecting an initial contact lens material, and for continuous care.

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Contact Lens Selection

Author: Robyn Marsden

With continuing advances in technology, eye care professionals now have a larger range of contact lens products to choose from than ever before. So, how can we be sure we are prescribing our patients with the right product to meet their needs?

This article uses patient examples to explore the contact lens selection decision making process, with the aim to ensure we are making personalised contact lens recommendations for each of our patients based not only on their contact lens requirements, but also on their ocular health. In ensuring we provide patients with personalised recommendations, we hope to optimise our patient satisfaction and increase contact lens wearer retention. This practice will also ensure we are meeting the General Optical Council (GOC) Standards of Practice, treating our patients as individuals, taking into account their views and preferences when making decisions about their care.[1]

In creating a personalised contact lens recommendation for each patient, we need to consider the attributes of the lens we select to ensure it can provide our patient with optimum vision and comfort, whilst delivering safe and healthy wear.

The following detailed contact lens properties should always be considered; material properties, optical design, and modality. These elements, together with the patient's lifestyle, ocular health and prescription requirements will help to inform our ideal contact lens choice.

Material Properties

The first decision to consider here is the material of the contact lens; should you fit a hydrogel (Hy) or silicone hydrogel (SiHy) soft contact lens, or would a rigid gas permeable (RGP) contact lens better meet the patient's needs?

Soft contact lenses continue to dominate most of the contact lens market, accounting for 87% of all fits worldwide.[2]

Options available to the practitioner continue to evolve, covering a wide range of parameters, designs and replacement frequencies. Historically, prescribing of either daily disposable (DD) or reusable (RU) Hy lenses exceeded that of SiHy lenses, however, increasing preference for SiHy led to a higher proportion of SiHy lenses being prescribed from 2015 onwards.

Whilst there is a shift towards use of SiHy lenses due to their higher oxygen permeability, hydrogel contact lenses, with their naturally hydrophilic nature, low modulus and reduced tendency to attract lipid deposits,[3] remain a good choice, particularly for patients who have marginal tear films and excess lipid contamination of the tears due to meibomian gland dysfunction.[4] Oxygen transmissibility should of course be a consideration for each patient, however, recent clinical insights show us that at a Dk/t of approximately 20 units, the central cornea receives the oxygen it requires for normal oxygen consumption in the open eye state[5] and many modern hydrogels fit within this range. There is also considerable evidence that market leading high-water content hydrogel lenses made of etafilcon A do not produce clinically significant levels of corneal oedema,[6] or show any difference in central corneal oxygen consumption compared to a SiHy material, lotrafilcon A.

SiHy contact lenses, first introduced to market in the late 1990s, are again available in both DD and RU modalities and now make up 57% of fits worldwide and 76% of fits in the UK.[2]

Incorporation of silicone into the contact lens, produces a material with significantly increased oxygen permeability, meaning oxygen consumption for SiHy lenses is 98-100%,[7] irrespective of make or model. When SiHy contact lenses first came to the market it was thought that greater oxygen transmissibility would also result in improved comfort levels and a reduction in adverse events, however, a comfort advantage with SiHy lenses has been hard to prove due to confounding factors[8] and research has shown no relationship between Dk/t and comfort.[9] This is likely due to the inherent hydrophobicity and stiff nature of silicone which meant that 1st generation SiHy lenses had a higher modulus and poorer wettability[10] compared to their hydrogel counterparts. More modern SiHy materials have dealt with these concerns, and now are available with highly desirable levels of comfort and tear film interaction.[11] With regards to adverse events, despite SiHy lenses causing a reduction in hypoxic events, they have not brought about a reduction in risk of microbial keratitis as was anticipated[12,13] and several studies have in-fact shown a nearly two-fold increase in relative risk for infiltrative keratitis.[14,15,16] These challenges aside, where consideration of oxygen transmissibility is important, for example, in patients who are predisposed to vascularisation secondary to the thicker designs of some toric lenses or higher spherical refractive errors, a SiHy would be the desired material of choice.

Whilst RGP lenses only account for 10% of contact lens fits worldwide,[2] their value should not be forgotten. RGP contact lenses can offer practitioners a larger prescription range, correction of corneal astigmatism up to 2.50DC with a simple spherical lens and are also available in toric and multifocal designs. Due to its rigid surface, RGP contact lenses have been shown to provide patients with preferable vision compared to soft contact lenses,[17,18] likely due to neutralization of corneal irregularities by the pre-corneal tear lens. As such, RGP lenses are often utilised for the correction of corneal irregularity, such as keratoconus, post corneal graft and post-refractive surgery, as well as for high levels of ametropia or astigmatism. In addition to excellent vision, RGP lenses can support excellent corneal health due to incomplete corneal coverage and retro-lens tear exchange, resulting in an excellent safety record and a very low risk of microbial keratitis.[18] However, these benefits come at a much longer adaptation period compared to soft contact lenses,[17] which may account for the reduced prescribing of these lenses in mainstream practice over the last 20 years.[2]

It is clear from the information above that RGP, Hy and SiHy contact lenses all have a solid place in modern contact lens practice and practitioners should always select the best contact lens material for patients based on overall comfort, visual performance, safety and clinical need. As soft contact lenses make up 95% of contact lenses prescribed in the UK,[2] the rest of this chapter will concentrate on the material properties associated with soft contact lenses only.

Deposition

Hydrogel and SiHy lenses differ in their deposition profiles, with wide variations also occurring within these lens types, depending upon the International Organisation for Standardization (ISO) classification as described in Table 1 and Figure 1. Both research and clinical experience recognise that, broadly, Hy contact lenses deposit more protein (Figure 2a) compared to lipid (Figure 2b), whilst the converse is true of SiHy. Further, higher water content, ionic hydrogel materials have a tendency to attract greater amounts of protein compared to non-ionic lower water content hydrogel lenses. Once deposited on the contact lens surface, the protein can become denatured, triggering the release of inflammatory biomarkers which could result in irritation.[19] However, if the proteins are simply taken into the lens and not denatured, as has been demonstrated in etafilcon A, a group IV hydrogel, they can support the maintenance of low levels of inflammatory biomarkers.[19]

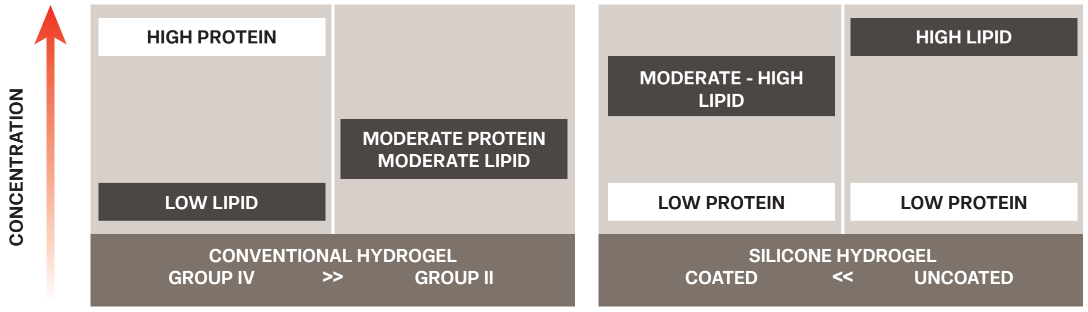
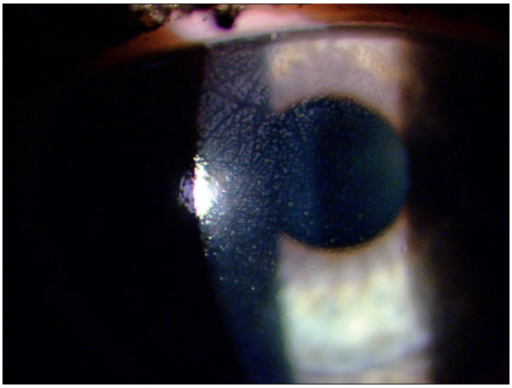


Figure 1. Schematic illustration of trends in lipid and protein deposits on different contact lens materials (After Mann A and Tighe B. Contact lens interactions with the tear film. Experimental Eye Research, 2013;117:88-98)

Knowledge of the differences in deposition profile can be useful when considering matching a contact lens material to a patient's ocular surface.

For example, a patient with meibomian gland dysfunction who is prone to exhibiting high levels of cholesterol in their tears, may benefit from being fitted with a hydrogel material where possibility of lipid deposition is lower.[20]



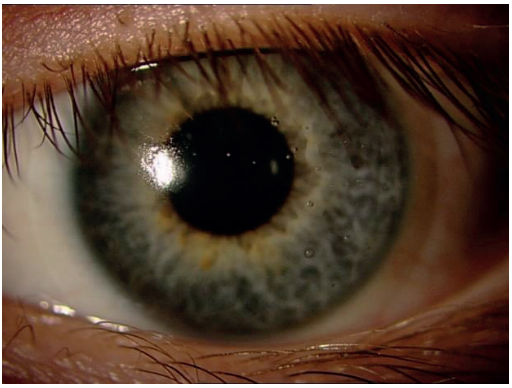


Figure 2. Deposition of protein (a) is more common with hydrogel lenses compared to lipid (b) with SiHy lenses.

Code Part	Code Name	Explanation	
1	**Prefix**	The term used to designate a specific identity of monomers and crosslinking agents. The prefix is administered by the US Adopted Names Council (USAN), with use optional for all countries outside the USA.	
2	**Stem**	Two stems are available; filcon, for materials that contain ≥ 10% water by mass (soft lenses), or focon, for materials that contain < 10% water by mass (rigid lenses).	
3	**Series Suffix**	Administered by the USAN Council, to denote changes in the original ratio of monomers of an exisiting contact lens material to make a new material. A capital letter is added after the stem; A is the original (first) formulation, B the second and so on.	
4	**Group Suffix**	Represented by Arabic numerals, indicating the range of water content and ionic content for filcon materials and the presence or absence of silicone/fluorine for focon materials.	
		Focon (Rigid) Lenses	**Filcon (Soft) Lenses**
	i	Materials not containing silicone or fluorine	< 50% water content, non-ionic
	ii	Materials containing silicone but not fluorine	≥ 50% water content, non-ionic
	iii	Materials containing silicone and fluorine	< 50% water content, ionic
	iv	Materials containing fluorine but not silicone	≥ 50% water content, ionic
	v		Enhanced oxygen permeable materials (e.g. SiHy)
	VA		Ionic
	VB		≥ 50% water content, non-ionic
	VC		< 50% water content, non-ionic
5	**Dk**	Oxygen permeability expressed in Dk units using mmHg	
6	**Water Content**	Water content, expressed as the percentage of water by weight in the material	
7	**Modification code**	The modification code, designated by a lower case 'm', denoting that the contact lens (from Group i-iv) has a modified surface which has characteristics different from the bulk of the material, e.g. plasma treatment. For Group v polymers, the modification code, designated by the lower case 'c' or 'w' denotes that the contact lens has a modified surface that has characteristics different to the bulk material. The lower case 'c' indicates the surface has been chemically modified (e.g. plasma or bonded surface modification). The lower case 'w' is used for materials having releasing or internal wetting agents.	

Table 1. ISO System of Contact Lens Materials Classification in a seven-part code[21]

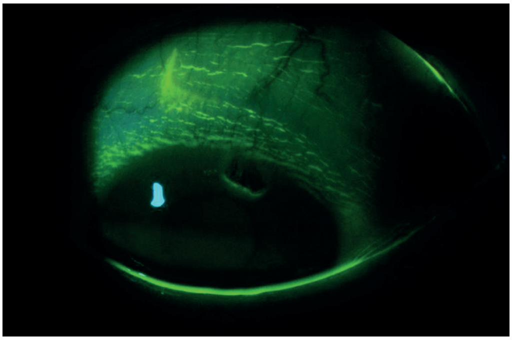


Figure 3. Superior Epithelial Arcuate Lesion, a mechanical complication associated with high modulus contact lenses.

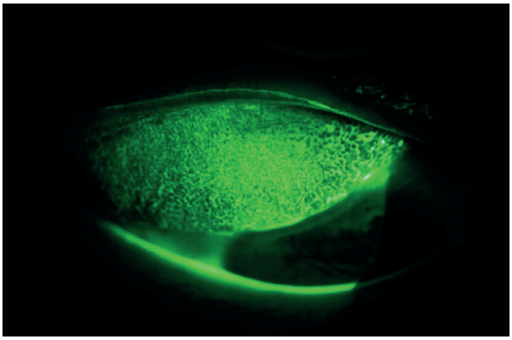


Figure 4. Contact lens papillary conjunctivitis (CLPC), a complication associated with high modulus contact lenses.

Modulus

When considering matching a contact lens to a patient, the modulus of the lens is one of the material properties that should be considered.

The modulus, a mechanical property of the lens, describes the tensile, or elastic, strength of the lens, and together with the lens thickness denotes how easily the lens will drape over the cornea.

Where the thickness of a lens remains constant, a reduction in the material modulus will create a lens which more easily drapes over the anterior surface. Whilst researching the effect of modulus on contact lens comfort is challenging due to confounding material factors, research suggests that a negative correlation exists between modulus and patient comfort, that is, as modulus increases, patient reported comfort decreases.[9] This was evident when fitting patients into first generation SiHy lenses where the tensile modulus was significantly higher than typical hydrogel lenses and an adaptation time was needed.[22] Risk of mechanically induced ocular complications, such as Superior Epithelial Arcuate Lesion (SEAL) stain (Figure 3) or contact lens induced papillary conjunctivitis (CLPC) (Figure 4), was high in first generation SiHy lenses, a complication which is rarely seen with more modern SiHy materials where the modulus is much lower.[23,24] Whilst a lower modulus may have a beneficial impact on comfort, it can cause problems with handling, so could cause challenges for patients with poor dexterity. Without a standard method for calculation of modulus, the values reported through different studies cannot be directly compared. The modulii values of a range of daily disposable contact lenses are shown in Figure 5, as reported by Sulley et al, and measured using one technique.[25]

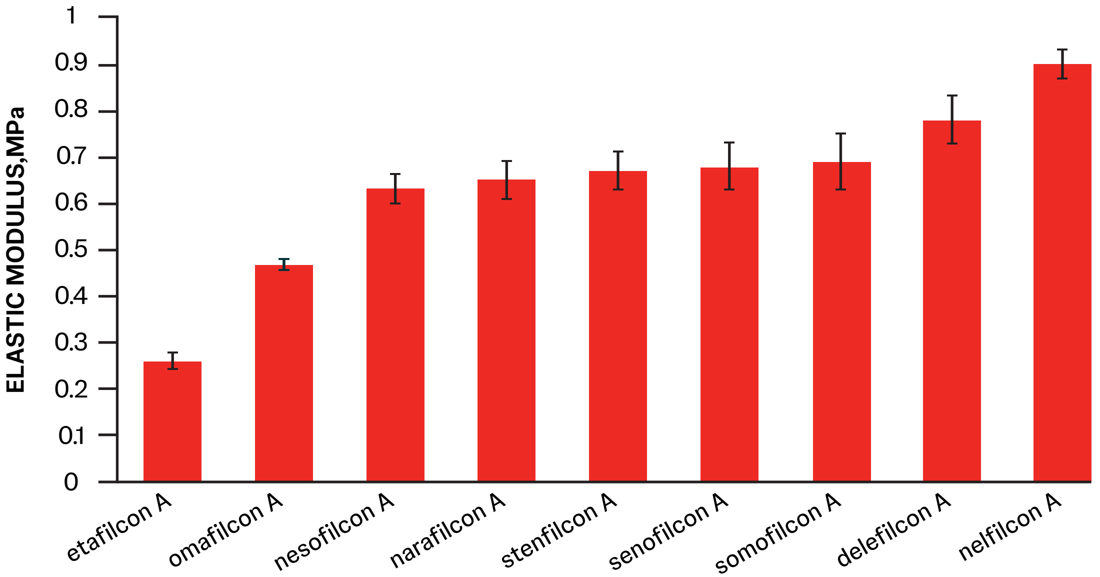


Figure 5. Mean modulus of elasticity values for a range of daily disposable contact lenses, investigated by Sulley et al.[25] Error bars represent the standard deviation of the mean.

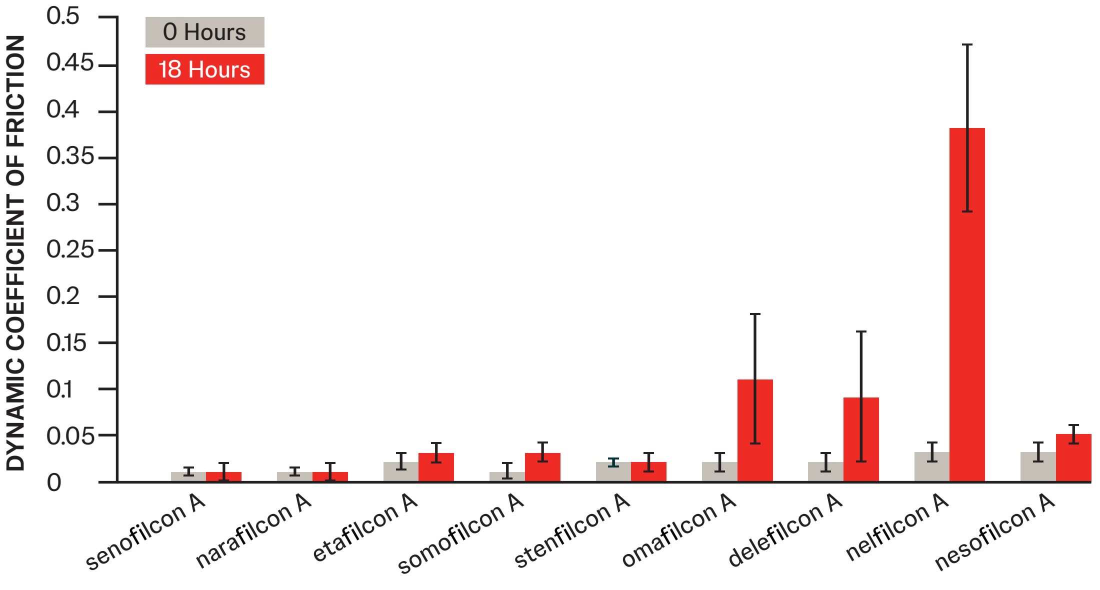


Figure 6. Mean dynamic coefficient of friction for a range of daily disposable contact lens materials at 0 hours (grey bars) and 18 hours (blue bars) simulated wear.[29,30] Error bars represent the standard deviation of the mean.

Coefficient of Friction

The co-efficient of friction of the lens material is another vital material property to consider. Defined as the force required to move an object divided by its mass, it indicates the resistance the upper lid will experience when passing over the contact lens surface during blinking.[18] A low coefficient of friction (or high lubricity) relates to the ability of the eyelid to travel smoothly across the front surface of the contact lens without irritation.

> There is considerable evidence showing a strong correlation between coefficient of friction and mean comfort, where comfort increases as coefficient of friction decreases.[9,26]

No standard method has been developed or adopted by the industry to measure coefficient of friction, therefore contact lens companies may use different methods, yielding different results, making comparison between companies challenging. The dynamic coefficient of friction of several different contact lens materials, measured using the same technique, are shown in Figure 6.

Lid-parallel conjunctival folds (LIPCOF, Figure 7) and lid wiper epitheliopathy (LWE, Figure 8) are thought to be clinical indicators of friction and are associated with increased contact lens discomfort.[27,28] Examination of the ocular adnexa for signs LIPCOF and LWE is therefore advised during contact lens aftercare, with presence indicating potential need to move the patient into a more lubricious material.

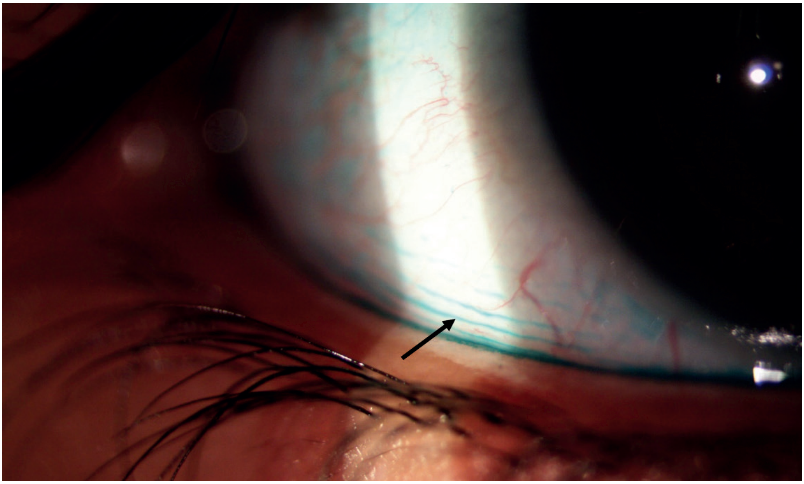


Figure 7. Lid parallel conjunctival folds (LIPCOF), utilising Lissamine Green Dye to enhance visibility

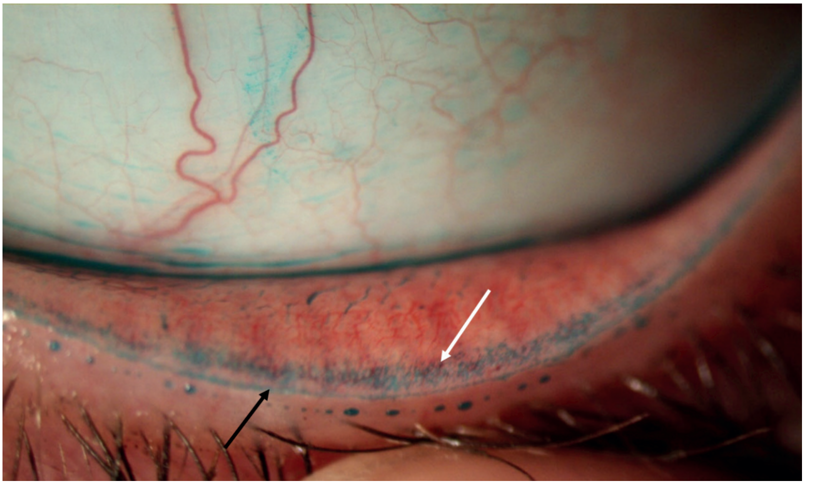


Figure 8. Lid wiper epitheliopathy (LWE) stained with Lissamine Green, with stain extending beyond Marx line.

Wettability

The term 'wettability' describes the ability of the tear film to spread across and remain on a contact lens surface. The more wettable the contact lens material is, the better the tear film forms a cohesive film across the lens surface and does not dry or thin between blinks. Wettability is intrinsically linked to the coefficient of friction of a lens, in that as wettability reduces, coefficient of friction will increase. Traditionally, wettability has been assessed *in vitro* by measuring the contact angle of a sessile droplet of water or saline on the contact lens,[31,32] with a lower contact angle indicating better wetting. However, these *in vitro* measurements do not appear to show any relationship to on-eye clinical wetting, therefore are of limited value. *In vivo* wettability is perhaps more useful, though the link between *in vivo* wettability and comfort is yet to be fully understood. *In vivo* wettability has been assessed in research using a variety of simple techniques which can be translated into clinical practice, including measurement of pre-lens non-invasive tear break up time (NITBUT)[33,34] and assessment using specular reflection.[35] Wettability can easily be assessed in practice using either of these techniques, as demonstrated in Figure 9.

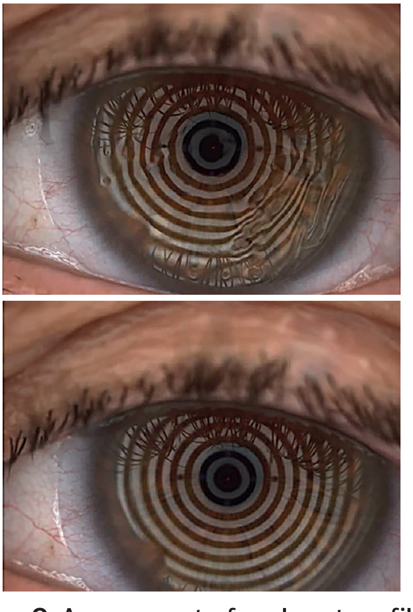


Figure 9. Assessment of prelens tear film break up time to provide information on contact lens wettability. Poor contact lens wetting is observed as distortion of placido rings (top), versus good wetting (bottom).

Design

All contact lenses are designed differently, with a range of base curves, diameters and edge profiles available and it's recognised that the comfort of the lens can potentially be affected by these differing design features.[22] Certainly, the design of a lens can influence how the lens fits the patient and the comfort this brings. Eye care professionals who regularly fit soft contact lenses know to assess movement of the lens on eye[36,37] and corneal coverage[38] to determine the success of a fit, as both of these elements are believed to impact patient comfort. Likewise, with RGP fitting we look at how the lens edge interacts with the lids on blink to consider optimum wearer comfort. The edge profile of a lens is another design element that can have an impact on comfort and that does vary between lenses. The edge profile of a lens can be classified as either a tapered, edge-on-eye design, or as a rounded/block, edge-off-eye design (Figure 10). Studies have shown that lenses with a rounded, edge-off-eye design tend to provide poorer comfort compared to lenses with tapered, edge-on-eye designs,[39] with the tapered designs providing a smoother transition between the conjunctiva and the lens surface,[40] with less movement.[22]

It is worth educating our patients to know that contact lens designs do vary. They will recognise and appreciate our clinically advised product recommendation even more if we are able to articulate to them the features and benefits of the specific lenses we are recommending. It makes sense to speak to contact lens manufacturers to obtain detailed design information regarding the products you routinely fit or have access to; having knowledge of the features and benefits of each design will again lead to more successful fitting and less potential for trial and error.

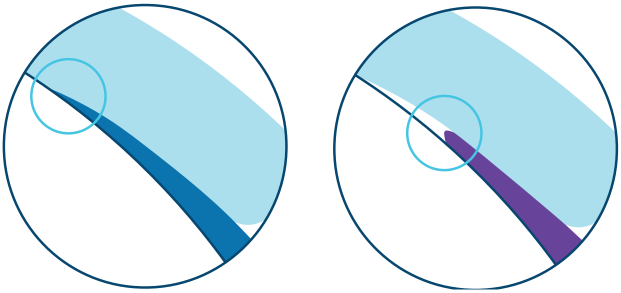


Figure 10. Diagrams showing a tapered, edge-on-eye design (left) and a rounded/block, edge-off-eye design (right). Images for illustrative purposes only.

Modality

Modality, or frequency of lens replacement, also needs to be considered when selecting a lens for patients.

In the UK, practitioners now prescribe daily lenses 62% of the time,[2] with this shift likely driven by convenience and reduced risk of infection.[41]

Re-usable lenses typically offer a wider range of prescription parameters and may well be the only option for some patients, whilst also offering a more cost-effective solutions for patients who are price conscious. Whilst there is no strong evidence showing a direct link between the modality of a lens and comfort,[22] it is widely recognised that build-up of deposits on certain lens materials can lead to higher discomfort in wearers of some re-usable contact lens materials on the market. It should also be noted that comfort in monthly lenses is likely to reduce over the month,[42] so patient satisfaction should be carefully assessed at each aftercare to avoid the patient ceasing lens wear due to comfort issues.

Cost

Once we have fully considered the patient's lifestyle needs, ocular health

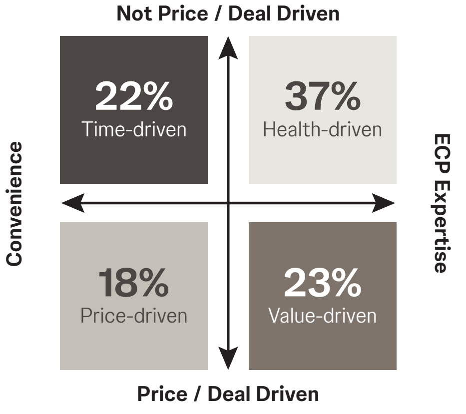


Figure 11. Patient motivations to healthcare[43]

and the material properties of the lenses available, the appropriate lens should be recommended to the patient with clear reasons as to why this lens best meets their requirements. Price is shown in studies to be a secondary consideration[43] for most patients (Figure 11), especially when you consider cost per wear which often equates to a difference of just a few pence per day. However, once the patient is informed of the cost of the recommended lens, if it isn't suitable, then you can work together to see if a more cost-effective option is available and advise them of the loss of benefit that this contact lens option may deliver.

Additional considerations for maximum success

Whilst it is paramount that eye care professionals stay fully up to date with new innovations in terms of design and material properties, it is the ability to apply these elements to each individual patient, that will ultimately lead to successful, long-term contact lens wear. If, for example, ocular examination revealed hyperaemia and papillae on lid eversion, and the patient reported suffering seasonal hayfever, we may wish to recommend daily disposable contact lenses. Daily disposable contact lenses would best serve the patient by minimising the build-up of both deposits and allergens, with research showing that hydrogel daily disposables provide both increased comfort and a protective element for such individuals.[44,45] Environmental factors and previous patient history should also be taken in to account when considering an appropriate contact lens recommendation. A patient with a history of infection would undoubtedly benefit from a daily disposable modality, where risk of infection is lower,[46] as would patients who smoke, due to the increased risk of corneal infiltrative events and microbial keratitis.[47]

Summary

In making tailored contact lens recommendations for patients, we must ensure we match our patients' needs and ocular health with the most appropriate contact lens, taking into account material properties and design in doing so. This personalised recommendation should then be clearly communicated with the patient, so that they are able to understand the importance of the contact lens fitting process - and indeed aftercare - in ensuring they have successful contact lens wear. The key to optimum recommendations for maximum success is to be knowledgeable about the products that are available, paired with ability to apply this knowledge when factors affecting suitability come in to play. Prescribing contact lenses is both a science and an art and can be very rewarding to both ourselves and our patients when we get it right.

Robyn Marsden is an Optometrist and a paid consultant faculty member for the Johnson & Johnson Institute, UK and a Professional Affairs Consultant for Johnson & Johnson Vision.

Patient examples:

<table>
<tr><th colspan="5">CONTACT LENS RECORD</th></tr>
<tr><td>Name</td><td>David Wrack</td><td colspan="2">Date</td><td></td></tr>
<tr><td>Age</td><td>39</td><td colspan="2">Last E/E date</td><td></td></tr>
<tr><td>Occupation</td><td>IT Support</td><td>Rx</td><td>R</td><td>-1.25 /-0.75 x 90</td></tr>
<tr><td rowspan="3">Current Lenses</td><td rowspan="3">Never worn</td><td></td><td>L</td><td>-1.50DS</td></tr>
<tr><td>Keratometry</td><td>R</td><td>7.75@180, 7.90@90</td></tr>
<tr><td></td><td>L</td><td>7.80@180, 7.85@90</td></tr>
<tr><td colspan="5">Reason for Visit</td></tr>
<tr><td colspan="5">Wants CLs for social/sport only
GH – Good, no meds or allergies OH - None
Hobbies - Basketball, comp gaming</td></tr>
<tr><td colspan="5">Ocular Examination</td></tr>
</table>

Right		Left
MGD G2	Lids / Lashes	MGD G2
Clear	Conjunctiva	Clear
No stain with Nafl	Cornea Staining	No stain with Nafl
TBUT 5secs, streaky Tear prism 0.2mm	Tears	TBUT 6secs, streaky Tear prism 0.2mm

KEY FACTORS

- MGD G2
- Streaky tear film with NaFl

CONSIDER

- Fitting a hydrogel lens due to MGD and higher risk of deposition on a SiHy material
- Treating MGD alongside contact lens fitting for efficiency and convenience for patient
- Daily replacement modality to meet the need for occasional wear
- Monocular astigmatism, therefore consider fitting with prism free optics

CONTACT LENS RECORD				
Name	Claire Wolds	Date		
Age	36	Last E/E date		
Occupation	Marketing Manager	Rx	R	-9.50/-1.75 x 180
Current Lenses	Never worn		L	-9.00/-1.50 x 5
		Keratometry	R	7.75@180, 7.40@90
			L	7.75@180, 7.45@90
Reason for Visit				
Wants CLs for full time wear, often at the office until 10pm. Air-conditioned environment using laptop/ipad 8+hours/day GH – Good, no meds or allergies OH - None Hobbies - Running				
Ocular Examination				

Right		Left
Clean / clear	Lids / Lashes	Clean / clear
Clear	Conjunctiva	Clear
No stain with Nafl	Cornea Staining	No stain with Nafl
TBUT 7secs Tear prism 0.2mm	Tears	TBUT 8secs Tear prism 0.2mm

KEY FACTORS

- High Rx
- Long wear time
- Potentially dry environment

CONSIDER

- Availability of Rx - re-usable soft/RGP ranges may accommodate more easily
- Spherical RGP as this may provide better vision whilst correcting astigmatism
- Fitting a SiHy lens due to the high Rx, and therefore lower Dk/t
- Material properties which will maintain wettability over the day in a dry environment

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J&J Institute

Soft Contact Lens Fitting

Author: Dr Byki Huntjens

Soft contact lenses continue to dominate the global contact lens market, accounting for around 90 per cent of all fits worldwide.[1] Materials, optical designs and additional features continue to evolve in an attempt to reach ever increasing levels of comfort, vision and health for patients. As efforts to improve long-term contact lens success continue, attention to lens selection and optimisation of fit should not be ignored. Although there are fewer parameters to consider when fitting a soft lens compared to a rigid gas permeable lens, for example, it is still of upmost importance to assess the fitting accurately and monitor the ocular response to contact lens wear.

Contact lenses should interfere minimally with corneal metabolism and provide crisp, clear, stable vision while being comfortable at all times. Prescribing the right material, lens dimensions and wearing modality to match the wearer's ocular surface and lifestyle, should be the goal of every eye care professional. Sub-optimal fit or inappropriate lens selection can result in discomfort and/or have potential physiological impact. In turn, discomfort has been shown to contribute significantly to contact lens wear discontinuation if not addressed appropriately.[2]

An ideally fitting soft contact lens comprises a well-centred contact lens, showing 0.2-0.4mm movement on blink, full corneal coverage in all positions of gaze, regular edge alignment with the conjunctiva and easy movement on push-up with smooth recovery. Furthermore, the patient should report high levels of comfort and crisp, stable vision. Although it can be argued that the skill of achieving an ideal fit is relatively straightforward, its success relies very much on making correct decisions based on clinical judgements when monitoring the ocular physiology of the patient over time. In addition, an 'acceptable fit' is not necessarily the most optimal fit for that individual, so communication with your patient remains paramount. This chapter provides a practical overview of the key aspects and principles associated with spherical soft contact lens fitting, and can be applied to both hydrogel and silicone hydrogel contact lenses.

Establishing a routine

Good clinical practice does not involve viewing one observation in isolation. Therefore, eye care professionals are encouraged to follow a structured routine, acting on sub-optimal findings, taking all results into account.

A schematic overview of a soft contact lens fitting routine is shown in Table 1. Each element of the fitting process is described in more detail in the following sections.

Initial trial lens selection

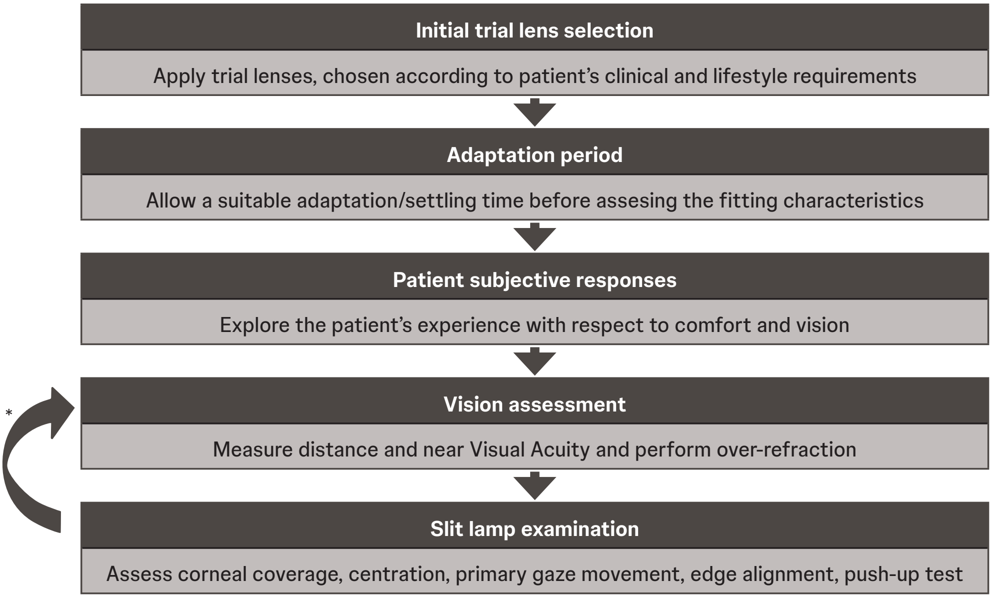
Although eye care professionals have relatively little control over the available lens designs, the first trial lens should be selected using the following criteria as closely as possible. In order of importance, these are:

Material

The selection of the soft lens material is considered the most important factor in achieving excellent contact lens comfort and subsequent patient satisfaction. It can also be argued that lens material is the first parameter to be modified when attempting to optimise a lens fitting. Material properties should allow sufficient oxygen transmission to maintain ocular health, be resistant to deposits, and attain high surface wettability. The two principal material choices are hydrogel and silicone hydrogel, each with their own advantages and disadvantages,[3,4] as discussed in the previous chapter.

Back vertex power (BVP)

Should be as close as possible to the patient's prescription to allow them to judge the visual benefits of contact lens wear correctly and to facilitate adaptation. If the exact power is not available, it is preferable that the lens is chosen to under-correct rather than over-correct, to avoid



*Order may be reversed as appropriate

Table 1. Schematic flow chart of soft contact lens fitting procedures

unnecessary accommodative effort that would influence the over-refraction. If the spectacle power is above ±4.00DS in any meridian, adjustments should be made to account for the change in back vertex distance.

Total diameter

must be larger than the Horizontal Visible Iris Diameter (HVID) by approximately 2 to 3mm to allow for full corneal coverage. The majority of spherical soft lenses are manufactured in diameters between 14.0 to 14.5mm; consequently, the choice is very much dependent on availability.

Back optic zone radius (BOZR) / Base curve (BC)

The historic general rule of thumb describes a choice of BOZR within the range of flattest keratometry readings plus 0.7 – 1.0 mm, however, little correlation has been seen between BOZR and optimal fitting.[5] The underlying assumption of this rule is that steeper corneas have a greater sagittal height, therefore requiring a lens of greater sagittal depth, in the form of a steeper base curve. However, sagittal height is a function of not only the corneal curvature, but also the corneal asphericity, corneal diameter and curvature of the paralimbal sclera.[6] As such, when a choice of base curve is available within the same lens, follow the manufacturer’s guidelines to decide which lens to try first, without regard to keratometry readings.

Adaptation Period

Once the lenses have been applied, the fit must be assessed after a suitable settling period. Once placed on the eye, soft contact lenses will lose water, which will cause a subsequent change in parameters including diameter and base curve, which in turn may influence the fitting characteristics. Other parameters that have been shown to change following application of a contact lens are pH, temperature, and osmolarity.[7] Intuitively, it is therefore important that the fit is assessed once the lens is in equilibrium with the tear film.

It has been shown that lens movement significantly decreases within the first 30 minutes of wear, independent of the water content of the contact lens material.[8] The same study also reported that in 75% of patients, the most effective time to predict the final fitting characteristics is approximately five minutes after the lens has been applied. Another study has shown that contact lens fitting characteristics after 10 to 20 minutes of initial lens wear is predictive of 8 hours contact lens wear.[9]

As such, common clinical practice would involve selecting an alternative trial lens if the contact lens fit is unacceptable after a settling period of 10 minutes.[9]

Whilst ten minutes may be enough to assess lens stabilisation, it is clearly insufficient to judge the ocular physiological response to the lens, or for the patient to appreciate what wearing contact lenses entails. Ultimately, this is the objective of ongoing aftercare, enabling the practitioner to monitor not only the physiological response to lenses, but also any changes in a person's routine, including wearing time, work environment, and evening/weekend activities.

Patient subjective responses

Once the contact lens has been applied to the eye, the patient response to the contact lens in respect to comfort and vision should be ascertained. In contrast to a rigid contact lens, a soft lens should feel virtually indiscernible on the eye. Any initial discomfort due to differences between the osmolarity and pH of the lens storage solution and the patient's tears should be quick to resolve. Lens sensation should be consistent, with no significant differences on versions or following blink.

As a general rule, comfort should be reported as 8/10, on a 10-point scale, or better. Should comfort be reported as lower than this, an alternative lens material and/or fit should be considered.

Assuming the correct prescription has been selected, vision should be reported as stable and clear, although patients with higher refractive errors may notice peripheral distortion and could encounter some initial difficulty in judging distances due to magnification changes. These should, however, soon resolve. If vision is reported as fluctuating between blinks, this could indicate a poorly fitting and/or poorly wetting lens.

Vision assessment

Distance and near visual acuity should now be assessed, and a standard over-refraction performed, including binocular balancing as appropriate. For single vision spherical lenses, a trial frame or phoropter can be used. The refraction should have a clear endpoint, and visual acuity should be stable and crisp. Fluctuations in acuity could indicate a poor lens fit. Unstable vision tends to indicate a loose fit; however, if this becomes clearer following a blink it may indicate a tight fitting. The use of the retinoscope is recommended to exclude uncorrected refractive power and confirm that the optic zone covers the pupil, especially in high-powered lenses.

Slit lamp examination

The lens fit should be assessed using the slit lamp biomicroscope to allow for sufficient magnification, and assessment should be based on moving from the least to the most invasive technique. Diffuse direct illumination and medium to high magnification is recommended to visualise the whole of the contact lens on-eye. The following assessments should be made:

Lens surface quality

Before any of the fitting characteristics are evaluated, the lens surface quality should be recorded. Scan the lens surface using a parallelepiped beam at medium magnification (16x) or observe the 1st Purkinje image to assess initial wettability of the lens (Figure 1). A Placido ring topographer (Figure 2) or a one-position keratometer can alternatively be used. The lens surface is expected to be excellent after the initial adaptation period, although this depends on the quality and composition of the tear film as well as compatibility with the contact lens material.

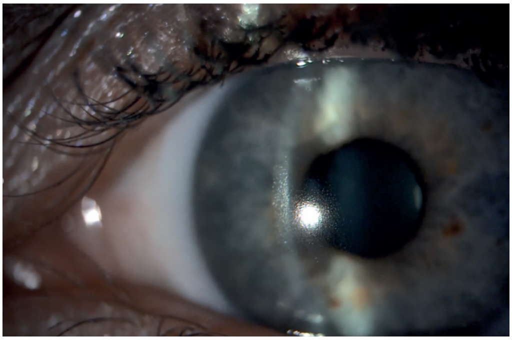


Figure 1. Assessment of contact lens wettability through observation of the 1st Purkinje image, with time to scatter following blink noted as the pre-lens thinning time

Corneal coverage & centration

With the eye in primary position, the lens should show full corneal coverage before, during and after the blink (Figure 3) and ideally display around 1 mm of limbal overlap. Incomplete corneal coverage can lead to more lens awareness, corneal desiccation

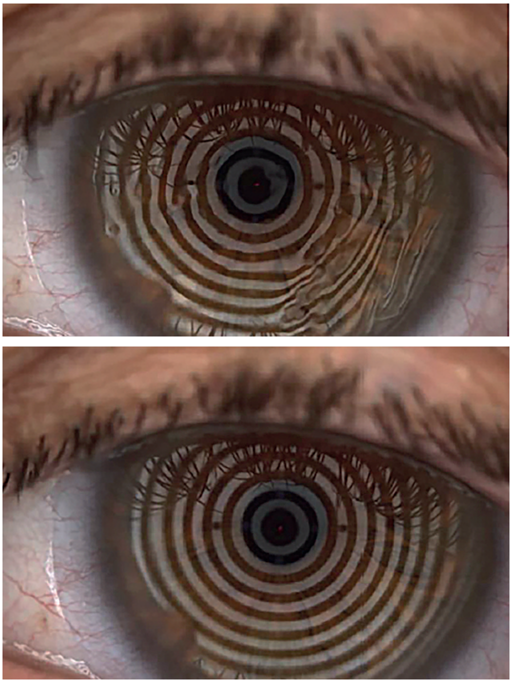


Figure 2. Assessment of prelens tear film break up time to provide information on contact lens wettability. Poor contact lens wetting is observed as distortion of Placido rings (top), versus good wetting (bottom)

staining (Figure 4), and mechanical stress on the peripheral cornea.

Movement on excursions

As well as assessing coverage in the primary position, coverage and movement should also be assessed on excursions, to ensure full coverage in all directions of gaze. Although traditional training and fitting guides recommend assessing lens movement on right and left gaze (known as lag, Figure 5) and on up gaze (known as sag, Figure 6), studies indicate that these measures have little predictive value in deciding if a lens fit is ideal or not,[8,10] though movement on horizontal gaze may be more useful of the two.[11] Movement should be quantified in millimetres and can be assessed by comparing the amount of movement to the limbal overlap, which should be around 1mm. Alternatively, movement can be quantified by comparing to a known beam width as measured by the slit lamp graticule.

Edge alignment

The edge of the contact lens should be aligned with the conjunctiva, and not indent the conjunctival vessels. Failure to achieve a smooth transition could result in local limbal or conjunctival hyperaemia and/or limbal nipping. Indentation would indicate stagnation of tears in this region and reduced oxygen supply to the limbus. If available, a flatter base curve could be trialled, or a different lens design with a different edge profile. Signs of indentation are more commonly observed with high modulus silicone hydrogel lenses.

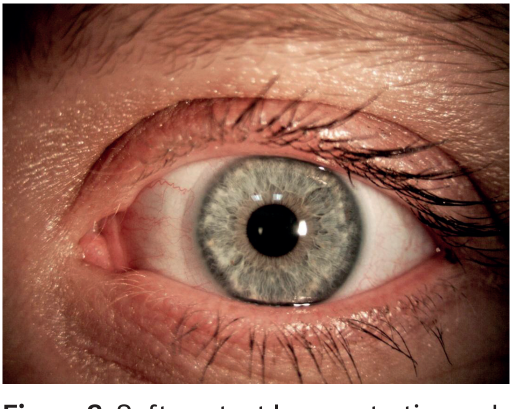
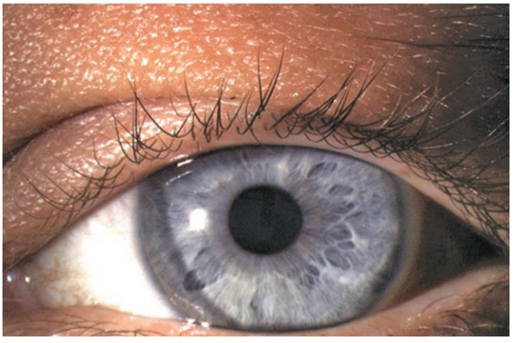


Figure 3. Soft contact lens centration and coverage in primary position, showing 1mm limbal overlap



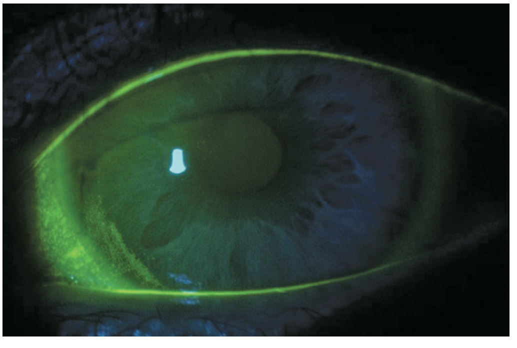


Figure 4. Incomplete corneal coverage (top), can lead to corneal desiccation straining (bottom)

Similarly, the lens should also show no edge stand-off (lens buckling, or fluting, Figure 7), which could lead to discomfort. This aspect of the lens fitting is often overlooked, as higher magnification is needed to observe this finding. Even slight edge stand-off in an otherwise optimal lens fit can cause discomfort due to its interaction with the eye lid. If available, a steeper base curve should be trialled and assessed. Otherwise, a different lens design or material will be required.

Primary gaze post-blink movement

This should ideally be measured with a graticule, by looking at the bottom of the lens during the blink or, if the lower lid obscures the inferior lens edge, at 4 or 8 o'clock. In absence of a graticule, the movement can be measured in relation to a fixed beam height, of 1-3mm, for example. In addition, it is helpful to watch the lens border move in relation to an underlying conjunctival or scleral blood vessel.

The ideal lens movement should be 0.2mm to 0.4mm; however, this depends on the lens material. In modern, thin, high water content and low elastic modulus lens designs, the movement is often less compared to older, thicker, lower water content designs. Even less movement can be observed with silicone hydrogel lenses.[12] In some cases, the lens shows no or hardly any movement,

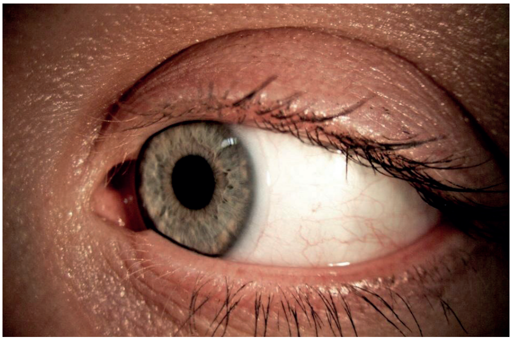


Figure 5. Soft contact lens lag, examined on left and right gaze

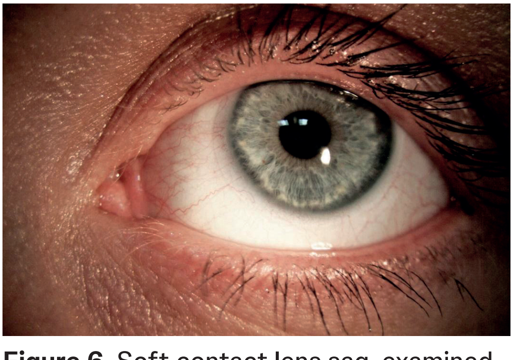


Figure 6. Soft contact lens sag, examined on upward gaze

even though the lens exhibits a good fit otherwise. As such, it is difficult to judge the fit on post-blink movement alone, and a better assessment of lens fit dynamics can be made using the push-up test.

Push-up Test

The push-up test is considered the most effective way to judge the dynamic fit of a contact lens. To perform this assessment, the practitioner moves the lens vertically, through pressure on the lower eyelid using their finger (Figure 8), then allows the lens to re-centre naturally. The tightness of the lens is determined by evaluating the relative force required to move the lens upwards, together with the speed of its recovery to its original position. A percentage grade can be used for record keeping, with 100 per cent representing a lens that is impossible to move and 0 per cent a lens that falls away from the cornea without lid support. An optimum fitting lens would be recorded as 50 per cent.[13]

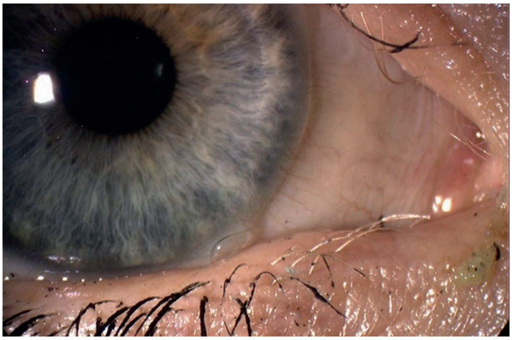


Figure 7. Edge fluting seen in a flat fitting contact lens.

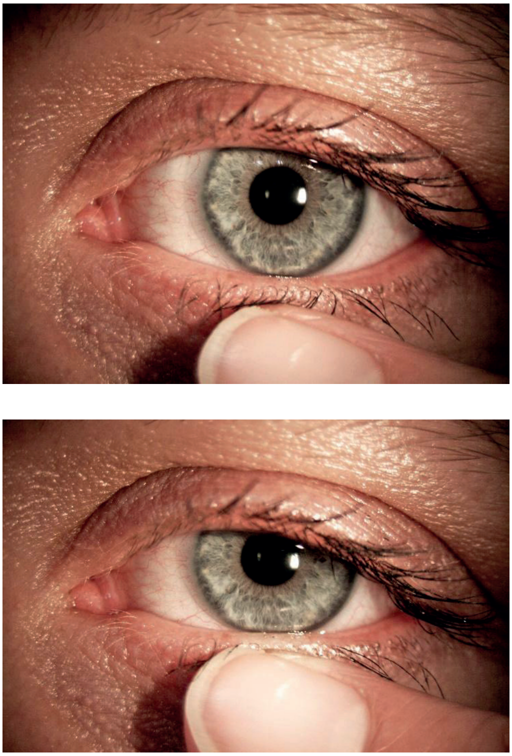


Figure 8. The push up test. The lens is manually moved by pushing the bottom of the lens (top) up vertically (bottom) using the lower lid, before being released and recovery observed

Interpretations of findings

Accurately assessing the fit of a soft contact lens involves evaluating both static and dynamic criteria, and consistent with good clinical practice, one observation should not be used in isolation to make conclusions.

Table 2 reviews both the physical fit and performance requirements of an ideal lens fit, as well as the characteristics of loose and tight fits.

Ocular factors affecting soft contact lens fit

Factors which could affect a soft contact lens fit and subsequently the subjective performance of a lens on-eye are discussed in more detail here. As previous, interpretation of these should not be viewed or managed in isolation.

Ocular Sag

The sagittal height or sag of the cornea is a function of the corneal shape factor, diameter, and radius, as well as the scleral shape factor and radius. So corneal geometry, including sagittal height, is determined by the corneal asphericity and diameter as well as the corneal curvature. Although ocular sag plays a significant role in the optimal soft contact lens fitting, it is not considered a key parameter because it is difficult to measure. As a result, diagnostic lens fitting using trial lenses is the only way to judge the effect of the sag on the lens fit.

Corneal Apex

A displaced corneal apex will typically lead to a decentred lens. To ensure full corneal coverage, opting for a lens with a larger total diameter should prevent exposure and subsequent desiccation of the cornea. In cases of a displaced corneal apex, changes in the base curve will have little effect on centration.

Lid Pressure

Tight lids may result in high-riding lenses and possibly, excessive lens movement. This can be managed by refitting with a thin lens design and/or increasing the lens diameter. Loose lids generally have less effect on the lens fitting.

Tear Morphology

Both pH and osmotic pressure can change lens parameters and affect the fit of the lens. A reduction in pH leads to steepening parameters of ionic contact lenses, and it has been shown that both ionic and non-ionic lenses tighten in fit as the tonicity of the tear film is reduced.[14] This is clinically significant because if a satisfactory fit cannot be obtained with one contact lens material, then it might be worth refitting with a material of a different ionicity or water content.

Procedure	Ideal fit	Loose fit	Tight fit
Comfort	Comfortable lens ≥9/10 None or minimal lens awareness	Uncomfortable lens ≤8/10 Significant lens awareness even after extended adaptation period	Comfortable lens ≥9/10 None or minimal lens awareness
Vision	Crisp, clear, stable vision Precise over-refraction with clear end-point	Variable vision, worse immediately post-blink	Variable vision, improves immediately post blink
Centration and coverage	Central fit, full corneal coverage with around 1mm limbal overlap Centred in all positions of gaze with around 0.5mm lag and sag	Poor centration, often displaced inferiorly Lag and sag greater than 0.5mm, with limbal crossings	Full corneal coverage Centred in all positions of gaze with very little lag or sag
Edge alignment	Regular alignment to conjunctiva	May show stand-off or buckling, particularly in higher modulus materials	Possibly local limbal and/or conjunctival hyperaemia, limbal nipping or conjunctival indentation
Primary gaze movement	0.2 to 0.4 mm movement	Possibly excessive >0.5 mm movement	None to minimal <0.1 mm movement
Push up test	Smooth push-up followed by smooth recovery	Easy to push-up followed by a quick or erratic recovery	Resistant to push-up with slow recovery

Table 2. Characteristics of ideal, loose and tight soft contact lens fittings

Lens variables affecting soft contact lens fit

In addition to ocular factors, lens variables can also influence the performance and fitting characteristics of soft contact lenses. The key lens factor variables that can affect fit are described below.

Back Optic Zone Radius

Although traditionally one would choose a larger back optic zone radius to increase lens movement, it is now well established that the base curve has no predictive value on lens movement.[15,16] This does not imply that a change in base curve has no effect on lens movement at all, only that a steeper base curve would not automatically result in a tighter fit, as one would predict. In addition, practitioners should be aware that changing to a different contact lens brand with identical base curve and total diameter will not guarantee the lens behaves identically on the eye. This is due to the variations in peripheral lens design between contact lens brands, which informs the relationship between the front and back peripheral curves. As well having a marked effect on the lens fitting characteristics, the peripheral design influences lens handling characteristics and comfort.[17]

Total Diameter

Increasing the total diameter will expand the sagittal height of the lens and tighten the fit, whereas reducing it will have the opposite effect. Total diameter should also be increased to improve corneal coverage in a lens fitted onto a cornea with a displaced apex. Changes to the lens diameter tend to have a greater impact on the fit of a soft contact lens compared to changes to the BOZR.

Adaptation advice

Traditionally, practitioners would instruct all new contact lens wearers to adhere to an adaptation schedule to ‘ease’ into lens wear in an attempt to maximise the clinical performance of the contact lenses over the first few days of wear. However, it was recently shown that this is not required with current modern soft daily disposable contact lens materials, whether these were hydrogel or silicone hydrogel lenses.

The lack of clinical benefit for a gradual adaptation schedule supports the adoption of a ‘no need to adapt’ approach for neophyte daily disposable lens wearers, and is likely to improve compliance.[18]

Conclusions

As soft contact lenses continue to dominate the global contact lens market, it is essential that soft contact lenses are accurately fitted and assessed to ensure maximum success. Patient subjective response, vision and slit lamp examination should all be taken into account when determining whether the fit of a lens is optimal. Of course, the process for assessing soft contact lens fit does not cease after the initial assessment. The effects of factors such as wearing time, environmental conditions and ocular physiology, including dry eye, must be monitored constantly. Ongoing aftercare is key to continued contact lens success.

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J&J Institute

Soft Toric Contact Lens Fitting

Author: Dr Katherine Evans

Whilst soft toric contact lens fitting was previously regarded as a 'speciality', in recent years the number of designs available has increased and the fitting approach simplified. This is reflected by a continuous increase in toric lens prescribing over a 15-year period observed in an international survey of toric lens prescribing.[1] In a 2019 UK contact lens prescribing survey detailing over 1000 fits, a considerable proportion of new fits and refits were soft toric lenses (31% and 28% respectively).[2] Overall, a continued trend of decline in the proportion of soft spherical-only fits was observed due to the increasing popularity of both toric and multifocal designs. Similarly, the popularity of RGP torics is dwindling as practitioners increasingly favour soft lens designs.[2]

The increasing popularity of soft toric lenses has been fuelled by the release of innovative lens designs, which are available in different lens materials with an increasingly wider parameter range, even for daily disposable lenses. The availability of comprehensive fitting banks now makes trialling astigmatic patients with toric disposable diagnostic lenses as convenient as spherical lens fitting. One of the reasons for this increase in the simplicity of fitting toric lenses has been an advance in manufacturing technology. The advent of new low-cost moulding technology and wet moulding techniques – allowing the lens to remain hydrated throughout manufacture – has led to improvements in contact lens reproducibility and optical quality. This should give practitioners greater confidence that the lenses being dispensed are predictable to fit.

Power of correcting cylinder, in Dioptres	Percentage of total sample
0	32.0
0.25-0.50	34.6
0.75-1.00	17.7
1.25-2.00	9.8
2.25-3.00	3.8
3.25-4.00	1.5
Over 4.00	0.6

Table 1. Incidence of astigmatism, from Bennett[3]

The incidence of astigmatism in the general population is shown in Table 1.[3] The percentage of prospective lens wearers with ≥ 0.75DC in at least one eye, who could be fitted with toric contact lenses, has been estimated at 45.4%[4] and more recently at 47.4%.[5] Whilst the prevalence of with-the-rule and against-the-rule astigmatism was similar (≥ 0.75DC; 15.3% and 14.5% respectively), astigmatism in myopes was almost twice the prevalence of that observed in hyperopes (≥ 0.75DC; 31.7% and 15.7% respectively). It was estimated that 90% of the patients considered in the study could be fitted with a toric lens power range of +6.00D to -9.00D, three cyl powers, and 18 axes. A separate study suggested that up to 96.4% of 101,973 patient prescriptions analysed could be fitted with the soft toric contact lens power ranges of frequent replacement lenses that are currently available.[6]

Despite the increasing proportion of soft toric lens prescribing, the level still falls below the prevalence of astigmatism identified in prospective lens wearers.

Studies have indicated that patients are often unaware they have astigmatism, were unaware there were lenses for astigmatism or were not offered toric lenses by their practitioner.[7] Therefore, practitioners should be proactive in these discussions. Practitioners often underestimate the effect on visual performance, of even low levels of astigmatism. A wealth of studies have indicated that visual acuity is significantly improved with toric contact lenses when compared to spherical lenses.[8-12] Similar improvements have been observed for low contrast visual acuity,[11,12] contrast sensitivity[13] and subjective vision.[8,11,14] Research data suggests that correcting even low to moderate astigmatism (-0.75 to -1.75DC) may be important for safety when driving.[15] More recently, a study found that correction of astigmatism (-0.75 to -1.50DC) with toric lenses resulted in significantly improved night driving performance when compared to correction with spherical contact lenses.[13]

Practitioner concerns about increased chair time should be dispelled; the time taken to successfully fit toric and spherical lenses in a crossover study was not significantly different (mean fitting time 10.2 and 9.0 minutes, respectively).[14] In a clinical evaluation of 200 astigmatic patients, who had not previously worn toric lenses, 88% were successfully fitted at the first attempt with the average fitting appointment taking 22 minutes.[8] Patients were fitted with either daily disposable or two-weekly disposable lenses and observed an overall success rate of 75% following a wearing period of one month. High levels of satisfaction with comfort and vision were also reported (85% and 93% respectively).[8] Similarly high levels of general satisfaction (96%) have been reported in a recent post-market evaluation study of over 1200 patients fitted with daily disposable toric lenses.[16]

The increased cost of toric lenses compared to spherical lenses may be off-putting to patients. When used on a full-time basis, it was reported the annual cost of monthly disposable toric lenses was 11% greater compared to a spherical correction in the UK.[17] Therefore, it is important to effectively demonstrate the benefits of toric correction not only to neophytes but to existing spherical lens wearers with suitable levels of astigmatism. Whilst this can be easily demonstrated using a trial frame during the consultation, the real-world improvement (such as differing contrast levels and the effect on driving performance in both photopic and scotopic conditions) is most effectively demonstrated by dispensing toric lenses for a trial period. Whilst uptake is likely to be dictated by the visual demands and wearing frequency of the individual, this at least allows patients to make an informed choice of whether toric lens correction is appropriate for them.

Soft toric contact lens design

Whilst the tear lens formed by a spherical RGP will correct corneal toricity without the need for a toric lens, this is not possible with soft lenses, which simply drape over the cornea.

Thick soft lenses or high modulus materials cannot effectively mask corneal astigmatism.[18-20]

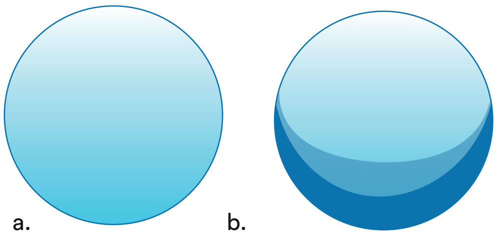

Figure 1. Thickness profiles of a prism ballast (a) and peri-ballast (b) toric soft contact lens, where darker colour indicates greater thickness.

Furthermore, the use of aspheric spherical contact lenses to reduce spherical aberrations do not effectively improve visual acuity when compared to toric lenses.[21] For success, a toric lens needs to position the correcting cyl at the desired axis and the lens needs to maintain rotational stability during and after a blink, as well as during a change in direction of gaze. Manufacturers use a number of methods to achieve this; prism ballast, peri-ballast and thin zone designs (known as double slab-off, dynamic stabilisation and Eyelid Stabilised Design).[22] The following sections will review each of these designs in turn.

Prism-ballast

This lens design relies on vertical prism to orientate and stabilise the lens. In principle, the lens is produced with an increasingly thicker profile towards its base (Figure 1a). The thinner portion of the lens locates under the upper eyelid, which then squeezes the thicker portion of the lens towards the lower lid, which has been described as the "watermelon seed" principle. With more modern lens designs, a thinner inferior lens periphery, or comfort chamfer, is used to reduce the thickness differential and improve oxygen performance.[23]

Peri-ballast

Although similar to the prism-ballast design, this design utilises eccentric lenticulation and a thinned superior lens edge to produce a prism-like rotational stabilisation effect.[24] This modification means that prism is restricted more to the lens periphery allowing for potentially prism-free optic (Figure 1b).

Thin zone designs

These designs also rely on the interaction between lids and the lens to achieve stabilisation. Both eyelids play an active role unlike with prism-ballast designs that primarily involve interaction from the upper lid. The design utilises thin zones; the lids squeeze against the thickness differential across the lens aligning the thicker central portion within the palpebral aperture and the thinner zones under the eyelids (Figure 2a). Refinement of this stabilisation approach includes designs that isolate the optical correction within an optic zone resulting in independent stabilisation areas.[25] This allows orientation consistency across all powers and a thin overall thickness profile[25] (Figure 2b). More recently, Eyelid Stabilised Designs have sought to maximise effectiveness by locating thicker 'stabilisation zones' within the palpebral apertures while minimising any thickness variation of the lens under the eyelids (Figure 2c).[25]

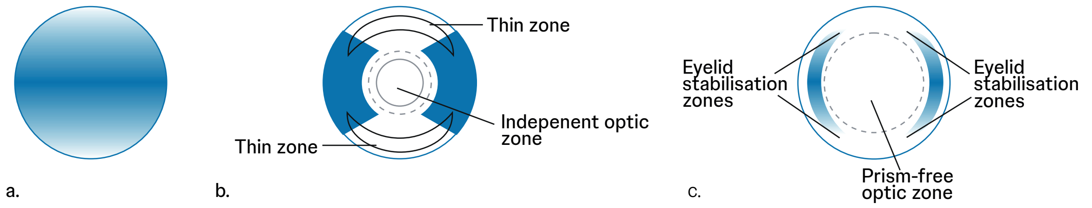

Figure 2. Thickness profiles of thin zone toric contact lens designs where darker colour indicates greater thickness in original designs (a), refined designs with independent optic zone (b) and in Eyelid Stabilised Designs (c)

Toric lens performance

When we consider contact lens performance, we must always consider comfort, vision and health. Currently, there are no published trials that have compared the different toric designs on ocular comfort. However, the impact of lens thickness on oxygen performance should be considered when selecting a lens material, particularly for higher prescriptions as this could have consequences for ocular surface physiology.

The quantity of vertical prism within the central optic zone has been investigated for a variety of stabilisation designs by Sulley et al.[26] Despite advances in prism ballast and peri-ballast designs to reduce unwanted prism, significantly higher levels of vertical prism were observed in the prism ballast and peri-ballast designs (range, 0.52Δ to 1.15Δ) compared to the non-prism ballast designs (0.01Δ). The authors concluded that practitioners should consider this factor, particularly when fitting monocular astigmats with binocular vision anomalies, as unwanted vertical prism may be present if fitted with a prism ballast or peri-ballast design.*

Stability of lens rotation must also be considered and has been investigated across several studies. Rotational stability when performing large saccadic versional tasks was deemed to be superior with an Eyelid Stabilised Design compared to a prism ballast lens, although reading and a visual search task resulted in similar levels of stability.[27] In a comparative study of three prism ballast lenses and an Eyelid Stabilised Design lens, both designs showed fast re-orientation speeds after manual rotation by 45 degrees (22-25 degrees per minute).[28]

* Vertical heterophoria possibly caused by prism dissociation due to the presence of induced optical prism is a relevant factor for practitioners to consider when fitting toric contact lenses for monocular astigmats or those requiring a mix of toric soft contact lens designs.[38,39] Clinical studies have not been done to fully characterize the clinical effects of differences in base down prism among different contact lenses.

However, significant differences between lens designs were observed when patients were moved to a recumbent position, with prism ballasted lenses rotating further than the Eyelid Stabilised Design lens (Figure 3). Similar findings of increased rotational stability during ocular movements and reduced gravitational effects for Eyelid Stabilised Design lenses compared to other lens designs have also been reported.[29] Conversely, in a recent study, an optimised prism ballast lens showed the lowest level of lens rotation from the vertical position and an improved re-orientation speed after manual rotation by 45 degree when compared to four other lenses of differing designs.[30λ] Lid position, the upward or downward slope of the lids and palpebral aperture size have been shown to be the main patient factors associated with lens orientation and stability.[31] Whilst it is impossible to predict which lens will offer superior stability for an individual patient, it may be preferable to fit Eyelid Stabilised

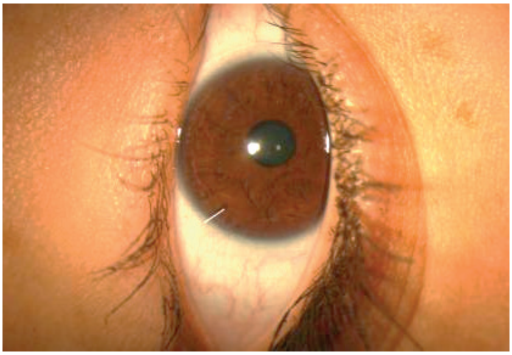

Figure 3. The effect of gravity on a prism ballasted soft toric contact lens (Image courtesy of Graeme Young)

[λ] Study contact lenses included: PureVision Toric, Air Optix for Astigmatism, Acuvue Advance for Astigmatism, Biofinity Toric and Proclear Toric.

Designs for more dynamic situations (watching or playing sport) or occupations such as dancers or mechanics.

Lens orientation marks

Soft toric lenses feature an orientation marking to allow the practitioner to assess the amount of lens rotation and lens stability. It should be noted that the orientation mark does not indicate the cyl axis. A variety of orientation marks are used by manufacturers, typically either at the six o'clock or the three and nine o'clock positions (Figure 4). Lens rotation can either be measured by rotating a fine slit beam to align with the lens orientation marking and reading the axis from the external protractor scale using a graticule (Figure 5) or estimated using the orientation marks as a guide (Figure 6). An advantage of a toric lens with two markings opposite each other is that by passing a slit-beam through both markings, a more accurate measurement of lens rotation is achieved. Certain orientation markings can be difficult to observe and viewing the markings in indirect or retro-illumination, rather than direct illumination can help.

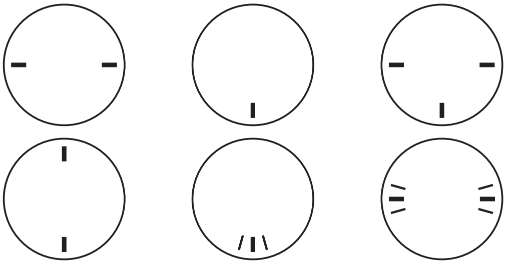

Figure 4. Examples of the different orientation markings used on soft toric contact lenses

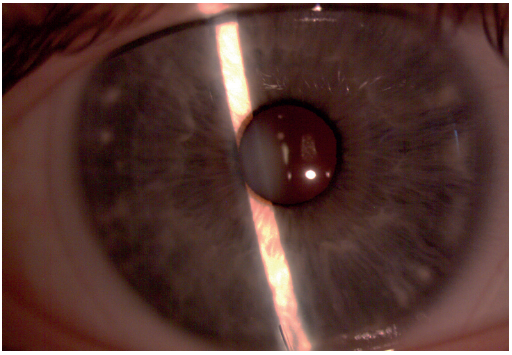

Figure 5. Measurement of soft toric contact lens rotation by rotating a fine slit beam to align with the lens orientation marking and reading the axis from the external protractor scale.

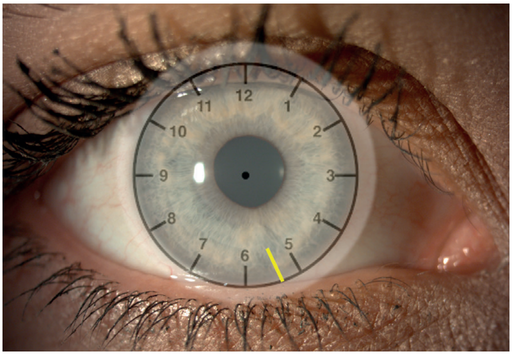

Figure 6. Estimation of rotation using a clock face as a guide, where rotation to the '5 o'clock' position would indicate 30 degrees of rotation. In this example, the yellow line indicating the toric marking is sitting approximately two thirds of the way between the 5 and the 6 o'clock, indicating rotation of around 20 degrees.

Adjusting for rotation

The amount of lens rotation indicates how far the cyl axis has rotated compared to the intended position. As long as the lens rotation is stable, the lens can be re-ordered to compensate for this rotation.

The axis of the next lens to trial is decided by the following mnemonic:

LARS where
Left rotation = **A**dd and
Right rotation = **S**ubtract (Figure 7)

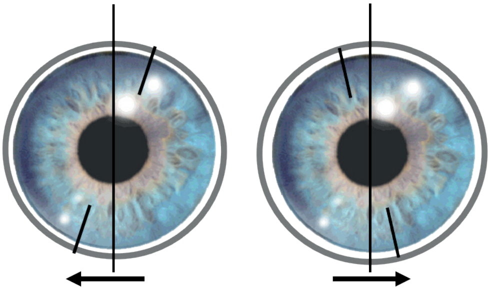

Figure 7. LARS rule where Left rotation (left image) = Add and Right rotation (right image) = Subtract

CAAS where
Clockwise rotation = **A**dd and
Anticlockwise rotation = **S**ubtract
(Figure 8)

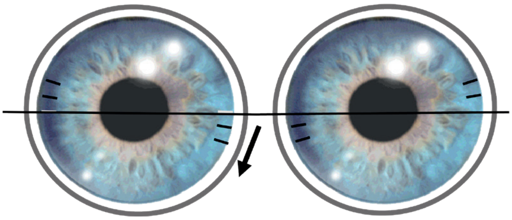

Figure 8. CAAS rule where Clockwise rotation (left image) = Add and Anticlockwise rotation (right image) = Subtract

Although both mnemonics are useful, LARS may be preferred for lenses with orientation markings at 6 o'clock and CAAS for lenses with orientation markings at the three and nine o'clock positions.

For example, a trial lens of -3.00/-1.75x180 is fitted initially and rotates anticlockwise, or right, by 10 degrees when placed on the eye. The correction the patient experiences will therefore be -3.00/-1.75x10 degrees and the vision will be blurred. To compensate for this, using the LARS or CAAS mnemonic the new trial lens to be ordered will be -3.00/-1.75x170. When the new lens is placed on the eye, the interaction between the lids and lens will be the same, rotating the lens 10 degrees anticlockwise again. This rotation will bring the axis round to desired 180 degrees to allow for optimal visual correction (Figure 9).

Toric lens fitting

The exact fitting procedure for soft toric lenses and for the supply of diagnostic or trial lenses may vary among the different brands and practitioners are encouraged to follow individual manufacturer's guidelines. A standardised fitting process is described below.

Initial trial lens selection and application

The choice of back optic zone radius (BOZR), lens material and replacement modality for a soft toric lens should be made in the same way as one would select a spherical soft design. The effect of the back vertex difference (BVD) should be carefully considered and calculated empirically for each meridian or determined using manufacturer's effectivity tables or online calculators. Mistakes can be made by guessing the optimal power, particularly in plus power lenses where practitioners often mistakenly reduce the cyl power (Table 2).

Spectacle prescription (BVD 12mm)	Contact lens power
-5.00DS / -2.75DC x 180	-4.75DS / -2.25DC x 180
+5.00DS / -2.75DC x 180	+5.25DS / -3.00DC x 180

Table 2 Calculated contact lens power for myopic and hyperopic spectacle prescriptions. Note the relative increase in contact lens cyl power for the hyperopic prescription and the decrease for the myopic prescription

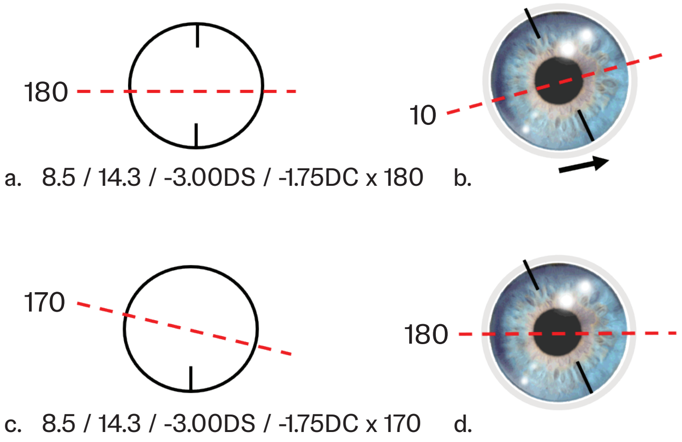

Figure 9. Using LARS and CAAS to manage toric rotation. Here a toric contact lens with a cyl axis at 180° (denoted by the red dashed line) is ordered (a). Once applied to the eye, the contact lens rotates 10° anticlockwise, or right, meaning the cyl axis lies at 10° (b). A new trial lens is ordered using the LARS or CAAS calculation with a cyl axis of 170° (c). Once applied to the eye, the contact lens again rotates by 10° anticlockwise, meaning the cyl axis is now along the desired 180°.

Typically, toric contact lens cyl powers are only available in 0.50DC steps. Where the desired lens falls between two powers it is generally advisable to select the lower cyl power initially. Unwanted lens rotation will have a detrimental impact on visual quality and this can be exacerbated if the cyl is over-corrected. The cyl power can be checked during the over-refraction and amended if the higher power is beneficial however. Axis availability for most disposable lenses is in 10-degree steps around the clock, or even five degrees for extended power ranges. Where the desired lens falls between two axes it can be beneficial to use a trial frame with the patient's spectacle prescription to determine which axis they prefer.

Whilst several patient factors and lens fit characteristics influencing soft toric lens orientation have been identified, the findings fall short of allowing practitioners to accurately predict toric lens orientation. Hence, no initial compensation of the cylindrical axis should be made when choosing the initial trial lens. The patient should be forewarned of an initial increased level of lens awareness with a toric lens, particularly if fitted unilaterally or if a spherical lens patient is being refitted with a toric lens. Lens awareness is due to the thickness differential from the lens stabilisation design and typically resolves after a short period of adaptation. Following application, the lens should be allowed to settle, as for a spherical soft lens, before the fit is assessed. Whilst some practitioners prefer to apply toric lenses with the orientation mark in the correct position to optimise the speed of orientation, this isn't necessary. With more recent designs, speed of orientation is faster allowing assessment within one to three minutes following application.[8]

Lens fit assessment

As for a spherical lens, an optimal lens fit with good centration is desirable; a steep fitting lens is likely to impair re-orientation whereas a flat fitting lens is likely to result in reduced lens stability and increased rotation.

The location of the orientation marking should be assessed whilst the patient fixates in the primary position initially. If the orientation marking is stable in the primary position of gaze, the practitioner should note the position in relation to the intended position and the direction and degree of rotation seen (if any). The method used to measure lens rotation is described earlier in the lens orientation marking section. If the lens position is more than 30 degrees from the intended position it suggests that there is inadequate stabilisation and an alternative lens design should be considered.

With the patient in primary gaze, the lens may show a minimal amount of nasal rotation, typically of up to five degrees either during or immediately after a habitual blink, which is due to the movement of the lower lid during a blink. Excessive rotation following a habitual blink, particularly for higher cyl powers, is likely to result in unstable vision, and an alternative lens design is indicated. Orientation stability should be assessed further while the patient performs forced blinks and during versional movements. To simulate real world eye movements, ask the patient to look up, down, left and right, while looking for any significant lens rotation. Provided the lens remains stable it should provide relatively consistent vision. The efficacy of the lens re-orientation can be assessed by manually rotating the lens off-axis using the lower eyelid. If the stabilisation method is optimal, the lens should return to its original position quickly following a few blinks. As long as the lens is stable, any consistent rotation that impairs the visual performance can be corrected with the LARS or CAAS mnemonic, as described earlier.

Over-refraction

An over-refraction should be carried out to determine the optimal lens power and to provide further information on lens stability.

If the patient reports that the vision blurs with each blink, this confirms the lens fit is unsuitable or the rotational stability of the lens is poor. In either case, another lens needs to be applied, either a different parameter (in the case of a poor fit) or stabilisation design (if the lens is rotationally unstable).

Visual performance should also be assessed at near.

If the trial lens orientation marking lies within 10 degrees of the intended position, vision can be assessed and a spherical over-refraction carried out to determine whether an alternate spherical power should be ordered. A full sphere-cyl over-refraction is unnecessary and will over-complicate the process.

Lenses that position off-axis will produce a residual refractive error, which is a function of the cylinder power and degree of mis-orientation. For example, a toric soft lens of power -3.00DS /-1.75DC x 180 that matches the patient's ocular prescription but orientates 20 degrees off-axis will result in an over-refraction of +0.50DS / - 1.25DC x 55. The stability of the end-point gives a good indication that lens fit is adequate; however, it is impossible to determine whether the spherical component of the final prescription to be ordered requires adjustment. Consequently, a new trial lens should be applied after compensation of the cylinder axis for lens rotation to allow a meaningful spherical over-refraction.

Troubleshooting

Poor visual performance

The most common reason for reduced visual performance is rotation of the axis or poor lens stability. If the lens has rotated but remains stable then the degree of rotation should be corrected with the LARS or CAAS mnemonic. If the lens axis has previously been altered to compensate for rotation, it can be beneficial to check the lens is sitting in the expected "off axis" position. Checking the lens power in relation to the spectacle prescription may identify mistakes with back vertex distance compensation or even simple human error. If poor lens stability is observed or the patient reports unstable vision then the lens fit should be optimised. A steep fitting lens is likely to impair re-orientation whereas a flat fitting lens is likely to result in reduced lens stability and increased rotation. Furthermore, a change in the lens stabilisation design is likely to be beneficial where there is inconsistent lens rotation. Figure 10 suggests a flowchart procedure to tackle poor visual performance.

Poor comfort

Discomfort should be managed with the same approach as for a spherical lens. Increasing the lens replacement frequency is likely to be beneficial. Whilst the range of parameters may not be quite as wide in daily disposables as reusables, particularly for the higher cyl powers, a study has shown that under correction of the cyl by up 0.50DC, while maintaining the spherical equivalence has no significant adverse effect on visual performance.[32] Another

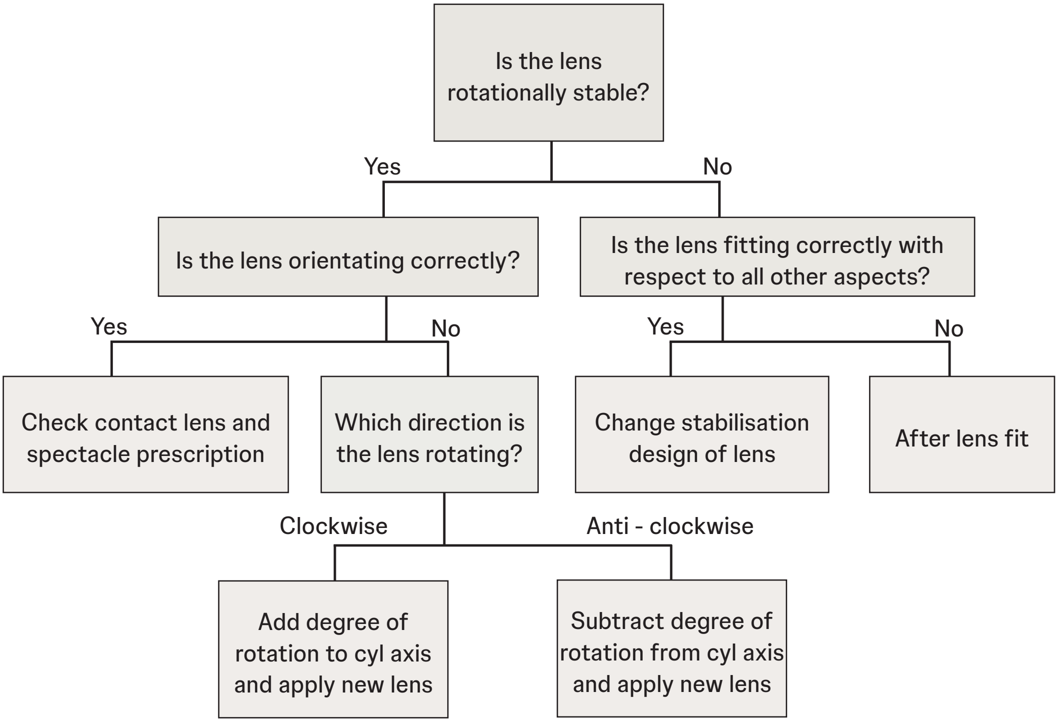

Figure 10. Flowchart to aid problem solving with poor visual acuity

factor to consider is the likely thickness differential of the current lens as refitting with a different stabilisation design may be beneficial.

Contact lens wear dropout

Discomfort and poor vision are the primary causes of permanent discontinuation of contact lens wear, or dropout across all lens types.[33, 34]

In a prospective study of retention rates over a 12-month period, within the toric lens group the main reasons for discontinuation were poor vision (48%) and expense (19%).[34] In a study published in 2011, soft toric lens wearers reported more frequent and intense discomfort and dryness compared to spherical lens wearers.[35] More recently however, a retrospective study by Sulley and colleagues investigating neophyte wearers found no significant difference in dropout between spherical and toric lens wearers with 79% and 73% still wearing lenses after 12 months.[36] It was suggested this may reflect more recent advances in toric lens design or increased practitioner confidence in fitting such lenses.

The practitioner is key to identifying patients at risk of dropout. Disappointingly, considering the toric lens patients that discontinued lens wear in the study by Sulley, less than a third were offered an alternative lens by their practitioner.[36] Real world eye movements are difficult to reproduce on the slit lamp, therefore subjective reports of poor lens performance may not correlate with objective measures such as lens rotation and stability. Furthermore, high contrast visual acuity may not indicate the real-world visual performance of soft toric lenses. Therefore, practitioners should ask patients about fluctuations in vision during specific activities and in different environments to identify their level of satisfaction.[37] To avoid dropout patients should be proactively refitted and informed of new lens developments.

Conclusions

With a greater understanding of the forces that influence soft toric lenses on the eye, designs continue to improve with faster orientation when first applied, as well as being more predictable and more stable during dynamic vision situations. In many ways, fitting a soft toric lens today is as straight forward as fitting a spherical lens for most patients and with improving performance and patient satisfaction, should continue to be an integral part of contact lens practice. Practitioners should be proactive in explaining the effects of astigmatism and the possible benefits of toric lenses, encourage trials and identify and refit current wearers at risk of dropout.

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RGP Contact Lens Fitting

Author: Dr Katharine Evans

The increasing availability and power ranges of disposable soft contact lens designs has led to a steady decline in the popularity of rigid gas permeable (RGP) lenses. Despite many advantages over hydrogel lenses, an international survey of rigid lens fitting revealed that between the period of 2007 and 2011 only 10.8% of contact lens fits were with rigid lenses.[1] In a 2019 UK contact lens prescribing survey detailing over 1000 fits, compared to soft lenses, only 1% of new fits and 10% of refits were into RGPs.[2]

Whilst the initial lens awareness and period of adaptation that comes with RGP lenses can be unappealing to patients, the stable lens surface of the RGP can provide superior visual quality compared to soft lenses.

As a result of the tear lens - the thin layer of tears formed beneath the RGP - moderate amounts of corneal astigmatism and even irregular astigmatism can be effectively corrected. In patients with stable prescriptions, RGP lenses are also a cost-effective alternative to disposable soft lenses in full-time wearers. When compared to soft lenses, RGPs tend to be fitted to older patients, with a greater proportion of bifocal or multifocal fits.[1] Despite poor levels of compliance in RGP wearers,[3] daily RGP contact lens wear is associated with the lowest risk of microbial keratitis.[4] Increased post-lens tear exchange with RGPs compared to soft lenses is thought to reduce exposure time to debris, toxins and antigens trapped behind the lens surface.[5]

Sophisticated lens design and manufacture mean a wealth of parameters, power range and lens designs are available. While using custom-made multi-curve lens designs increases the practitioner flexibility in dealing with a range of corneal contours, many spherical and aspheric 'system' lens designs can cover most eventualities. In a study of 22 neophytes fitted with RGPs, 73% successfully completed the one-month study period. Successful lens wearers achieved high levels of subjective vision and comfort within 10 days.[6] High levels of RGP fitting success have also been reported in larger scales studies.[7,8] Whilst practitioners may be reluctant to fit RGP lenses, assuming more clinical skill and patient chair time is needed, the principles to select an initial lens and assess the fit are actually very straightforward. This chapter concentrates on basic procedures and techniques required to fit RGP contact lenses in routine practice.

Lens design

The back-surface design of RGP contact lenses may be spherical, toroidal, aspheric or a combination. Spherical lenses may be bi-curve, tri-curve or multi-curve designs, where each radius of curvature progressively increases to mimic corneal flattening. Figure 1 shows the design of a tri-curve spherical RGP. The radius of curvature of the back surface of the lens is known as the back optic zone radius (BOZR) and the size of this optic is termed the back optic zone diameter (BOZD). The total diameter (TD) describes the overall size of the lens.

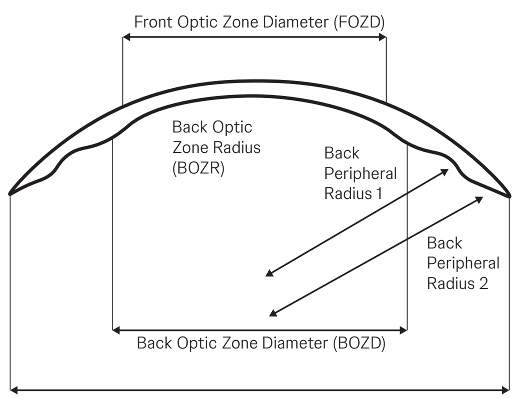


Figure 1 Dimensions for a tri-curve spherical RGP

For an ideal or alignment fit, the back surface of the RGP will align with the anterior corneal surface. This ensures that pressure exerted on the cornea is evenly distributed across the whole area under the lens, limits the mechanical effect of the lens on the corneal surface, and minimizes lens flexure, promoting lens comfort. In an alignment fit a thin layer of tear film - the tear lens - forms between the cornea and back surface of the lens. The periphery of the lens is designed to allow for edge clearance to facilitate tear exchange and lens removal. A lens with an alignment fit will allow for effective tear exchange to maintain normal corneal physiology. In the case of steep fitting, lens pooling of the tear lens can cause stagnation, whereas mechanical complications can occur in the case of corneal touch with a flat fitting lens.

Contemporary “system” lenses have been designed and manufactured to ensure that the back surface is blended into one continuous, smooth surface and are designed to fit the majority of patients with typical corneal shape factors. RGP materials used today include silicone acrylates and fluorosilicone acrylates which offer good oxygen permeability, with the latter also benefitting from better wettability and fewer deposits.

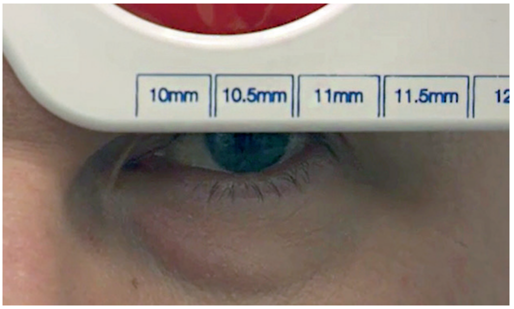


Figure 2 Measurement of the horizontal visible iris diameter (HVID) with an adapted ruler

Initial measurements

Besides the standard investigations undertaken prior to soft lens fitting as described in the previous chapters in this series, a small number of additional initial measurements are necessary to select the different parameters of the trial lens.

Horizontal visible iris diameter (HVID)

This is most easily recorded with an adapted ruler (Figure 2) and informs the total diameter (TD) of the trial lens, which should be approximately 1.5-2mm smaller than the HVID.

Visible palpebral aperture (VPA) and lid position

The VPA and lid position in relation to the limbus can be used to inform the TD, as a smaller palpebral aperture may benefit from a smaller TD. The upper eyelid position can affect the extent of lid attachment whilst centration may be affected if the lower lid lies significantly below the limbus. Consideration of the lid position can be particularly useful when troubleshooting a poorly centered lens.

Pupil diameter

Habitual and maximum pupil size, measured in a darkened room with the eye illuminated using the UV light on the Burton lamp, should be recorded. Whilst the BOZD is typically pre-determined for a particular lens, it should ideally be at least 1.0mm larger than the maximum pupil size to avoid symptoms of flare.

Assessment of central corneal curvature

Central corneal curvature can be recorded with either a keratometer or corneal topographer. Central keratometry readings (K-readings) are used to determine the BOZR but also allow calculation of the extent of corneal astigmatism.

As a rule of thumb, 0.05mm difference between the K-readings equates to 0.25D corneal astigmatism.

When fitting a spherical lens, the initial trial lens should be chosen using the manufacturer's recommendations for a specific lens design, which typically follow the guidance shown in Table 1. For corneas with no or low levels of corneal astigmatism the suggested initial BOZR is that of the flattest K-reading. As the extent of corneal astigmatism increases the difference in the radius of curvature of the two corneal meridians increases. This results in increasing levels of clearance between the steeper corneal meridian and the back surface of the lens, which can have a detrimental impact on comfort and lens stability. The initial BOZR is therefore slightly steepened according to the magnitude of corneal astigmatism. However, this cannot be achieved with higher degrees of corneal astigmatism because of unstable fitting characteristics. In cases where corneal astigmatism exceeds approximately 2.50DC, a back surface toric RGP is required to achieve a satisfactory fit. It is recommended to follow the manufacturer's fitting guide when fitting an aspheric design, as the initial BOZR will be related to the degree of asphericity of the lens design.

When the K-readings are considered in relation to the refraction it is possible to determine the site and degree of any astigmatism whereby: Total ocular astigmatism = corneal astigmatism + lenticular astigmatism. Spherical lenses can correct moderate corneal astigmatism through neutralization by the tear lens. If astigmatism is lenticular, a spherical RGP lens will have no effect on its correction and a front surface toric RGP will be required. Toric RGP fitting is discussed in greater detail later in this chapter.

Initial lens selection

Lenses can be fitted either empirically, where the baseline data is supplied to the manufacturer, or with a diagnostic lens from a fitting set. When fitting "system" lenses, practitioners typically only need to specify the BOZR, TD, back vertex power (BVP) and lens material. Whilst some practitioners prefer the use of diagnostic lenses as it can reduce chair time, diagnostic sets typically only come in a single power. This can result in changes to the fit due to variation of power; the lens thickness, centre of gravity and even edge profile can vary between different lens powers. Therefore, myopes should be fitted with minus powered diagnostic lenses and hypermetropes with plus powered diagnostic lenses. Whilst

Corneal astigmatism	Suggested Initial BOZR	Example K-readings (mm)	Calculated corneal astigmatism	Initial BOZR (mm)
Spherical – 0.75DC	Fit on flattest K-reading	7.80@180/7.75@90	0.25 DC	7.80
0.75 – 1.00 DC	Between 0.00 to 0.05 steeper than flattest K	7.80@180/7.60@90	1.00 DC	7.75
1.00 – 2.50 DC	Between 0.05 to 0.10 steeper than flattest K	7.80@180/7.35@90	2.25 DC	7.70
Over 2.50 DC	Back surface toric recommended	7.80@180/7.20@90	3.00 DC	Back surface toric recommended

Table 1 Choice of BOZR based on K-readings for spherical RGP lenses

fitting lenses empirically has the advantage that patients get to appreciate the visual correction/quality it can lengthen the fitting process if the lens parameters need to be altered.

Lens application and initial adaptation

Where possible, new lenses should be hydrated in a soaking solution for at least 24 hours prior to lens application. Whilst it remains contentious amongst practitioners, the use of topical anaesthetic prior to lens application has been shown to improve initial comfort, reduce anxiety during adaptation,[9] improve overall satisfaction and reduce dropouts without increasing corneal staining in a placebo group.[10] The use of topical anaesthetic is also beneficial to reduce the initial reflex tearing response, which will aid in the fit assessment.

Immediately prior to lens application, patients should be instructed on the lens awareness sensation they are likely to experience. This experience can be likened to having an eyelash in the eye. Patients should be encouraged to look downwards to minimise the interaction of the lid on the lens edge and reduce the sensation of lens awareness.

Assessment of the lens fit should not take place before reflex tearing has subsided as the lens will move excessively and fluorescein will be washed away too quickly.

A group of over one hundred experienced practitioners (known collectively as the GP Consensus Group) concluded an ideal initial adaptation period of at least 20 minutes.[11]

After initial adaptation, the patient should be tolerably aware of the lenses and any reflex lacrimation should have stopped. If the patient reports discomfort or a foreign body sensation, lifting the upper eyelid will enable the practitioner to judge whether or not any discomfort is due to normal adaptation (in which case it will disappear when the lid is lifted) or a foreign body trapped between the lids (in which case it will remain).

Lens fit assessment

The assessment of RGP lens fit involves the evaluation of both static and dynamic criteria. The dynamic fit should be assessed with the slit lamp using white light (ideally with a diffuser), low magnification and with sufficient illumination to aid observation but not too bright as to initiate lacrimation. Examination should include assessment of the following:

Dynamic assessment with low-medium magnification and diffuse white illumination

Centration

Lens centration should be assessed in the primary position, with the relationship to and the interaction with the lids considered. Lenses may fit between the VPA, known as interpalpebral or show lid attachment, where the upper lid controls centration. Centration can be recorded using a fitting cross, or in combination with coverage as follows:[11]
C: adequate centration
L: lens crosses the limbus
P: optic zone crosses the pupil in mesopic conditions

Movement on blink

Lens movement on blink can be estimated by comparing the movement to a known slit beam height or to the lens TD. It can also be beneficial to record the speed and direction of movement immediately following a blink. The RGP consensus group[11] advised that movement could be recorded on a -2 to +2 scale as follow, where 0 represents ideal movement:

+2: > 2.0mm movement
+1: 1.6-2.0mm movement
0: 1.0-1.5mm movement
-1: 0.5-0.9mm movement
-2: <0.5mm movement

Coverage

Lens coverage should be assessed by instructing the patient to look in the four positions of gaze, with any lens crossing of the limbus recorded. Care should be taken to ensure appropriate initial adaptation has been allowed as reflex tearing can cause excessive lens movement and an inaccurate interpretation of lens fit.

Static fluorescein fit assessment with low-medium magnification and cobalt blue illumination

Assessment of the static fit allows the practitioner to interpret how the back surface of the lens aligns with the cornea; fluorescein dye is used to aid visualisation of the tear lens. The fluorescein strip should be moistened with saline before being applied to the superior temporal bulbar conjunctiva to facilitate effective mixing with the tear lens and maximize retention on the ocular surface.[11] Following application, the optimum time to observe the fluorescein pattern has been shown to be between 30 seconds and three minutes.[12] The fluorescein pattern should be observed using a slit lamp with a cobalt blue filter in combination with a Wratten filter to enhance the contrast. Although a Burton lamp can also be used, many modern RGP materials contain a UV blocker, which will hinder fluorescence.

The fluorescein pattern is best evaluated when the lens is centred, which may require manipulation of the eyelids. Failure to re-centre the lens can lead to misinterpretation of the fluorescein pattern. The level of fluorescence is a function of the thickness of the tear lens. Therefore, areas of touch or minimal clearance will appear dark whereas areas of excessive clearance, showing pooling of the tear lens, will appear very bright. By assessing the change in intensity of the fluorescein across the lens, the distance between the posterior lens surface and the cornea can therefore be interpreted. The practitioner should systematically assess the fluorescein pattern in three regions: centre, mid-periphery and periphery. The GP Consensus Group suggest that the fluorescein pattern should be recorded in these three regions along the two principle meridians.[11] The Group also suggests using a 5 point scale to record fluorescein intensity where +2 indicates dense pooling, 0 indicates alignment and -2 indicates corneal touch (Figure 3). Table 2 summarises the fitting characteristics for different lens fits. An example of a complete fit record is given in Figure 4 and Figure 5 shows the fluorescein pattern for three differently fitting lenses.

Fitting characteristic		RGP Lens Fit		
		Flat	Alignment	Steep
Dynamic Fit	Centration	Typically unstable, decentres inferiorly	Good centration in primary position and blinking With lids held apart, lens should slowly decentre inferiorly	Typically good centration in primary position
	Movement on blink	Excessive movement on blink	1-1.5mm smooth vertical movement on blink	Limited or no movement on blink
	Coverage	Lens edge may cross limbus on excursions	Lens edge shouldn't cross limbus on excursions	Lens edge typically doesn't cross limbus on excursions
Fluorescein Fit	Centre	Central touch	Apical clearance	Central pooling, sometimes trapped bubbles of air causing dimple veiling
	Mid periphery	Mid peripheral pooling	Slight mid peripheral touch/alignment	Excessive mid peripheral touch
	Periphery	Excessive edge clearance (>0.5mm)	Narrow band edge clearance (0.4-0.5mm)	Very narrow band edge clearance (<0.4mm)
	Borders	Boundary between central touch and mid peripheral pooling may be well defined	Boundary between centre and mid periphery reasonably undefined	Boundary between central pooling and mid peripheral touch may be well defined
	Dissipation of NaFl	NaFl may dissipate quite quickly due to excessive tearing from uncomfortable lens	NaFl dissipates very quickly due to optimum tear exchange	NaFl remains trapped under lens for considerable time due to poor tear exchange
Comfort		Poor comfort due to excessive movement, adaptation severely compromised	Reasonable initial comfort, continually improves during adaptation	Typically fairly good comfort initially due to limited lens movement
Vision		Inconsistent vision, due to excessive movement on blink	Clear and stable	Typically fairly clear and stable
Over-refraction		Negative tear lens formed; plus over refraction	None/minimal over-refraction expected if correct power selected initially	Positive tear lens formed; negative over refraction
Amendment		Steepen lens by reducing BOZR or increasing TD	No amendments needed	Flatten lens by increasing BOZR or reducing TD

Table 2. Fitting characteristics of different RGP contact lens fits

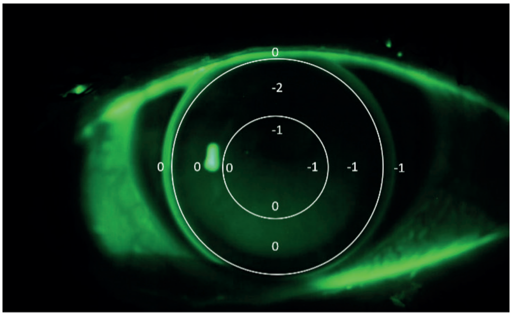
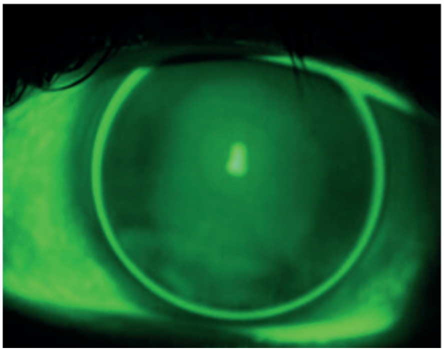
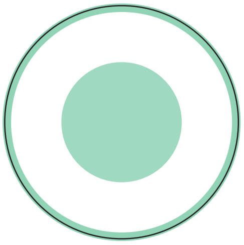


Figure. 3. Fluorescein picture with overlaid central, mid-peripheral and edge zones, graded for fluorescein intensity on a +2 to −2 scale along the principal meridians according to the GP Consensus Group.[11] On this scale +2 refers to areas of pooling where the fit is too steep, 0 is alignment and -2 refers to areas of touch where the fit is too flat.





No7, Quasar, 7.70/9.60/-2.00

Settling time: 20 mins

Centration: C

Movement on blink: -1

Coverage: Full in all positions of gaze

Comfort: 3/5

Fluorescein Fit; C M E
V: +1 -1 0
H: +1 -1 0

Figure 4. An example fit record for a steep fit, shown in the slit lamp photograph. The fit record shows a drawing of the fluorescein fit, along with written notes, as described by the RGP Consensus group report.[11]

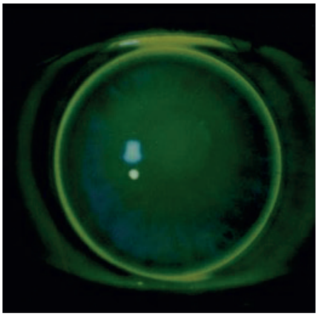
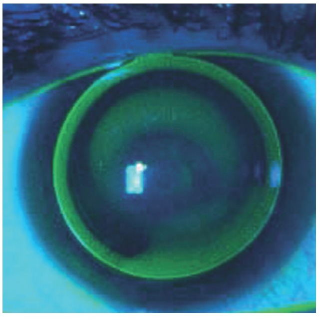
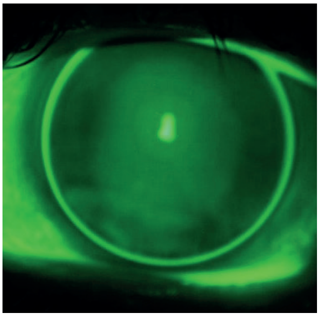
a.  b.  c. 

Figure 5 Fluorescein patterns for alignment (a), flat (b) and steep (c) fitting lenses (Images a and b courtesy of Bill Harvey)

Vision assessment & over-refraction

A spherical over-refraction is essential to determine if a change in the final lens power is necessary. For an alignment fit the visual acuity should be crisp and stable with a precise endpoint of refraction.

If a stable result cannot be obtained with spherical lenses, a cylindrical over-refraction should be attempted. A stable result indicates that residual (lenticular) astigmatism exists and that a toric lens may be required. For a lens that is fitted in alignment with the cornea the final lens power can be easily calculated as follows:

BVP = power of trial RGP lens + over-refraction

For example, the following lens is fitted (8.0/9.6/-3.00; this indicates the BOZR is 8.0, the TD is 9.6 and the BVP is -3.00) and an alignment fit is recorded with a +0.50DS over-refraction needed to optimize the visual acuity. Therefore, the final lens specification will be 8.0/9.6/-2.50.

BVP = -3.00 + 0.50

BVP = -2.50

However, if the lens is not fitting on alignment, the tear lens will induce unwanted power (Figure 6). If the lens is fitting steep, a positive tear lens will result, and a negative over-refraction will be required. If the lens is fitting flat, a negative tear lens will result, and a positive over-refraction will be required. Determining the power of the tear lens can also be useful to confirm the lens fit. As a general guide, the tear lens induces +0.25D for every 0.05mm that the BOZR of the lens is steeper than the corneal radius. Conversely, the tear lens induces -0.25D for every 0.05mm that the BOZR of the lens is flatter than the corneal radius. Therefore, considering a lens that is not fitted in alignment with the cornea the final lens power should be easily calculated as follows:

BVP = power of trial RGP lens + over-refraction + tear lens power

For example, the following lens is fitted (7.9/9.6/-3.00) and is determined to be 0.1mm too steep based on the fluorescein pattern, with a -0.50DS over-refraction needed to optimize the visual acuity. The steep lens induces a positive tear lens with a power of +0.50DS causing a negative over-refraction to compensate. The lens needs to be flattened by 0.1mm to correct the fit. Therefore, the final lens specification will be 8.0/9.6/-3.00.

BVP = -3.00 + 0.50 + -0.50

BVP = -3.00

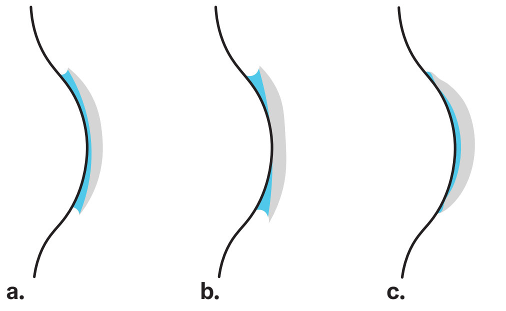


Figure 6 Tear lens profiles for an aligned fit (a) that does not induce unwanted power, a flat fit (b) that forms a negative tear lens and a steep fit (c) that forms a positive tear lens.

Interdependency of fitting variables

Every variable in RGP lens design has an inter-dependency on other variables. If there is a need to change one parameter on the lens, such as BOZD, then, if the same fitting relationship is to be maintained, the BOZR also must be altered to maintain the same sagittal height. The basic rules of thumb in making alterations to lens parameters to maintain equivalency are outlined below.

- An increase in BOZD/TD of 0.5mm will require a flattening of the BOZR by 0.05mm
- A decrease in BOZD/TD of 0.5mm will require a steepening of the BOZR by 0.05mm

Troubleshooting

Modern “system” lenses are designed to fit the majority of patients. Undesirable patient symptoms or fitting characteristics can often be managed by modifying certain lens parameters, which are summarized in Table 3 with a suggested remedy. Discomfort that persists past the initial adaptation period is typically associated with poor lens fit, excessive corneal astigmatism or even a trapped foreign body. Whilst unstable vision is likely to be caused by a flat fitting lens, poor vision may be the result of incorrect lens power, residual astigmatism or even lens flexure. Decentration in any direction is typically an indication the lens is too flat. However, it may also be caused by corneal astigmatism; with-the-rule astigmatism typically causes vertical decentration whereas against-the-rule can cause lateral decentration. It is worth noting that most RGP lens manufacturer’s provide invaluable technical support and can provide comprehensive advice when troubleshooting.

Toric RGP fitting

Toric RGP contact lenses are indicated if an adequate fit cannot be obtained with a spherical lens. Furthermore, a toric lens may be necessary to improve patient comfort or the quality of vision if there is a significant amount of residual (lenticular) astigmatism (typically >0.75 to 1.00DC). Table 4 shows examples to demonstrate how the site of astigmatism affects the contact lens choice. A toric lens may be

Complaint	Possible cause	Management
Poor comfort	Excess movement	Tighten fit
	Excess edge clearance	Reduce edge clearance
	Edge too thick	Thinner edge
	Foreign body	Remove and replace lens
	Damaged lens edge	Replace lens
	Astigmatic cornea	Refit with toric lens
	Patient sensitivity	Increase TD
	Poor wetting	Change material
Poor vision	Refractive change	Refract and change power
	Corneal shape change	Assess fit and modify
	Residual astigmatism	Refit with toric lens
	Flexure	Refit with aspheric or toric lens
	Deposits	Clean lens, change material
	Heavy surface scratches	Replace lens
	Poor wetting	Remove and clean lens, replace if old, change material
Lens centering high, not dropping after blink	Excessive TD	Reduce TD
	Lens too thick	Reduce thickness
	With-the-rule astigmatism	Modify fit, consider aspheric or toric design
Lens decentering inferiorly	Lens too flat	Steepen fit
	Inadequate TD	Increase TD
	Lens too thick	Reduce thickness
Lens decentering laterally	Lens too flat	Steepen fit
	Inadequate TD	Increase TD
	Against the rule astigmatism	Modify fit, consider aspheric or toric design
Lens is stationary	Lens too steep	Flatten fit

Table 3 Causes and management of common undesirable patient symptoms or fitting characteristics

necessary to improve lens centration as lenses can decentre vertically in with-the-rule astigmatism and laterally in against-the-rule astigmatism. Furthermore, long-term issues with lens flexure or corneal molding can also occur. When fitting a toric cornea with a spherical lens the area of alignment is reduced. As the magnitude of corneal astigmatism increases, the area of alignment along the steeper corneal meridian reduces causing increased edge clearance and lid interaction. This can be visualized as a characteristic “dumbbell” shaped fluorescein pattern (Figure 7a). To aid interpretation of a spherical fit on a toric cornea, the practitioner should consider the fluorescein pattern along each of the principle meridians. Reducing the TD can be used to minimize the edge clearance in the steeper meridian although this can lead to issues with lens centration and/or comfort. If the peripheral cornea is more toric than the centre, and the fit cannot be improved with reducing the TD then a peripheral toric lens design may be indicated. Alternatively, an aspheric lens design may offer an improved fit due to reduced levels of edge lift.

In cases of excessive corneal astigmatism, typically >2.50DC, it is often necessary to fit a back surface toric lens.

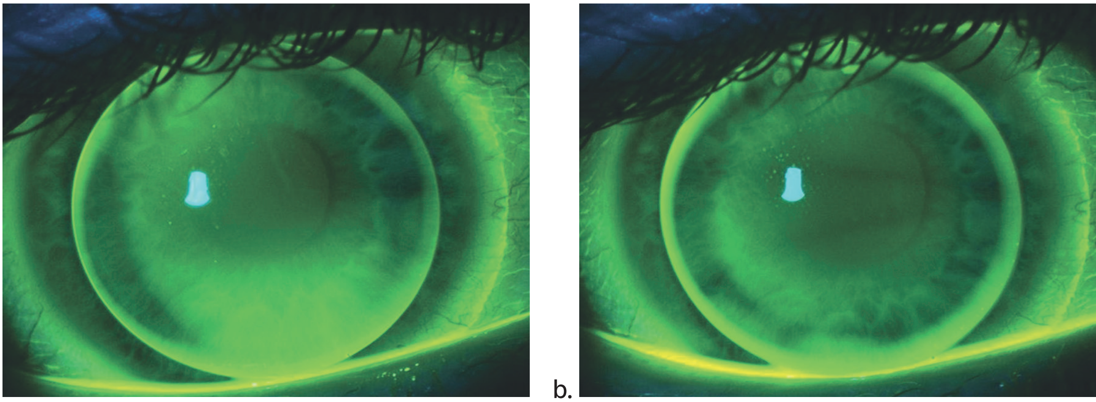
This allows the back surface of the lens radii to align with the principle meridians forming a spherical tear lens fluorescein pattern (Figure 7b). This results in more equal distribution of the lens over the toroidal cornea, improved centration and lens stability as well as subjective comfort. With a closely aligned fit, lens rotation is minimal so the incorporation of additional prism stabilisation is not required. A back surface toric lens is also beneficial in cases where the cornea is toric but ocular refraction is spherical. The formation of a spherical tear lens ensures that the compensation of the corneal astigmatism by the lenticular astigmatism is not interrupted. Most lens designs are bitorics, where a compensating toric is added to the front surface. In patients where residual (lenticular) astigmatism limits the quality of vision, a front surface toric is necessary. Due to the spherical back surface of the lens, stabilisation is required; typically a prism ballast is utilised. Whilst toric fitting sets are available, empirical fitting is more practical and is likely to reduce chair time. Baseline measurements, including the spectacle prescription, BVD and K readings should be supplied to the lens manufacturer.

Ocular refraction	K - Reading (mm)	Corneal astigmatism (DC)	Residual (lenticular) astigmatism (DC)	Site of Astigmatism	CL Options
-3.00DS	8.00@180/8.00@90	0.00	0.00	None	Spherical RGP, spherical soft
-3.00DS/ -1.50DCx180	8.00@180/7.70@90	-1.50	0.00	Corneal	Spherical RGP, soft toric
-3.00DS/ -1.50DCx180	8.00@180/8.00@90	0.00	-1.50	Lenticular	Front surface toric RGP, soft toric
-3.00DS	8.00@180/7.70@90	-1.50	+1.50	Mixed	Back surface toric, spherical soft
-3.00DS/ -2.00DCx180	8.00@180/7.80@90	-1.00	-1.00	Mixed	Bi-toric or front surface toric RGP, soft toric
-3.00DS/ -3.00DCx180	8.00@180/7.40@90	-3.00	0.00	Corneal	Bi-toric RGP, soft toric

Table 4 Examples to show how the site of astigmatism affects the contact lens choice. (Note that the residual astigmatism is calculated as the difference between the ocular astigmatism and the corneal astigmatism.)

Scleral, mini-scleral and hybrid lenses

Hybrid lenses consist of a central rigid lens, bonded to a peripheral hydrogel or silicone hydrogel skirt with the aim of providing the visual performance of an RGP with the stability and comfort of a soft lens. Whilst the initial hybrid lenses, introduced over 30 years ago, had issues with durability and fitting, modern designs benefit from superior manufacturing techniques and bonding technology. Scleral contact lenses are large diameter RGP lenses. The Scleral Lens Education Society specify mini-sclerals as lenses up to 6mm larger than the HVID and large-sclerals as lenses greater than 6mm larger than the HVID.[13] The lens rests entirely on the sclera, allowing the cornea



a. b.

Figure 7. (a) Spherical RGP lens on a cornea with 3.00D with-the-rule astigmatism (steeper vertically). Note increased pooling and a wider band of edge clearance across the vertical meridian compared to the horizontal meridian. (b) Back surface toric contact lens on the same eye. Note the relatively consistent 360 degree edge lift and light fluorescence over the centre, indicating an alignment fit. (Images courtesy of David Ruston)

to be vaulted. Whilst scleral lenses are therefore ideal for irregular corneas, they are also used to correct ametropia and for the management of ocular surface disease. The popularity of these "specialist lenses" is growing due to developments in high Dk lens materials, designs and advanced manufacturing processes. Advances in ocular imaging technology, such as corneal topography and anterior segment optical coherence tomography (OCT) have also aided fitting. Mini-sclerals in particular have gained popularity as they are often thinner than large-sclerals, typically require less corneal clearance and can be easier to fit by avoiding the asymmetry of the more peripheral sclera.[13] In a cross-over study to assess the objective and subjective performance of mini-scleral lenses in astigmatic participants, 75% preferred the vision with the mini-scleral lens compared to a soft toric.[14] Furthermore, there were no significant differences in wearing time and subjective comfort between the two lens types.

Conclusions

Practitioners should keep an open mind to the merits of RGP lenses. It is important to counsel prospective RGP wearers about the benefits of RGPs but also give realistic advice about the fitting and adaptation process. A systematic approach to lens selection and fitting is important and support from technical services, where necessary, is crucial for success.

Key Points

- RGP lenses can be a practical option for many patients, particularly those with more complex prescription requirements.
- If indicated for a new patient, always fit an RGP first – it is easier to move from RGP lenses to soft than vice versa.
- Use of an anaesthetic during the initial fitting can aid fit assessment by reducing reflex tearing.
- Reflex tearing can be reduced, and comfort increased by asking the patient to adopt a downward gaze whilst the lens is settling.
- If making a change to the TD/ BOZD, be sure to compensate for the change by adjusting the BOZR appropriately.

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J&J Institute

Managing the Presbyope

Author: Dr Louise Madden

Presbyopia is a global problem affecting over 1.8 billion people worldwide[1] and in the UK, around 42% of the population is presbyopic (>45 years of age).[2]

Traditionally perceived as challenging, contact lens fitting of presbyopic patients has steadily risen over the past 15 years from 20% to 35% of all fits, with multifocal contact lenses now prescribed to presbyopes around 40% of the time.[3] This may be due, in part, to the visual demands of emerging presbyopes including increasingly active lifestyles, desire for continuation of successful contact lens wear, or cosmesis.[4] Advances in optical designs, daily disposability and enhanced materials have improved the visual and physiological outcomes making contact lenses an integral choice of vision correction for these patients.

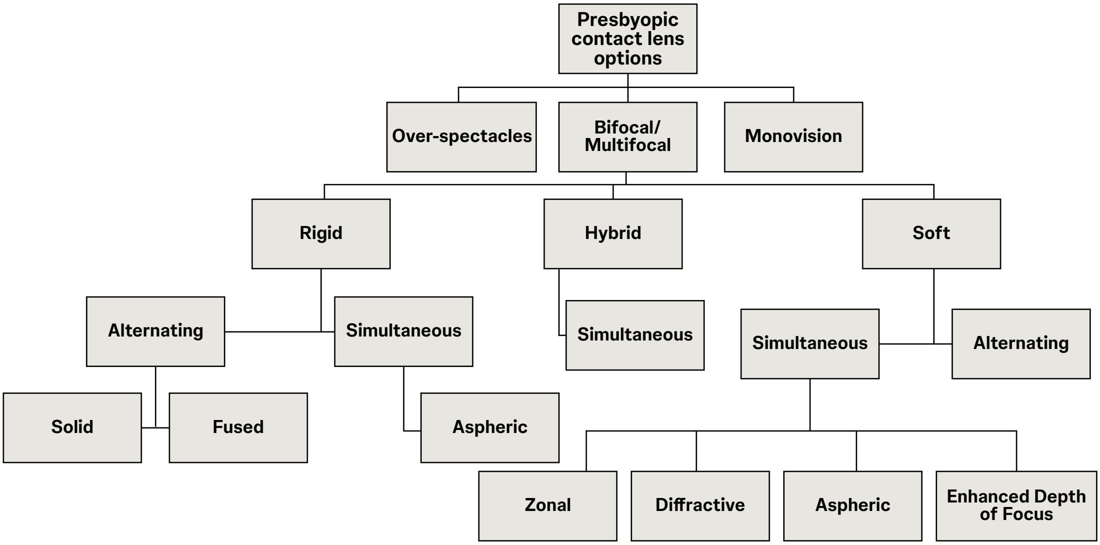

Figure 1. Presbyopic contact lens options

Currently, there are three general approaches for correcting the presbyopic patient with contact lenses: single-vision with over-spectacles, monovision, and multifocals (Figure 1). Each option has advantages and disadvantages with the success dependent upon the lens type and design, the fitting approach used and the degree of presbyopia. Whilst all options will be presented here, this article will focus on the most common correction options used; monovision and simultaneous.

Patient Selection and Expectations

Consideration should be given to patient selection prior to fitting contact lenses for presbyopia (Table 1). Motivation plays a major factor in contact lens fitting and the practitioner should ensure their patient is aware of the advantages and disadvantages of all options prior to fitting. Expectations should be set using positive language, reinforcing the benefits of contact lens correction, i.e. spectacle free vision, vision in all directions of gaze, no peripheral distortion, whilst acknowledging the limitations compared to spectacle correction. Thought should also be given to the binocular status of the patient, as compromised binocular vision will impact outcome. High and low-contrast VA charts (Figure 2) give more information about acuity, and the difference in low-contrast acuity between spectacles and contact lenses gives some indication of possible success. As well as the VA charts, the practitioner should have access to other near tasks, such as mobile phone, laptop etc. to mimic ‘real-life’. It is generally accepted that patients’ expectations should be realistically managed during visual assessment, in our experience the aim is to meet around 80% of a patient’s visual needs.

	Monovision	Simultaneous	Alternating
Good candidates	Significant refractive error or astigmatic	Existing soft contact lens wearers who are emerging presbyopes	Early & advanced RGP wearing presbyopes
	Reading positions other than standard downward gaze	Reading positions other than standard downward gaze	Lower lid above, in line with or no more than 1mm below the limbus
	Motivated and realistic expectations	Moderate intermediate vision requirements	Myopic or low hypermetropic powers
	Displaced corneal apex	Spherical or near spherical refractive errors	Normal to large palpebral apertures
			Normal to tight lid tension
More challenging candidates	Emmetropes, previously uncorrected hyperope, low myopes	Will not accept any compromise to distance vision	High hyperopes
	Concentrated specific visual needs	Emmetropic or near emmetropic distance Rx	Small palpebral apertures
	High visual demands and expectations	Astigmatic	Loose lower lids
	High adds	Small pupil size (<3mm)	
	Amblyopes		

Table 1. Patient selection for presbyopic contact lens correction. (Modified from Bennet 2018)[4]

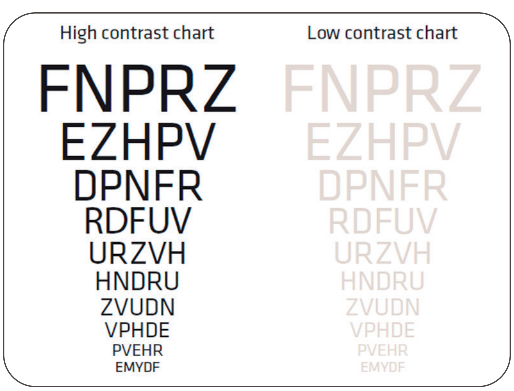

Figure 2. High and low contrast visual acuity chart

Initial measurements

Ocular Dominance

It is important to establish ocular dominance in order to determine which eye to correct for distance vision when fitting monovision and for adjustments when fitting a simultaneous lens design. Dominance can be assessed using either sensory or sighting (motor) dominance, with the former being the recommended method by most manufacturers. Sensory dominance is assessed by placing the best binocular distance refraction in the trial frame and, while the patient observes the lowest line they can read on a distance chart, a +1.00D is placed alternatively in front of each eye, with the patient indicating when the vision is clearest. If the +1.00D lens is in front of the left eye when the image is reported as clearest then the right eye is considered as distance dominant and *vice versa*. Should a patient be unable to spot a difference between the two, the test should be repeated using a +0.75DS lens.

Lighting

Lighting plays an important role in assessing vision for the presbyope. Ideally, the consulting room should have a wide range of lighting possibilities. These should range from bright, direct illumination on targets to maximise the chances of a patient first seeing the in-focus image, through to the ability to decrease the level of illumination so visual performance at, or near, darkness can be assessed.

Ocular Health

As with any contact lens fitting, careful examination of the anterior eye should be conducted prior to fitting. The prevalence of clinically diagnosed dry eye and meibomian gland dysfunction increases with age.[5] This should be noted and considered when deciding on the most appropriate lens material for each patient in order to maximise comfort. For further information on soft contact lens material properties see chapter 6.

Pupil Size

Thought should also be given to factors that affect pupil size, due to the impact pupil size could have particularly when fitting some multifocal lens designs.

> Whilst it is well acknowledged that pupil size decreases with age, reduced working distance and increased light intensity, it is perhaps less well acknowledged that pupil size also varies with refractive error.

Research shows that myopes tend to have larger pupils than hypermetropes, particularly in mesopic conditions.[6,7] Though most multifocal contact lens designs account for the change in pupil size with age by varying the optical design with increasing add, to date only one also takes into account pupil changes with refractive error,[8] optimising optics across 183 different designs (Figure 3).[8]

Overview of correction options

Over-Spectacles

The simplest method of correcting the

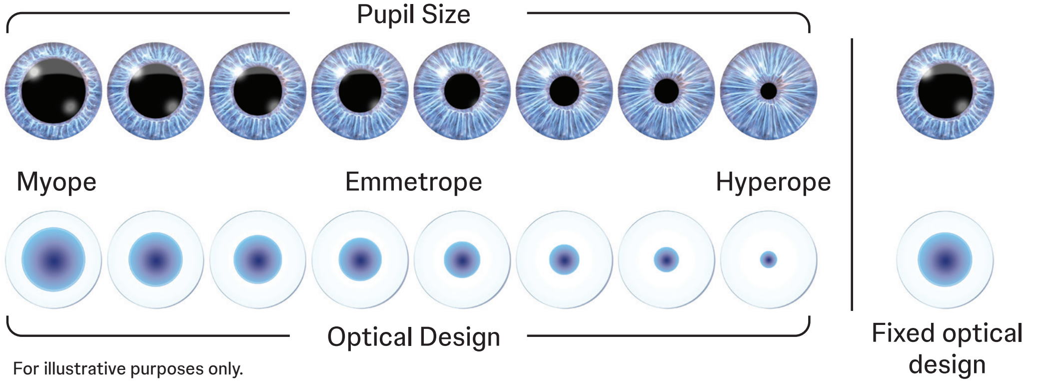

Figure 3. Illustration showing how pupil size varies with refractive error and how the optical design of one simultaneous vision multifocal has been optimised to take this variation into account

contact lens-wearing presbyope is with a pair of reading spectacles worn over the distance contact lens correction. These may either be single vision, bi/trifocal, or progressive lenses depending on the needs of the individual.[9]

There are obvious advantages to this method in that the contact lens correction requires no modifications, and improvements in progressive lens technologies make this option more visually acceptable for patients.[10] However, there are still fundamental limitations such as inadequate intermediate vision correction, appearance, gaze dependence and general inconvenience. For a longstanding contact lens wearer, or a previous emmetrope, this option is likely to be poorly accepted due to the inconvenience of glasses wear.

Despite these disadvantages, the use of over-spectacles is still one of the most popular methods of presbyopic correction with research reporting approximately 50% of all presbyopes fitted with soft contact lenses, receive a distance-only correction.[3]

Monovision

Another common method of correcting the contact lens-wearing presbyope is monovision, which accounts for 10-15% of the total lenses prescribed for presbyopia.[3] Here, an unbalanced correction between the two eyes is utilised, with one eye corrected for 'distance' (usually the dominant eye) and one for 'near'.[11] This approach works on the principle that the visual system can alternate central suppression between the two eyes, thus enabling the object of interest to be seen clearly.

Monovision tends to work more successfully in younger presbyopes with residual accommodation and where a lower add value is used.[10] The optimum near addition for monovision has been reported to be around +1.50D, with lower or higher levels having a negative impact on vision.[12] The main benefits of monovision include ease of fitting, relative low cost and flexibility, allowing the practitioner to choose the most suitable lens material and design for the patient.

One of the main disadvantages of monovision is the disturbance to stereopsis. For patients who have either little tolerance for visual disruption or who are engaged in detailed visual tasks, this may prove too great. A recent study published by Fernandes et al.[13] reviewed the objective and subjective results for vision corrected by both multifocals and monovision and concluded that stereoacuity was significantly better in multifocal contact lens patients compared to those wearing monovision. Reduction in contrast sensitivity[14] and glare when driving at night[15] are also noted disadvantages of monovision.

For patients with high near vision demands across all illuminations, monovision may be a good option. Whereas, when critical or sustained tasks requiring good binocularity predominate, it is advisable to avoid monovision or to consider supplementary correction.

Principles of Monovision fitting

Physical fit

This should be the same as the fit required for any other spherical or toric soft, or RGP contact lens fit, as described in previous chapters.

Trial lens power selection

For most patients, a good starting point in selecting appropriate lens power is to fit the dominant eye with the distance correction and the non-dominant eye with the near correction. It is important to correct any astigmatism equal to or greater than 0.75D in either or both eyes which, if left uncorrected, can result in reduced visual performance, asthenopia and poor tolerance.

Visual assessment

Under binocular viewing, looking at a high-contrast, well-illuminated distance chart, the patient should be asked to read as far down the chart as possible without comment on visual quality. This should then be repeated for near type. If the patient is unable to read the distance or near type, the practitioner should not occlude either eye. Instead, the ‘non-viewing eye’ should be progressively blurred with spherical lenses until the image comes into view. When the distance or near type is seen clearly, the amount of blur should be progressively reduced while asking the patient to continue to read. Once the full extent of the blur has been removed, the patient should be asked to view a distant object (if it was the near test that was causing problems before) and then return to reading. This technique will demonstrate the ability of the patient to suppress the ‘non-viewing’ eye. Once the ability to suppress has been demonstrated, the practitioner should optimise the refraction, again binocularly, to check that the optimum correction for distance and near has been achieved.

After static visual acuity has been assessed, the patient should be encouraged to walk around the practice wearing the full monovision correction and dynamic vision assessed. Dynamic visual assessment should start with an appreciation of the effect of suppression on peripheral acuity before allowing the patient to carry out other tasks, such as judging distance. These assessments are important, both clinically and ethically, in showing the patient the advantages and limitations of the correction. Ideally, an extended trial period is preferred in monovision correction so that the patient can fully assess the benefits of the correction. Before this occurs, the onus is on the practitioner to explain fully the type of correction fitted and to make sure the patient understands that the adaptation period may involve problems in close work and a 'learning curve' in driving, especially at night.

When fitting monovision, and indeed all presbyopic contact lens corrections, the practitioner has an obligation to inform patients of the adaptation that may be required.

If a patient is unable to adapt to any visual disturbance caused by monovision in specific situations, a practitioner may consider prescribing a spectacle over-refraction.

Partial monovision

The acceptance and therefore the success of monovision reduces as the reading add increases.[16,17] As the spectacle add exceeds +2.00D, tolerance can often be improved if a reduced reading addition is given in the contact lens prescription. This method is called partial monovision. This is advantageous for social users whose near vision demands will be lower than full-time wearers and for those with greater intermediate vision needs. However, patients may need supplementary glasses for certain near tasks or indeed additional glasses for driving.

Enhanced monovision

Enhanced monovision involves fitting one eye with a multifocal lens and the other with a single-vision lens. Most commonly, the dominant eye is fitted with a single-vision distance lens and the non-dominant eye with a multifocal lens, though other options are available. This improves binocular summation and offers some level of stereo-acuity to the wearer that is experiencing increasing blur with a higher reading add. Alternatively, the same approach can be used when fitting patients that require sharper distance vision than bilateral simultaneous vision multifocals can offer. In this scenario, the multifocal lens in the non-dominant eye may require more bias for near vision. This modification can be achieved by increasing the distance power of the multifocal lens by +0.50D to +0.75D.

Modified monovision

One way to alleviate visual problems associated with monovision is to employ a modified approach. This involves adjusting the lens power or utilising different lens designs in each eye to improve the distance vision in one eye at the expense of the near vision and vice versa. This can be done in several ways such as minimising plus on the dominant eye to enhance distance vision, while 'pushing' plus in the non-dominant eye, or to utilise different add powers in each eye with the lower add power being fitted to the dominant eye to maximise distance vision. Another option would be to fit a centre-distance simultaneous design lens in one eye and a centre-near design in the other. Some recent lens designs use this modified monovision approach automatically when fitting presbyopic patients. The advantage of this method is that binocular summation will still occur, providing acceptable vision at all distances under binocular conditions.

Multifocal

Use of multifocal contact lenses is growing in popularity due to advancements in materials and lens design. In the most recent international survey, Morgan et al.[3] reported the continued increase in multifocal prescribing from approximately 25% of lenses fitted to presbyopes in 2005 to around 40% in 2019, indicating a preference for multifocal lenses over monovision which are fitted only 10-15% of the time.

There are a vast array of multifocal lens designs available in both rigid and soft materials, offering spherical and toric optics with designs typically using either the simultaneous vision- or alternating-image principle. In contact lenses which utilise the simultaneous-image principle, distance and near images are simultaneously presented to the retina through a stable lens, with the visual system 'selecting' the clearer image. Conversely, alternating-image lenses rely upon lens displacement on the eye to correctly position the appropriate portion of the lens over the pupil.

Simultaneous Vision Designs

In simultaneous vision contact lens systems, the basic principle of the system remains the same irrespective of whether the power varies in a discrete or progressive manner across the surface. A wide variety of simultaneous lens designs are now available, with the introduction of daily disposable aspheric soft contact lenses resulting in increased prescribing of this form of lens correction in recent years.[18]

Bi-concentric

Early simultaneous vision designs had discrete zones of distance and near power (Figure 4). A centre-distance design has a central portion for distance vision surrounded by a near vision periphery. Conversely, a centre-near design has a central portion for near surrounded by a distance vision periphery. The main disadvantage of these lenses is their dependency on pupil size. These bi-concentric designs are still available from some RGP manufacturers, although are rarely used due to the availability of more advanced, easier to fit designs, and single-use disposable lenses.

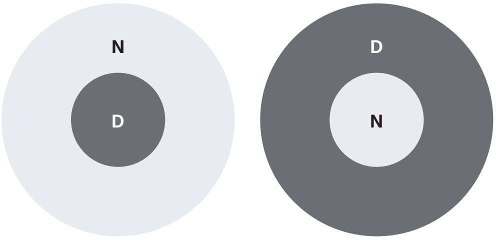

Figure 4. Bi-concentric simultaneous vision contact lenses. Centre-distance, left; centre-near, right.

Diffractive bifocals

Diffractive bifocal lenses utilised refraction and diffraction and worked on the principle of placing a 'phase plate' on the rear surface of the lens, which split the light passing through into two discrete focal points, one for distance and the other for near vision (Figure 5). Unlike bi-concentric designs, diffractive bifocal lenses were largely independent of pupil size, although were sensitive to lens centration. The main limitation with diffractive bifocals is the loss of around 20% of incident light to higher orders of diffraction,[19] resulting in a reduction in low contrast visual acuity.[20] This design was available in both soft and rigid materials, but neither product is currently available.

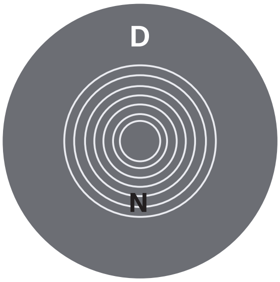

Figure 5. Diffractive bifocal lens design

Multi-zone

An approach to minimise the impact of pupil size on vision, especially in relation to different lighting conditions, was to increase the number of concentric zones alternatively powered for distance and near vision. This concept resulted in a centre-distance multi-zone design consisting of five alternating distance and near powered zones (Figure 6).[21] The width and spacing of the zones are based on the variation of pupil size in different illuminations within the presbyopic population. Theoretically, the lens design favours distance vision in extreme high and low lighting conditions and provides a more equal ratio of light division in ambient illumination conditions.[8]

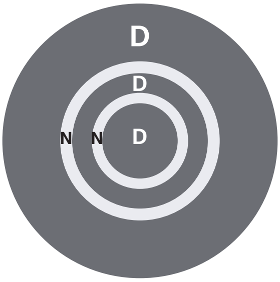

Figure 6. Multi-zone concentric centre-distance design

Aspheric

Most modern simultaneous vision designs utilise aspheric optics to achieve a gradual change in the power distribution across the lens and have hence been described as multifocal or progressive lenses.

Aspheric lenses can be subdivided according to whether the power changes from distance to near (most minus, least plus centrally) resulting in a centre-distance design or from near to distance (most plus, least minus centrally) resulting in a centre-near design (Figure 7). Both options are available in a range of materials, although the most prevalent design in current soft multifocal contact lenses is centre-near front surface aspheric.

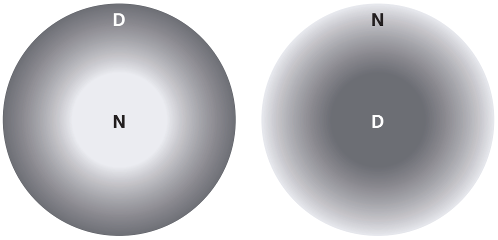

Figure 7. Left: Front surface centre-near design. Right: back surface centre-distance design. White denotes the near prescription, whilst dark grey represents distance prescription. The gradient illustrates the gradual change in power from one zone to the next.

Centre-distance

A centre-distance lens usually has a back surface aspheric curve resulting in the central portion of its optical zone correcting distance vision, surrounded by an area containing the power required for near work. This is achieved by the aspheric curve inducing positive spherical aberration. Rays of light from a distant object are focused by the central zone on the retina and compete with the out-of-focus rays being formed by the surround (Figure 8). When viewing a near object, the reverse occurs, where the light rays from the peripheral zone come into focus. At each moment the visual system picks out the clearer of the two images.

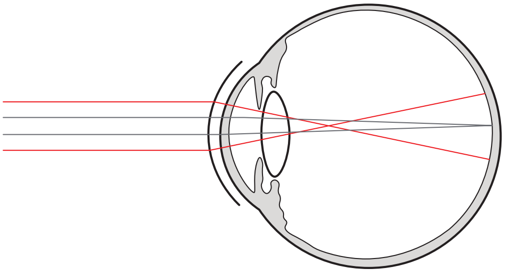

Figure 8. Principle of a simultaneous vision centre-distance design, where the grey rays illustrate light passing through the distance portion of the lens and the red rays illustrate rays passing through the near portion of the lens

The greater the eccentricity (or rate of flattening) of the back surface aspheric curve, the higher the reading power in relation to distance power. However, the higher the reading addition, the more likely that distance vision will be adversely affected, especially in low contrast and/or low light conditions where the pupil is larger. A fundamental concern of this design is its dependency on the pupil size. The near pupil reactions mean that as a near object is brought into view, proportionally less of the pupil allows light in from the near zone of the lens.

Centre-near

Centre-near designs were introduced to address the problem of pupil constriction for close work. The optical principle is the same as for the centre-distance lens, although reversed, so this time it is the central portion of the lens that provides the near correction, with the surround providing the required distance power (Figure 9). This is achieved by utilising a front surface aspheric design which generates negative spherical aberration from the centre of the lens.

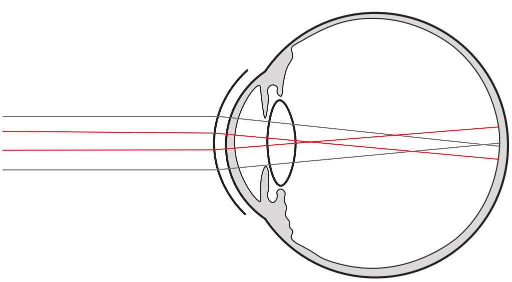

Figure 9. Principle of a simultaneous vision centre-near design where the red rays illustrate light passing through the near portion of the lens and the grey rays illustrate rays passing through the distance portion of the lens

It would be expected that the visual performance achieved would depend upon the interaction of the optical characteristics of the lens design with the natural aberrations of the eyes of the wearer. Consequently, variations in ocular aberration between individuals may explain in part why lenses of this type meet the needs of some wearers but not others.[22] The power distributions of centre-near lenses are seen to vary from one lens to another, therefore, it is often worth attempting a different lens to see if performance can be improved if vision is unsatisfactory with the first design.

With improving levels of optical performance and patient satisfaction, centre-near lens designs now dominate much of the soft multifocal contact lens market and have contributed to the recent growth in presbyopic contact lens correction.[3]

Principles of Simultaneous vision lens fitting

Physical fit

Simultaneous image lenses, particularly aspheric designs, should be fitted with good centration and minimal movement. It is critical that the lens is well centred over the visual axis to enable the correct portion of light to pass through each part of the lens. As the lens decentres away from the optical axis, aberrations increase, to the detriment of vision. Slit lamp assessment of centration is not sufficient to determine centration with regards to the pupil. A simple method to assess whether higher order aberrations are impacting vision involves directing the patient to observe a spot of light under dim illumination and to describe the shape of the light. Should they describe the light as having a 'streak' or 'tail' this is indicative of induced coma. Alternatively, if a topographer is available, corneal elevation maps can be used to help determine centration.

Trial lens power selection and visual assessment

Initial lens power will vary, with manufacturers recommending different strategies for different designs, as such the corresponding fitting guide should be followed. A good starting point for any fitting is an up to date refraction, measured best vision sphere and an add that delivers adequate functional vision. Most designs are sensitive to 0.25D adjustments to the distance lens power which can have a profound effect on distance or near visual performance. Pushing the highest plus acceptable for distance, and the least plus for near, helps avoid excess accommodation (in patients that have residual accommodation) with an over-minused refraction. Over-refraction of multifocal contact lenses is not often recommended due to the complex optics employed. Instead, adjustments should be made to the contact lens power according to the fitting guide.

Both static and dynamic visual assessment should be carried out as previously described. If a satisfactory distance and near correction cannot be achieved, many manufacturers recommend moving towards a 'modified monovision' technique, by over-correcting one eye and under-correcting the other.

Extended Depth of Focus

Recently, contact lenses referred to as 'extended depth of focus' (EDOF) have been introduced. This terminology is rather ambiguous, given aspheric lenses, by their very nature, aim to increase the depth of focus rather than creating separate, discrete foci. Whilst aspheric multifocal contact lenses are monotonic, with gradual changes in the power distribution, EDOF lenses tend to be non-monotonic, non-aspheric and contain aperiodic profiles. EDOF tend to utilise spherical aberration, along with additional multiple higher order spherical aberrations.[23] The optical design of EDOF lenses is expected to mitigate the impact of pupil size, contact lens decentration and individual ocular aberrations on the final visual outcome.[24] At the time of writing, there are limited studies which compare the visual performance achieved with traditional aspheric multifocals, versus EDOF. A study by Tilia et al. in 2016 reported improvements in intermediate and near vision with EDOF versus an aspheric design,[25] whilst a more recent study by Martinez-Alberquilla in 2021[26] found no such difference. Further research is required to determine if there are true differences between these two designs.

Alternating

The alternating bifocal was one of the first types of bifocal contact lenses to be produced, designed in a similar way to bifocal spectacle lenses. With alternating contact lenses, the patient looks through the distance portion of the optic zone in primary gaze, then on down gaze, the lens is held up against the lower eyelid, allowing the visual axis to be directed through the near portion (Figure 10). The advantage of this design is that visual quality will remain high if the visual axis is directed through the appropriate part of the lens. The disadvantage is that for this to occur, significant eyelid/lens interaction needs to occur, which can lead to decreased patient comfort through increased lens bulk and mobility as well as suffering with issues from lens rotation and stability. The majority of alternating designs are available as RGP lenses due to the requirement of the lens to move effectively on eye; however, soft options are available though not widely prescribed.

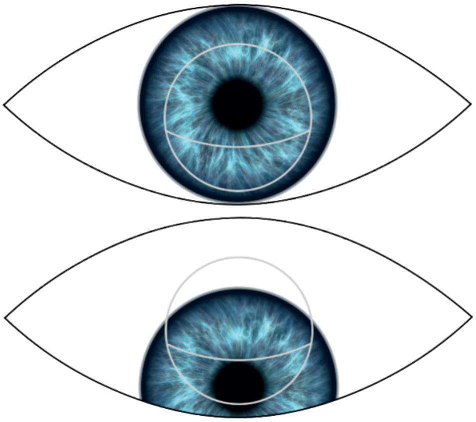

Figure 10. The principle of the translating bifocal contact lens

Principles of Alternating lens fitting

Physical fit

An alternating vision rigid bifocal must be fitted to allow translation between the distance and near zones to occur. The lens should, therefore, be mobile and supported by the lower eyelid. This is normally achieved by fitting on alignment or with minimal apical clearance. In primary gaze, the lower pupil margin should be in line with the top of the near segment (Figure 11). On near vision, the pupil should look through the near segment (Figure 12).

Trial lens power selection

Once the lens fit has been optimised, a normal binocular over-refraction should be carried out at both distance and near. The use of a trial frame and lenses is preferred to a phoropter as it allows a more natural head posture, which is critical in fitting this type of lens.

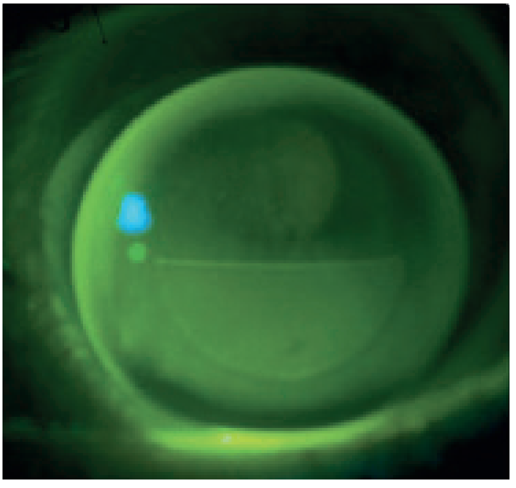

Figure 11. Alternating RGP lens fit showing segment position in primary position of gaze

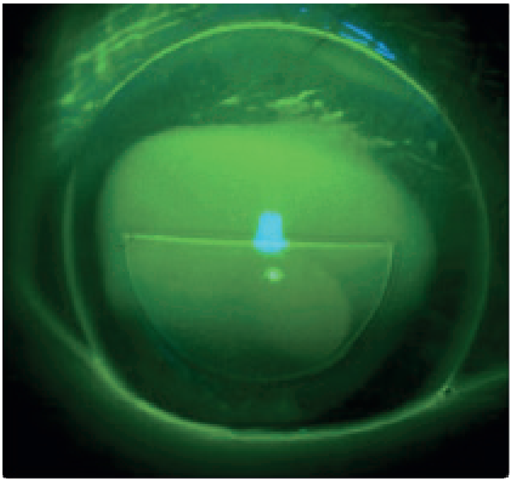

Figure 12. Alternating RGP lens fit showing near segment positioned over the pupil in downgaze due to successful translation

Conclusions

As the number of presbyopes rises, so too does the demand for contact lens correction for these individuals. Being aware of the different lens designs, fitting approaches and the associated advantages and disadvantages (Table 2),[27] along with the patient's personality, occupation and previous lens wearing history, helps in understanding which is the more appropriate starting point in meeting the patient's visual needs. With 70% of presbyopic patients stating poor vision as a reason for drop out,[28] every effort should be made to maximise the visual outcome.

There are now more lens options than ever to offer our presbyopic patients and the lack of the 'perfect' solution (spectacles included) for the presbyope shouldn't discourage practitioners from fitting this ever-increasing patient base. New simultaneous designs with improved optical performance are now quick and easy to fit, with a high fit success rate and good acceptance as the add increases. Daily disposable multifocal lenses offer patients greater levels of convenience and more flexibility for the part-time wearer. As no one lens design fits all, practitioners should be proficient in fitting two or three alternative lens designs so that a sound clinical approach can be developed and used with confidence, with the result that this form of fitting becomes an integral part of contact lens practice.

Advantages	Disadvantages
Simultaneous Vision	
Wide variety of lenses available in both RGP and soft designs	Some visual adaptation required
Vision in all directions of gaze	Some contrast sensitivity loss, particularly in low luminance
High success rate with modern designs	Optical performance can depend on pupil size
Stereopsis maintained	Lens centration critical to success
No rotational stability required	Limited availability of toric designs
Simpler to fit than alternating designs	
Typically more comfortable than alternating designs	
Monovision	
Simple fitting method	Significant reduction in stereopsis, particularly with increasing add
Wide range of lens designs and materials to choose from	Unsuitable for monocular patients or those with significant amblyopia
Can be less expensive than multifocal options	Some loss of contrast sensitivity
Patients quickly accept or reject the technique	Reduced intermediate correction as reading add increases
Can easily correct astigmatism	Reducing success rate as reading add increases
	Glare from headlights can be difficult to tolerate
	Reduced binocular summation
Alternating	
Distance and near acuity can be comparable to spectacles due to the dedicated segments	Fitting more complex
Minimal reduction in stereopsis	Vision gaze dependent
Minimal reduction in contrast	Intermediate correction not always an option
	Lid position and tension critical to success
	Comfort can be worse compared to simultaneous vision designs
	Only available as RGP

Table 2. Advantages and Disadvantages of Lens Fitting Options for Presbyopia Correction (Adapted from Efron[24])

Key points

- With an ageing population, the number of presbyopic patients in our practices is rising
- Advances in optical designs, daily disposability and enhanced materials has improved the visual and physiological outcomes making contact lenses an integral choice of vision correction for presbyopic patients.
- Have access to several different lens designs and be aware of alternative fitting approaches.
- Lens power adjustments should not be based on objective visual acuity alone and should look to find the optimal balance between near and distance vision to meet the patient's visual needs.
- Subjective visual performance assessment is most effectively achieved by experiencing lens wear in both the work and home environment.
- Follow the manufacturer's fitting guide in order to select the right lens and maximise success.

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The Contact Lens Teach

Author: Louise Munns

For all new contact lens wearers, the teach is an exciting part of their journey; the final step before independent lens wear at home. The fact that many eye care professionals delegate this part of the fitting is not due to lack of importance but more as a testament to the time required to ensure patients leave the practice feeling confident and motivated to wear their lenses. Done well, the teach appointment builds an important relationship between the practice and their contact lens wearers, instilling trust by offering professional advice and support.

Overcoming challenges faced by new wearers often requires motivation and persistence. Handling difficulties are the principle reason given by 1 in 4 new spherical lens wearers for dropping out of lens wear in the first year.[1] Therefore, appropriate and personalised support, both during and after the teach appointment is important. Understanding a patient's motivation for contact lens wear and recognising concerns and anxieties is essential to allow you to personalise the teach experience. Simple methods for continued support once patients leave the practice can then be employed to help reduce drop out in new wearers.

Are you sitting comfortably?

Practices need a designated private, clean area with a comfortable chair, wash basin and mirror for patients to learn how to apply and remove lenses (Figure 1). First ensure you have everything you need; contact lenses, case and solutions (if needed), lint-free tissues, support materials and alcohol wipes to clean between patients. A magnifying mirror can also be a great help to high hyperopes and presbyopes. While setting up you can discuss the home environment and possible options for a suitable clean space where they can apply and remove lenses. Pointing out that sitting at a desk or table, rather than standing looking into a mirror over a crowded sink next to the toilet in the bathroom can be helpful advice for a novice wearer.

Applying lenses

Before application or removal of lenses, the first step will always be to ask the patient to wash their hands with soap (preferably anti-bacterial liquid soap) and dry them on a lint-free towel (Figure 2). Whilst many patients understand that hand washing helps to reduce the risk of infection in contact lens wear, they may cut corners and not always comply with hand washing advice. A study by Morgan et al. in 2011 across 14 countries, found only around 40% of patients were correctly washing their hands before handling their lenses.[2] With studies showing an increased risk of contact lens associated infections in patients following inadequate hand-washing,[3,4] it is important to take time to discuss a proper hand washing routine at this stage before reinforcing it later in the appointment.

Preparing the lens

The patient can now learn to handle the lens (Figure 3). They may be concerned about damaging the lenses and this is a good time to discuss the importance of short fingernails for novice wearers. Reassurance can be given, if needed, that as they become more proficient many wearers manage to safely apply and remove lenses with longer nails. Comparing the size of the lens to their eye aperture can help the patient understand that they need to hold their eyelids wide apart to get the lens on the eye. At this point the patient should be advised to check that the lens is also clean, tear-free and safe to use (Figure 4).

Figure 1. A clean private space is essential to teach successfully

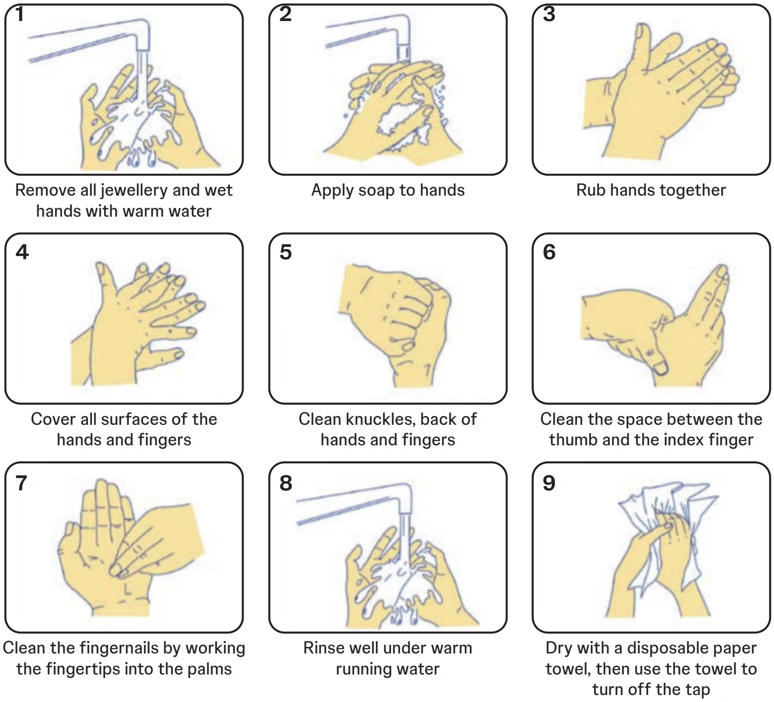

Figure 2. The first step for both application and removal is effective hand washing. (Image from the Johnson & Johnson Institute)

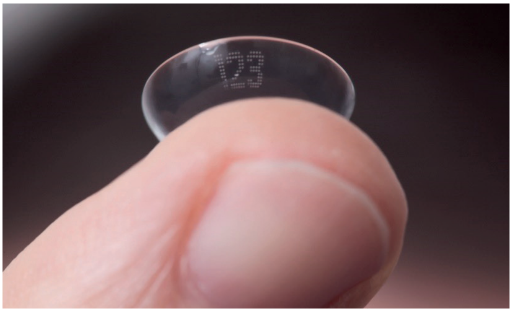

Figure 3. Check for short clean fingernails as you allow the patient to handle the lens. Inversion indicator '123' can be seen here, showing the lens is the correct way round.

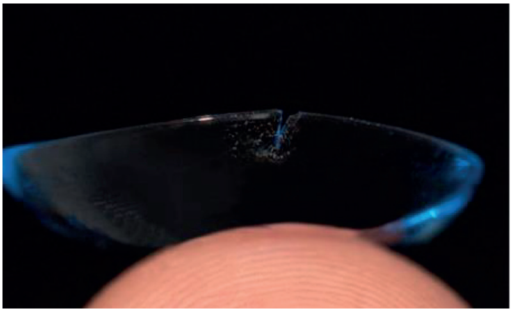

Figure 4. Before application, the lens should be inspected to ensure there is no dirt or debris on the lens and to check for tears, as shown here

Which way round?

Preparing and positioning the lens for application is a key concern for patients and clear instructions should be given. Ask the patient whether they would like to apply the right or left lens first and encourage them to stick to this as it helps to prevent lenses getting mixed up.

Remove the lens from the blister pack or storage case. After checking the finger is still dry, carefully position the lens on the pad of the finger. Hold the lens up to the light and check it is the correct way round; if the edges flare out, it's inside out (Figure 5). If it looks like a smooth-edged cup then it's the correct way round. Some lenses have indicators (Figure 3) to help identify the correct way round and knowledge of these for the lens fitted is helpful.

Apply gently and slowly

Both upper and lower lid should then be secured. This is an important step but often proves challenging for the patient. A flexible approach is needed to establish the best option for each patient. For their right eye, start by suggesting that the left hand is placed over their head using the fingertips to lift the upper lid. This may not work for left-handed patients so any approach which allows the patient to firmly hold the lids can be used. It is important the lid is grasped at the lid margin (Figure 6). Reminding them that they need to hold lids firmly to overcome the natural blink reflex helps. Consider asking them to try and blink while looking in the mirror can help them understand whether they are grasping the lid firmly enough as the upper lid should not move.

The lower lid should then be pulled down to open the eye wide. As a guide, the lids need to be held wide enough for them to observe the entire cornea (Figure 6). Lowering the chin slightly so they are looking up a little to the mirror can help widen the aperture. The patient can then be encouraged to slowly

Figure 5. Check the lens is the correct way round before application. Inside-out markers, if available, may help this process.

place the lens directly onto the cornea. The patient should be instructed to keep both eyes wide open throughout the application process, allowing the eye which is not having the lens applied to fixate and suppress the image of a finger coming towards the other eye. This can take a little time to master and a slow methodical approach is generally more successful. Patients often release the upper lid too soon and so are unable to successfully place the lens of the eye. This leads to frustration and may raise anxiety. Encouraging the patient to stop before application when the lids are not held correctly or if the lens is not in the correct place can help. Repeated attempts lead to anxiety and frustration; focus on a few slow quality attempts. Continue to talk to the patient and ask how they are feeling; remember patients may not recall what you have advised if they are feeling stressed. Positive feedback and encouragement, reminding them of their motivation for wearing contact lenses, is important at this stage.

Figure 6. Holding the lids correctly – An essential step for successful lens application and removal in a new wearer

Key Steps - Application

1. Wash and dry hands
2. Sit lens on the pad of the index finger
3. Look directly ahead into a mirror
4. Secure upper and lower lid ensuring eye is wide open
5. Gently place lens directly onto cornea
6. Once lens is in place slowly look right and left
7. Release lids and gently close eyee

Removing lenses

As with application of lenses the first step for removal will be to wash and dry hands. Then, with the patient looking into a mirror, explain that the lids now need to be secured in the same way they were for application. Reinforce that there are different ways to achieve this and suggest starting with the method that worked best for application. Once both upper and lower lids are secured the patient should be instructed to look up slightly.

Remove the lens gently and slowly

While looking up place the pad of the finger on the lens and slide the lens downwards until it is on the white of the eye. Gently squeeze the lens between the thumb and index finger to remove (Figure 7). If unsuccessful at the first attempt, it is often best to encourage the patient to release their lids, blink and slowly start the removal process again. Once safely off the eye the patient should check the lens to ensure the whole lens has been removed. For both application and removal instruction, it can be useful to direct the patient to watch videos of other patients going through the process, some examples are available at www.acuvue.co.uk. If a patient continues to struggle with applying or removing their lenses, then you may want to reconsider their lens type. Some lenses can be a little easier to handle than others. Lenses with lower modulus can be more challenging to apply and remove.

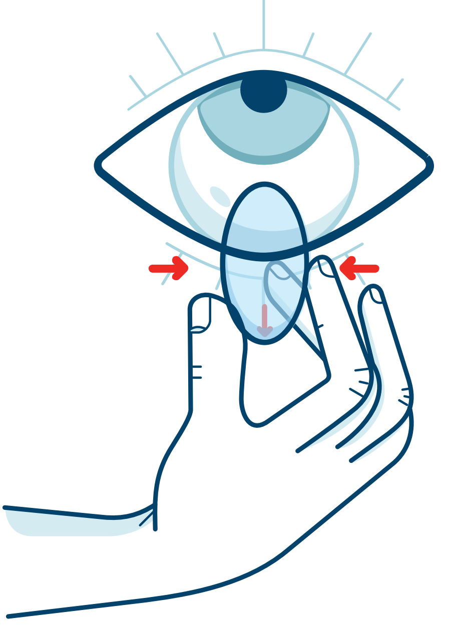

Figure 7. Whilst looking up, the patient should gently squeeze the lens between the thumb and index finger to remove.

Key Steps - Removal

1. Wash and dry hands
2. Look directly ahead into a mirror
3. Secure upper and lower lid ensuring eye is wide open
4. Gently slide lens downwards using the pad of the index finger
5. Gently squeeze lens between the thumb and index finger and remove
6. Check lens to ensure whole lens has been removed
7. Discard daily disposable or comply with cleaning advice for reusable lenses

Reusable lenses

Patients with reusable lenses can then be shown how to comply with their cleaning regimen and case cleaning. The patient instruction guide should always be followed when advising patients how to clean their lenses. Multipurpose cleaning regimens should all require a rub and rinse step; show the patient how to place the lens in the clean, dry palm of their hand, and apply a few drops of the Multipurpose solution. Then get them to gently rub the lens back and forth using one finger to clean the lens surfaces on the palm of the hand. The lens should then be rinsed in a little more Multipurpose solution before it is placed in a clean case with fresh solution. Case cleaning is also an essential part of the daily cleaning regimen; after applying lenses patients should empty the case discarding all old solution. The case and lid can then be cleaned by rubbing and rinsing with fresh solution, then drying with a clean tissue to remove any biofilm, before placing both the case and cap face down on a clean tissue. Careful consideration needs to be given to a suitable clean place to dry the case, with warm, humid bathrooms being avoided. Remind the patient that the case should be replaced regularly, typically every month. In a study by Dantum et al. in 2016, more than 80% of storage cases were contaminated with microorganisms after only 2 weeks of use,[5] with inadequate cleaning seen to increase the risk of microbial keratitis in another study.[6]

Lens disposal

Daily disposable lenses should be discarded responsibly after every wear. Setting phone reminders to dispose of reusable lenses at the required replacement interval can be helpful. Discussing local options for recycling of contact lenses and their packaging helps raise awareness of more ethical ways to dispose of lenses (Figure 8). Patients should be warned against disposing of their lenses in the toilet or sink as this can add to plastic water pollution.

Figure 8. ACUVUE® recycling boxes are available in some practices for all brand of soft contact lenses and their packaging

Struggling to apply or remove lenses?

Some patients find application and removal easier than others; some who struggle may require a second appointment to reassure both patient and practitioner while others just need empathetic, honest and open discussion. For this to take place those teaching application and removal should understand common patient anxieties and barriers to successful lens wear. Practitioners carrying out a teach appointment may assume that the barriers to successful lens wear have already been addressed, however, many of these fears and concerns may still remain. Exploring patient motivation to wear, anxieties and potential concerns at this stage is necessary if we want to minimise drop out in the first few months of wear.

Understanding common barriers to lens wear

Being aware of common concerns raised by patients will help address them. For example, around 5 in 10 non-lens wearers report that touching their eyes is a key barrier to contact lens wear.[7] Research has identified that patients experience a mix of rational and emotional barriers to lens wear. A rational barrier may be a patient who worries that they will poke themselves in the eye causing damage, how a contact lens may feel or whether it will roll behind their eye. An emotional one may be that they are concerned that their work colleagues will consider them as vain. To succeed in lens wear these barriers need to be outweighed by benefits of lens wear. If recognised at this stage concerns can be simple to address, perhaps offering a lens for the patient to feel how “soft” they are or explaining basic anatomy to a patient concerned about lenses rolling behind the eye.

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Patient motivation is important

So how do we help patients overcome barriers and progress to be successful contact lens wearers? Research shows that highly motivated patients achieve higher levels of satisfaction with their contact lens wear.[8] In the same way that a patient experiences a mix of rational and emotional barriers, they will also have a mix of rational and emotional driving forces motivating them to wear lenses. The intrinsic need of a patient to be self-confident at work or the extrinsic fact that they want others to think they are attractive are motivations that may not be discussed with the practitioner, but are perfectly valid reasons to improve the patient's overall wellbeing. Research shows that emotional motivation and barriers have greater impact on retention of lens wearers than rational ones (Figure 9).[7] It is these emotional factors that patients are less likely to discuss with you so finding ways to address these issues can help reduce drop out.

Reflecting on our own experiences and emotions when learning a new skill may enable a more empathetic approach. All of us have experience of learning new skills that we can relate to; perhaps learning to ride a bike, play tennis or drive a car. When reflecting on your own experiences some recollections will be more emotional than others. For many, learning new skills as a child or teen may have come more easily, whilst a relatively simple task learnt as an adult takes time and commitment, sometimes stirring up emotions of frustration, anger and blame as you struggle to achieve your goal. Success always feels good and for any task glimpses of success and achievement will motivate and encourage, but this often takes time and commitment. The stronger the motivation driving you towards your goal the more likely you are to persist. It is therefore important to identify which driving factor is most important to your patient, then consider using it to motivate them during the contact lens teach.

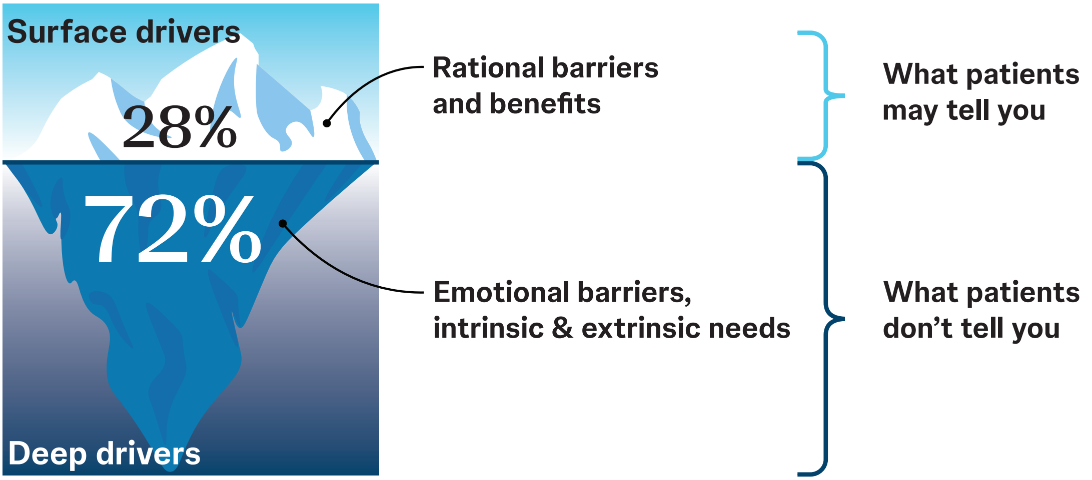

Figure 9. Understanding barriers and motivation to wear is important as patients may not always share their emotions with you.[7]

Top Tip!

Once you've recognised which driving factor is most important to your patient consider using it to motivate them during the contact lens teach. This will encourage them to continue.

Don't overlook patient anxiety

A study looking at anxiety levels for new wearers during the teach appointment found that anxiety peaks just before application and then again before removal.[8] Understanding this can alert you to look for changes in tone of voice or body language at appropriate times. Is your patient getting flustered or flushed, do they have a dry mouth or are they starting to sweat? Evaluating patient anxiety levels during fitting, Court et al.[9] found that increased anxiety led to disrupted recall of information, poor attention and reduced satisfaction. Practitioners should therefore anticipate anxiety and actively look for signs so that they can consider ways of managing it. Interestingly, anxious patients do not necessarily struggle more with application and removal; if they are highly motivated this helps them to persist and overcome their anxiety and handling difficulties.

Tips to help relieve patient anxiety

1. Ensure you have a calm environment, away from external distractions
2. Give exercises prior to fitting, such as touching the white of the eye with a clean finger, to help reduce the blink reflex
3. Ask patient to relax their breathing and jaw to relieve tension
4. Suggest the patient practices approaching the eye with the lens, but without putting it on
5. Regularly mention why the patient first wanted contact lenses to re-motivate
6. Consider the language you use carefully: use 'applying' or 'putting on' a lens rather than – more alarmingly – 'inserting' it
7. Ensure staff are prepared and confident in all aspects of the teaching session

Discussing the 'do's and don'ts' of contact lens wear

Ensuring that patients are aware of any risks involved when selling and supplying contact lenses is essential and practitioners should be open and honest with their patients when explaining the risks. The

British Contact Lens Association (BCLA) lists common ‘do’s and don’ts’ for contact lens wear on their website[10] and key points need to be discussed with all patients. For example, all wearers should know the importance of never using tap water on their lenses. Adding context to this statement by explaining that, although rare, *Acanthamoeba* Keratitis (AK) is a serious corneal infection that can affect contact lens wearers[11] is important. Expanding further to explain that *Acanthamoeba* can be found in UK domestic tap water as well as lakes, oceans, swimming pools and hot tubs will help to fully inform your patient of the risks associated with rinsing lenses with tap water, swimming or showering in lenses.

An understanding of what to do if the lens feels uncomfortable is important. A tiny filament, air bubble or other foreign body can occasionally become trapped under the lens. Carefully sliding the lens onto the white of the eye with a clean finger may sometimes dislodge it, but if discomfort persists explain that the lens will need to be removed, rinsed with saline or a multipurpose cleaning solution and re-applied, checking carefully that it is the correct way round. When summarising advice the BCLA suggest you get patients to ask themselves three questions every time lenses are worn: Do my eyes feel good with my lenses? Do my eyes look good? Do I see well? If the answer to any of these questions is no, lenses should be removed and the contact lens practitioner contacted for further advice.

Informed consent

Practitioners should be aware of the legislation dictating contact lens fitting in the UK. The General Optical Council (GOC) Contact Lens Rules 1988[12] states who can fit lenses and states that the teach is considered as part of the initial fitting process. The GOC standards of practice regarding informed consent[13] state that you should obtain explicit consent where the procedure, treatment or care being proposed is more invasive and/or has greater risks involved. It is therefore important when teaching a patient to apply and remove contact lenses that you obtain consent and provide your patient with clear and accurate information presented in a way that they can understand. You can use your professional judgement to determine the most appropriate way of providing information to a patient; this could be in writing, for example in a leaflet, or by talking to the patient. Many practitioners ask patients to sign a document stating that key points have been covered. The patient can then be given a copy which can also include information on recommended wear schedules, emergency advice, with an out of hours number, and other hints and tips for lens wear.

Delegated responsibility

Often optometrists and contact lens opticians choose to delegate the task of teaching a patient to apply and remove their lenses to another member of their practice team. The 2016 GOC standards for practice[14] gives advice on delegated responsibilities; the person supervising must only delegate to those who have appropriate qualifications, knowledge or skills to perform the delegated activity. The registered professional must be on the premises, so they are able to intervene, if necessary. Details of those being supervised or performing delegated activities must be recorded on the patient record. Professional guidance from the College of Optometrists[15] also provides advice on delegation making it clear that when you delegate care, you are still responsible for the overall management of the patient. It is therefore imperative that any person conducting a teach is well trained, ensuring they have the knowledge and skill to instruct a patient safely. To be done well, good communication between staff members is essential and anyone responsible for the teach should understand patient motivation for wear, type and modality of lenses worn, care regimen and recommended wearing times. A check list is useful when delegating responsibility as a way of ensuring everyone follows correct protocols (Figure 10).

Contact Lens Teach Check List

- ☐ Clean surfaces
- ☐ Wash and dry hands
- ☐ Teach application technique
- ☐ Get VA check and fit assessment, if necessary
- ☐ Wash and dry hands
- ☐ Teach removal technique
- ☐ Repeat application and removal until patient feels confident
- ☐ Discuss do’s and don’ts
- ☐ Discuss care regime and case cleaning
- ☐ Discuss wear times
- ☐ Give emergency advice
- ☐ Give written advice
- ☐ Complete patient record card
- ☐ Get patient signature to confirm teach complete
- ☐ Clean surfaces

Figure 10. Sample check list for a contact lens teach to ensure protocol is followed

Follow-up

The early stages of contact lens wear are crucial to ongoing success. Many patients need additional support during their trial period to move them from an apprehensive novice wearer to a happy confident wearer as the first few days can be overwhelming. Repeated application and removal failures once the patient is at home may result in frustration and this can increase anxiety.

Key points for delegation

1. Delegation provides the opportunity to reduce practitioner chair time and involve trained practice members in teaching and advising new contact lens wearers
2. Ensure the staff member conducting the teach is competent
3. Be clear about what you want to be covered
4. Ensure you are on the premises while the task is being carried out
5. Meet regularly with staff to discuss delegated functions
6. Encourage staff to suggest improvements

It is clear that lens wearers have issues with handling lenses as these difficulties feature widely in social media chatter.[8] This suggests our patients want more advice. If they turn to social media, practitioners have much less control over the advice that's given. Most manufacturers provide online support materials and giving them a link to manufacturer websites or a trusted YouTube video gives you more control over advice they receive at home. Most issues are simple to resolve; encourage the patient to call with any further questions or concerns and ensure they always have your number at hand.

Consider a follow-up call

In addition to the usual follow-up appointment, a phone or video call from a member of the practice team after a couple of days can be invaluable. Remember, once at home anxiety will often continue and new wearers may find it difficult to recall advice given. Furthermore, patients may find that they need more time than expected to apply and remove lenses successfully. New wearers may consider time needed is too long and so cut corners to try and speed up the process.[9] Practitioners should be aware that when a patient leaves the practice with new lenses it is simply the beginning of their journey as a lens wearer and further support at home may be needed to ensure the patient develops into a successful contact lens wearer. A call at this early stage can address difficulties that may have arisen early on and encourage patients to stay motivated. Enthusiastic communication is important remembering to relate back to their initial motivation, praise progress and give personalised advice relevant to their circumstances.

Key points for good communication with new contact lens wearers:

1. Use positive feedback and an enthusiastic approach to encourage and congratulate
2. Emphasise the importance of hygiene and hand washing
3. Give written information, with a link to application and removal videos
4. Provide contact details for queries and concerns.
5. Encourage patients to call if they need reassurance
6. Give information on the contact lens and why it was prescribed, and reassure them that other lenses are available if for any reason they are not satisfied
7. Phone after a few days to check progress
8. Book a follow-up appointment

Summary

Learning to wear and care for contact lenses can be an emotional time for patients. The mix of excitement and anxiety can overwhelm at times and all staff delivering this part of the contact lens fitting need to be empathetic and well trained. Practices need a clean, private space to give patients the time needed to learn this new skill. Understanding motivation for contact lens wear and exploring possible concerns and anxieties is essential to personalise the experience ensuring patients leave the practice feeling confident and motivated. Once home it may be difficult for patients to recall advice given or find the time needed to master the new art of applying and removing their lenses. Offering continued support is important to build confidence and ensure the patient stays motivated. Good communication and simple methods for continued support once patients leave the practice can be employed to help reduce drop out in new wearers.

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J&J Institute

Contact Lens Aftercare

Author: Dr Sandeep Dhallu

The aftercare examination is a fundamental aspect of contact lens practice and is especially important for the preservation of good ocular health, vision and comfort during lens wear. As is the case with other areas of health, the saying that "prevention is better than cure" applies here too, that is to say the best way to ensure successful long-term wear of contact lenses is to avoid complications from occurring in the first place. For ongoing contact lens success, the importance of effective aftercare cannot be over-emphasised, particularly given the high drop-out rate.

Among established wearers, the most common reason for discontinuation is discomfort, reported by around half of those who lapse.[1]

A patient's requirement from their contact lenses will be dynamic and may change for a variety of reasons such as a change in job, environment, or lifestyle. Thus, another key goal of the aftercare is to re-assess whether the patient's current contact lenses still meet their requirements, to avoid the risk of the patient becoming unhappy and dropping out of lens wear. Due to the speed of development within the contact lens industry, practices and recommendations should constantly be reviewed, keeping up to date with the latest lens materials, designs and care systems. The aftercare appointment provides the ideal opportunity to discuss any new products that may have been introduced to the market.

The aftercare routine for a soft contact lens wearer comprises six distinct elements, each of which will be discussed in this article (figure 1).

Aftercare routine

Patient discussion

Patient discussion is a vital aspect of the aftercare examination and clear communication is important to ensure that the correct information is gathered. During history and symptoms taking, it is best to adopt a conversational questioning technique with the use of both open and closed questions; this will encourage the patient to talk more freely and may allow additional important information to be elicited. A friendly and approachable manner will put patients at ease and is likely to result in them being more honest about their true practises.

Whilst no two patient discussions will be the same, it is important to ensure that each discussion follows a similar structure, to avoid missing important information. The most comprehensive and logical way to

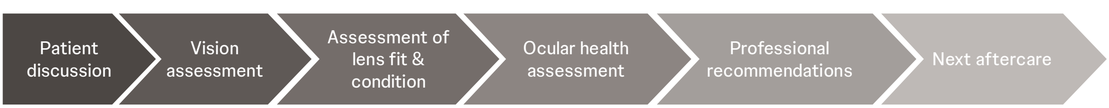

Figure 1. The aftercare routine

structure the history and symptoms taking during a lens aftercare is indicated in table 1. If a problem or issue is reported, then more probing questions should be asked in order to investigate this further. These might include questions such as asking whether the issue affects one eye or both, occurred suddenly or gradually, is constant or intermittent or worse at any particular time (such as after insertion), and so on. It is important to consider how best to word questions in order to ensure you gather the right information from the patient; some examples of questions that can be asked are given in table 1.

During the contact lens aftercare, it is especially important to review the patient's compliance with hygiene practises.

Poor hygiene can lead to a whole host of complications ranging from mild lens discomfort to severe sight-threatening infections,[2] so good hygiene practices should be reinforced at every appointment.

Research has shown that full compliance with the recommended lens and case regime is rare[3] and most contact lens wearers do not follow the guidance that is given in at least some aspects. Daily disposable lens wearers are more likely to be compliant, and this is thought to be due to the relative simplicity of this modality of wear compared to reusable lenses, where there are several additional steps to follow in order properly clean the lenses and case. Efron and Morgan[4,8] assessed the number of compliance steps that are needed for a lens wearer to be fully compliant and found there were 53 steps for those wearing reusable lenses compared with just 26 for daily lens wearers (Table 2). A thorough review of the patient's application, removal and cleaning routine will help identify any bad habits. Practitioners should also make use of their observation skills to assess patient compliance; this can be done by checking things like the general cleanliness of the patient's hands, length of fingernails, state of their lens case and observation of the process for contact lens removal.

Topics to address	Questions
Reason for visit	• I can see we have recalled you for your review appointment, is this your reason for visit or are you having any problems with your contact lenses?
Wear time	• What time did you put your lenses on today? • What time do you usually put your lenses on and what time do you usually take them off? • In a typical week, how often do you wear your contact lenses?
Lens replacement	• How old are the lenses that you are currently wearing? • How regularly do you replace your contact lenses? • Do you have an up-to-date pair of spectacles?
General habits	• Do you ever fall asleep in your contact lenses? If so, how many nights per week does this typically occur? • Do you ever swim or shower with your contact lenses in?
Satisfaction	• How would you rate your comfort out of 10 (with 10 being extremely comfortable) at the start of the day and at the end of the day? • How would you rate your vision out of 10 with lenses for tasks you regularly do, such as driving, computer use, watching television and/or reading? • Do you notice your vision fluctuating at all during lens wear? • How would you rate your comfort out of 10 when the lens is new and when the lens is due for replacement?
Handling	• How easy do you find handling your contact lenses? • Please talk me through the procedure for applying and removing your contact lenses. • Do you understand the importance of cleaning your hands thoroughly before applying and removing your lenses? *Note: You can observe the patient's application and removal techniques at the relevant points of the examination.*
Lens care (Re-usable lens wearers only)	• Please could you demonstrate the way in which you clean your lenses after you take them off at the end of the day? • What solution do you use to clean your lenses? • How do you store your lenses when they are not being worn? • How often do you change the solution?
Lens case (Re-usable lens wearers only)	• Could you show me the lens case you use to store your lenses? • How old is your current case? • Could you describe how and when you clean your lens case, and also how often it is replaced.
Any change to ocular history, general health, medication	• Have there been any changes to your ocular or general health and medication since your last review appointment/eye examination? • Do you smoke?
Further questions if problems are reported	• Are one or both eyes affected? • When did you first notice the problem? • Did the problem present suddenly or gradually? • Is the problem constant or intermittent? • Is the problem worse at any particular time, e.g. just after application, after x hours, or at the end of the day? • Have you experienced this problem before? • Does the problem persist after lens removal? • Have you taken any treatment to date? • Is there anything you do that makes the problem better?

Table 1: Recommended structure for patient discussion in an aftercare appointment

Applying a lens			Removing a lens			Other aspects of lens care and compliance		
Steps	**DD**	**RU**	**Steps**	**DD**	**RU**	**Steps**	**DD**	**RU**
Wet Hands	x	x	Wet hands	x	x	Replace case monthly		x
Apply Soap	x	x	Apply soap	x	x	Discard lenses at the scheduled times	x	x
Rub Hands	x	x	Rub hands	x	x	Discard solution bottle		x
Rinse Hands	x	x	Rinse hands	x	x	Do not exceed advised wearing time	x	x
Dry Hands	x	x	Dry hands	x	x	Attend for regular aftercares	x	x
Check eyes look healthy	x	x	Remove bottle lid		x			
Remove bottle lid		x	Fill R case with solution		x			
Open R lens case/blister pack	x	x	Remove R lens	x	x			
Remove R lens from case/pack	x	x	Apply solution to R lens		x			
Rinse R lens	x	x	Rub R lens		x			
Drain R lens		x	Rinse R Lens		x			
Check R lens	x	x	Put R lens in case		x			
Apply R lens	x	x	Close R case lid		x			
Open L lens case/blister pack	x	x	Fill L case with solution		x			
Removed L lens from case/pack	x	x	Remove L lens	x	x			
Rinse L lens		x	Apply solution to L lens		x			
Drain L lens		x	Rub L lens		x			
Check L lens	x	x	Rinse L lens		x			
Insert L lens	x	x	Put L lens in case		x			
Check vision is good	x	x	Close L case lid		x			
Check lenses are comfortable	x	x	Replace bottle lid		x			
Replace lid on bottle		x	Soak lenses overnight		x			
Empty case of solution		x						
Rinse case with solution		x						
Wipe case with tissue		x						
Leave case to air dry		x						

Table 2. A comparison of the number of steps required for compliant lens wear with daily (DD) versus reusable lenses (RU). Adapted from Efron and Morgan.[4]

Vision Assessment

Contact lenses are primarily worn to improve vision, although they may also be worn for cosmetic reasons, in myopia management or for therapeutic applications. In all cases, measurement of visual acuity (VA) is a legal requirement which must be recorded at every aftercare appointment.

There can be some disparity between VA and subjective experience of visual quality, and good VA does not necessarily equate to good visual quality, with one study showing a poor correlation between the two.[5]

Consequently, quality of vision should also be ascertained, and can quite easily be done using interval scales – as described in table 1 - or a visual analogue scale.

Visual acuities should be measured and recorded both monocularly and binocularly. Where appropriate, monocular or binocular over-refraction should then be conducted to determine the most up to date lens power to achieve maximum VA. The use of retinoscopy can be particularly helpful in assessing both the quality of the reflex and the degree of over-refraction required.

It should be noted that a reduction in acuity may not only arise as a result of a refractive change; there may be other causes such as the presence of pathology, which would require further investigation and appropriate management. Additional tests such as keratometry may be indicated at this point if any significant changes from baseline are observed.

Assessment of lens fit and condition

The fit and condition of a soft lens should be checked using a slit lamp while it is *in situ*. A study which looked at how initial fit reflected end of day fit found that soft lenses take up to 20 minutes to settle, and so should be evaluated after this point as the fit after 20 minutes is largely predictive of the fit after 8 hours of wear.[6]

First, an assessment of the lens surface condition should be made, checking for the presence of deposits and on-eye

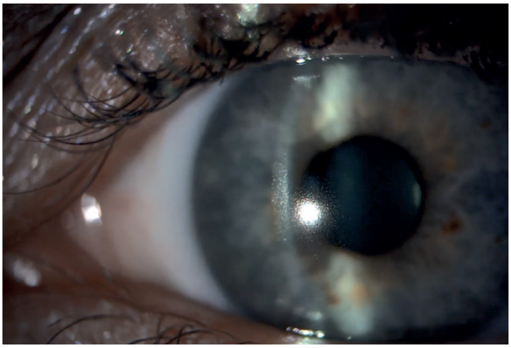

Figure 2. Assessment of contact lens wettability through observation of the 1st Purkinje image, with time to scatter following blink noted as the pre-lens thinning time.

wettability. Measurement of the tear film by non-invasive methods will help to determine lens wettability (figures 2 and 3). Where deposits or poor wettability is observed, the practitioner should consider if changes need to be made to the lens material or replacement frequency.

For soft lenses, corneal coverage, centration, edge alignment, movement on lateral gaze (lag), upgaze (sag), blink and push-up should all be assessed and recorded. An example record card is given in figure 4, as per Wolffsohn et al. 2009.[7] It is worth noting that fit can also be recorded in terms of millimeters of movement on blink and ease of recovery from push-up. For toric lens wearers, rotational alignment and stability should be checked using the markings on the lens. Any rotation can be assessed using the slit lamp graticule by overlaying a thin beam over the toric engraving and making the appropriate adjustment to the lens axis using either CAAS or LARS, as described in detail earlier in this series.

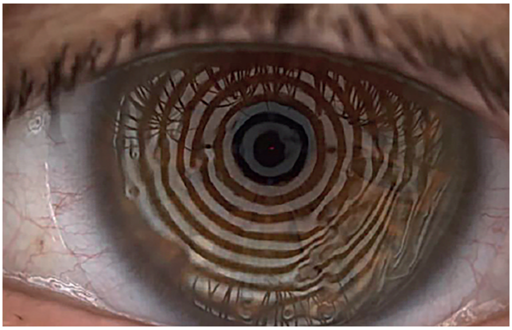

Figure 3. Assessment of pre-lens tear film break up time to provide information on contact lens wettability. Poor contact lens wetting is observed as distortion of Placido rings (left), versus good wetting (right).

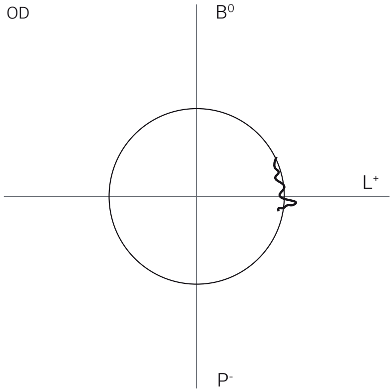

Figure 4. Example of a simplified method of recording soft lens fit according to Wolffsohn et al.[7] showing right eye central lens fit, with B^0 indicating medium (0.25-0.5mm) movement on blink, L^+ indicating large (>1.0mm) movement on excursions, P^- indicating slow (<2 mm/s) recovery on push up, and the mark on the nasal part of the lens showing incursion between the lens edge and limbus.

Ocular Health examination

> It is well known that contact lens wear can induce physiological changes to the eyelids, tear film, and conjunctiva as well as all layers of the cornea,[8] so it is important to conduct a thorough examination of anterior ocular health at every aftercare.

Advances in lens materials and the frequency with which most wearers now replace their lenses mean that serious contact lens complications are not as commonly encountered at follow up appointments as they once were, and the majority of complications tend to only mildly affect vision or are self-limiting.[9] Nevertheless, lens induced complications can still occur, and in general can be divided into those that are acute, chronic or both (figure 5). These complications should be kept in mind whilst examining the anterior ocular adnexa.

As with history and symptom taking, the best way to proceed with this is to use a systematic approach going from low to high magnification, and from least invasive to most invasive techniques. As contact lens wearers should always have an in-date eye examination, it is not obligatory to carry out a fundus examination during a contact lens aftercare. The exception to this is if an abnormality is suspected that requires further examination.

Clear and comprehensive record keeping is essential to good practice, as well as being

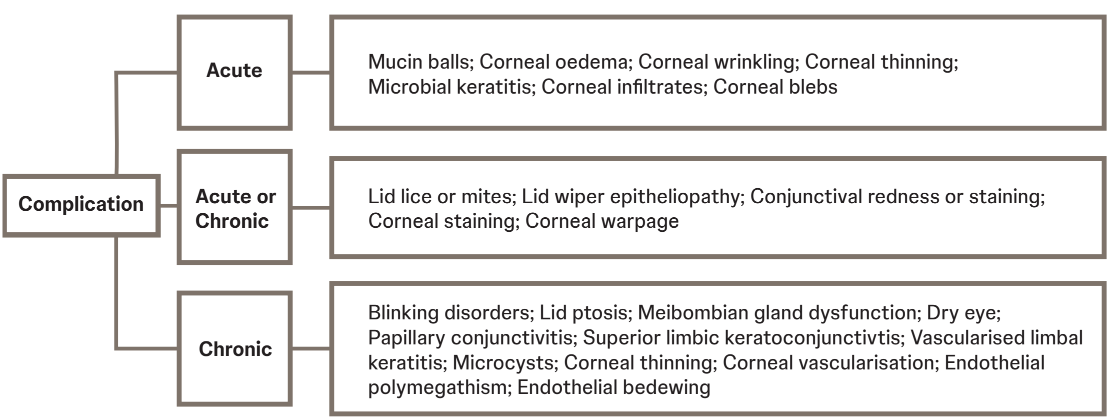

Figure 5. List of acute and chronic ocular complications that can occur from contact lens wear. Adapted from Efron and Morgan.[4]

a requirement by law. Grading scales like the one shown in figure 6 should always be used to document any findings as they help to ensure a standardised approach to record keeping, particularly when a patient's ocular complication is monitored by different practitioners within the same practice. There are different grading charts available and any can be used as long as the same one is used consistently each time and by all practitioners working together. It is recommended to make a note of which grading scale is used and record findings to one decimal place at every visit.[9] All measurements should be compared to the previous or baseline measures in order to recognise and appropriately manage any

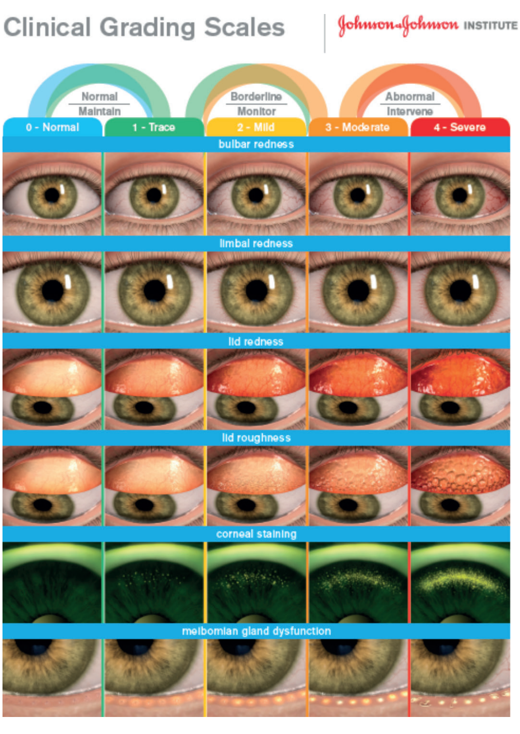

Figure 6. Grading scales should be used to document ocular health findings.

changes early on.

During a routine aftercare, practitioners should begin their examination of anterior eye health by checking that the lashes on both lids are clean and free of any crusting or flakes using diffuse illumination, a wide slit width and low to medium magnification. Lid margins should be checked for any signs of oedema resulting from lens wear, which may show as thickened lids with poorly contoured edges, and meibomian glands should be examined for any signs of dysfunction.

At this early stage and before manipulation of the lids or instillation of fluorescein, the tear film should be assessed using the techniques described earlier in this series. This should include assessment of tear quantity by measurement of tear prism height, as well as assessment of tear quality from measurement of non-invasive tear break-up time should suitable tools exist in practice.

Corneal and limbal health should be checked using a series of different slit lamp techniques and higher magnifications, in order to thoroughly check for signs of corneal oedema, neovascularisation or the presence of infiltrates. Whilst most modern contact lenses will meet the critical oxygen level of Dk/t over 24 x 10^{-9} for daily wear as defined by Holden & Mertz,[10] it remains important to check for signs of oedema as shown by the appearance of microcysts and stromal striae. Signs can fade quite quickly once the lens has been removed and so it is recommended to check for signs of corneal oedema at the beginning of the ocular health check. Microcysts are best viewed using retro-illumination, and will appear as small inclusions that do not move and show reversed illumination (figure 7). They can be mistaken for tear film debris and thus are often overlooked, however their presence in large numbers (>30) is indicative of epithelial metabolic distress. Vertical striae appear as a series of parallel white lines in the stroma (figure 6) and usually suggest that there is corneal oedema present that requires action. A further sign of hypoxia, neovascularisation, should also be assessed using retro-illumination or the red-free (green) filter on the slit lamp, and should be noted in terms of the millimetres of vessel growth into the cornea together with location.

Following examining for signs of corneal oedema, a full slit-lamp routine should be carried out to assess the anterior ocular adnexa in detail. Adverse effects, such as conjunctival hyperaemia and corneal infiltrates should be noted and graded, then managed where necessary.

> Fluorescein use is imperative at every aftercare visit for both soft and rigid lens wearers unless there are contraindications to its use such as in those with known hypersensitivity.

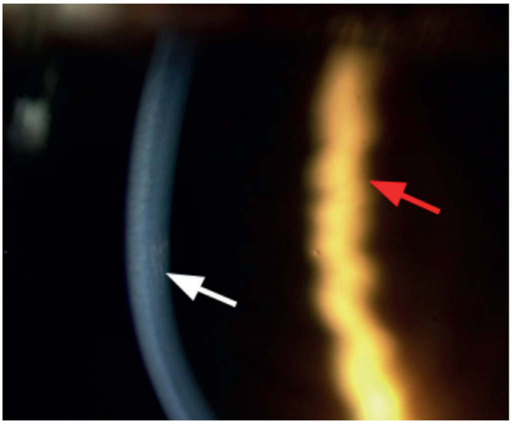

Figure 7. High magnification of the cornea showing simultaneous observation of striae (white arrow) in the optical section under direct illumination and a microcyst (red arrow) by direct, retro-illumination.

When instilling fluorescein, it is important not to flood the eye and instead use the minimal amount in order to optimise viewing of any staining.[9] The extent and depth of staining should be graded, with a particular focus on the pattern of staining as this can give an indication as to the cause (figure 8). With fluorescein instilled, invasive tear break up time can now be assessed.

Lid eversion should be performed at all aftercare visits so that the palpebral conjunctiva can be assessed, and any allergic or mechanical effects of lens wear identified. The presence of follicles and/or papillae (Figure 9) should be noted, along with their position, size, and number.

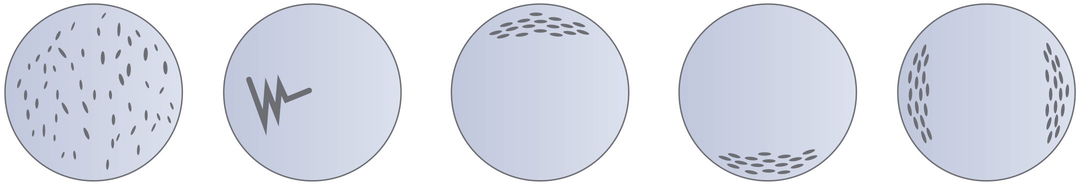

Figure 8. Epithelial staining patterns. (For illustrative purposes only)

Professional recommendations

Once all the relevant tests and observations have been performed, results need to be considered in order to decide on the best course of action, ensuring the patient is involved in decisions and that their best interests are at the centre of all management plans. If any abnormalities or complications have been noted, they should be addressed at this point. Additionally, any signs and symptoms that have been reported by the patient should also be dealt with. Common contact lens related signs and symptoms are given in table 3, along with suggestions for how to resolve them.

The recommendations you make at the end of the aftercare might include advising the patient to continue with their existing lenses, while addressing any compliance issues. Or, you might recommend trialling a different lens to resolve any observed ocular health complications, address any patient reported symptoms or to meet any changing needs. Alternative options might include trialling a different modality of wear, such as switching from reusable to daily disposable lenses for patients with

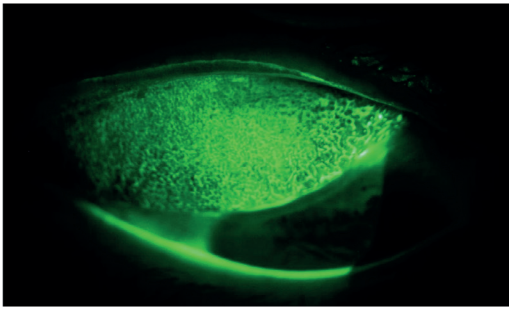

Figure 9. Examination of the super palpebral conjunctiva using fluorescein to enhance visualisation of papillae.

discomfort issues or trialling a different lens material in view of any mechanical complications or patient reported symptoms. Any new contact lenses should be inserted to check vision, fit and comfort before they are given to the patient to be trialled. This should then be followed up with a subsequent aftercare appointment after an appropriate interval.

Recommendations should be clearly communicated to the patient at the end of the aftercare, along with an explanation outlining the reasons for them as well as their potential benefits. It is good practice to give written instructions to supplement any verbal advice given. A summary of the advice given should be noted on the patient

	Symptoms	Possible Causes	Suggested Action
Discomfort	Upon lens application/ acute	• Foreign body • Damaged lens • Decentred lens • Lens incorrectly applied • Contaminated lens • Corneal abrasion	• Remove lens, rinse and re-apply • Replace lens • Re-centre the lens, if recurs check lens fit • Remove lens- turn inside out and re-apply • Remove lens, rinse and re-apply • Cease lens wear for 24 hours. If symptoms recur, seek immediate advice
	After a period of wear	• Lens deposition • Lens surface dehydration • Poor lens wetting • Trapped debris under lens • Toxic reaction to solution • Contact lens-associated • Papillary conjunctivitis	• Replace lens/consider refitting with a new material/more frequent replacement • Replace lens – consider refit with new material/more frequent replacement • Replace lens – consider refit with new material/modality • Remove lens, rinse and re-apply • Change solution/lens care system • Increase lens replacement frequency
	Following lens removal	• Corneal abrasion • Superior epithelial arcuate lesion • Corneal inflammation/infection	• Remove lens, find and resolve the cause • Refit with different lens design/lower modulus • Remove lens, refer for hospital treatment if necessary
	Periodically	• Lens surface drying • Environmental factors: - Smoke - Low humidity	• Blinking exercises if due to incomplete blink • Consider refitting with a new material • Avoid these environments where possible • Use humidifier
Visual Disturbance	Blurred vision-constant	• Lenses incorrectly applied • Change in prescription • Distorted lens	• Re-apply correctly • Refract and provide new prescription • Replace lens
	Blurred vision-transient	• Lens deposits • Excessive lens movement • Lens inside out	• Replace lens • Refit • Re-apply correctly
	Blurred vision-worse towards end of day	• Lens surface drying • Lens deposits	• Clean and/or replace lens or refit with different material • Replace lens or refit with different material
	Glare, ghosting diplopia	• Decentred lens • Back optic zone diameter (BOZD) too small • Uncorrected or residual astigmatism • Severe deposition	• Refit • Refit, larger BOZD • Refit with soft toric or RGP • Replace lens or refit with different material

Table 3. List of common signs and symptoms associated with contact lens wear, along with suggested actions to resolve them.

record card for both future reference and legal purposes. It would be pertinent to remind all contact lens wearer of the importance of avoiding contact with water due to the increased risk of acanthamoeba keratitis. Finally, the patient should always be given advice on what to do if they encounter any problems with their lenses before their next scheduled visit, as well as what to do in the event of an emergency including what signs or symptoms they should look out for.

Aftercare Frequency

The importance of regular aftercare appointments should always be stressed to every contact lens wearer, both new and existing, and the review date for the next aftercare clearly communicated to the patient at the end of each appointment.

There is balance to be had between seeing a contact lens patient regularly enough to be able to detect any adverse complications at an early stage, but not so frequent that it is becomes an inconvenience for the patient and they simply do not attend. In the early days of soft contact lenses, a more frequent approach was taken in the regularity of aftercare appointments since little was known about the long- term effects of lens wear. Current practice has evolved such that an initial aftercare is usually conducted one to two weeks after initially dispensing a soft contact lens to the patient for a trial. This will differ for extended wear patients who would normally be seen for an appointment the morning after their first night of sleeping in lenses, along with after 1 week and 1 month of continuous wear. Check-ups at these points allow the practitioner to ascertain whether the lenses are being handled and cared for correctly, and in accordance with the given instructions. It also allows lens performance with respect to vision, fit, comfort and ocular health to be verified to ensure this is in line with both the patient and practitioners expectations.

Following on from this initial aftercare, assuming both patient and practitioner are happy with the lens performance and patient compliance, the current guidance by the College of Optometrists is for all subsequent contact lens check-ups to be scheduled according to the patient's clinical needs.[11] This is in agreement with guidance issued by the Association of British Dispensing Opticians which states that the frequency of contact lens aftercares should be based on the eye care practitioner's professional judgement of the patient's clinical needs, the type of contact lens worn, the modality of wear and judgement of the risk of an adverse event occurring.[12]

A review by Efron and Morgan in 2017[13] proposed frequency of review should be based upon lens replacement frequency, lens type, wearing modality and predicated rate of refractive change. Recommendations were for soft daily disposable wearers to be reviewed every 24 months, based on a lower risk of keratitis, for soft reusable and rigid daily wearers to be reviewed every 12 months, enabling greater monitoring of compliance and for those in soft and rigid extended wear contact lenses to be seen every 6 months due to higher risk of keratitis. Based upon refractive change, it was advised young myopes (5-15 years) should be monitored every 6 months, and presbyopes every 12 months.

Summary

The aim of successful contact lens aftercare is to check a patient's ocular response to contact lens wear, ensure vision and comfort are optimal and to review compliance. Clear communication throughout the appointment is vital, as well as a systematic routine to ensure nothing is missed. Personalised recommendations should always be given at the end of the examination, ensuring that the patient is aware of the reasons for any changes in care needed. The importance of aftercare for the maintenance of eye health and comfort should be reinforced at every visit so that the patient appreciates the value of regular review.

Key Points

- A comprehensive aftercare is essential to ensuring long term success with contact lenses
- Implementing a systematic approach to the aftercare routine is recommended to ensure that all key information is elicited, and all necessary assessments are performed and recorded
- Patients' requirements from lens wear may evolve over time and so should be re-assessed at every aftercare to ensure their lenses continue to meet changing needs
- Attention should be paid to the health and ocular function of structures that come into direct and indirect contact with the lens
- Professional recommendations, tailored to each individual patient, should be made at the end of each appointment

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The Future of Contact Lenses

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Few areas of optometry evolve with the same rapidity as the world of contact lenses. Yet, despite the apparent speed of change, as signalled by growing product portfolios, behind the scenes developmental pipelines are often protracted with a need to overcome both technical and regulatory hurdles.

In this article we consider, in brief, the recent and expected future changes to lens categories, the supportive evidence, and future challenges.

Drug delivery through contact lenses

Eye drops can be an ineffectual vehicle for ocular drug delivery. Immediately upon instillation, drops will enter the lacrimal drainage system, dilute in the tears, and disperse across the ocular surface and inner eye lids. Thus, the amount of drug reaching the intended site of action, i.e., the bioavailability, can be limited.[1-2]

To obviate the risk of drug loss, an intuitive response may be to simply increase eye drop volume, however, the rich vasculature and larger surface area of the conjunctiva and surrounding ocular adnexa offer a diversion away from the cornea and a route into systemic circulation. Consequently, the risk of systemic adverse effects and interactions with other drugs may be increased.[2]

Another common obstacle is poor patient compliance, which may present a concern especially where repeated doses or multiple types of eye drops are required throughout the day.

Despite their shortcomings, eye drops remain the main method for ocular drug delivery; they are minimally invasive and can be self-administered unlike, for example, intraocular injections. Alternative topical drug delivery methods, such as ocular ointments, are beneficial for drug retention but can lead to temporary visual annoyance due to their high viscosity.[3] Systemic approaches have difficulty crossing the blood-aqueous barrier, and so higher drug doses are required to achieve the desired concentrations within the eye; a process which also increases risk of systemic toxicity.[4]

A potentially more efficacious approach could be in the form of drug releasing contact lenses. The proximity of the lens to the cornea could help improve bioavailability, whilst affording additional benefits such as dosage modulation and, if the patient is already a contact lens wearer, a potential for improved compliance.

Methods of drug release through contact lenses

Drug delivery through contact lenses has, until recently, proven elusive. Success depends upon lens properties (e.g., ionic charge, hydrophilicity), features of the drug (e.g. molecular weight, solubility), and how they interact with one another.[2] In theory, the drug will be released from the contact lens into the post lens tear film, where minimal tear exchange should prevent the drug from washing away, and thereby improve drug retention times.[5]

In actuality, impregnating a contact lens with a specific drug, with a slow-release mechanism, which has neither a deleterious effect upon optical performance, oxygen permeability, or comfort is a challenging feat.

Some of the past and current approaches for contact lens drug release are summarised below.

- **Soaking:** Commercially available contact lenses are soaked in the drug solution. Depending on the drug/lens material affinity there is potential for a 'burst release' effect for low affinity combinations, alternatively, a prolonged drug release delay for high affinity combinations. Other factors, such as drug concentration, will also affect drug release kinetics.[6-7]

- **Molecular imprinting:** A process by which memory sites that mimic the drug's natural receptors are formed (imprinted) within the lens.[6,8] Soaking the lens in the drug saturates these sites.[9] Benefits may include greater loading and a slower drug release.[10] With reusable lenses, to maintain similar levels of daily drug doses, the lens must be thoroughly cleaned to remove any residual drug solution before being reloaded for the next wear.

- **Drug reservoirs:** Biodegradable polymers containing the drug, that can be tailored to modulate drug release, are incorporated into the lens. Typically, these are positioned in the lens periphery to avoid interfering with the central lens optics.[6]

- **Drug release barriers:** A barrier, such as vitamin E, is added to extend the path that a drug must follow prior to release, thus extending the drug release time.[11-12,6] Some barriers are added as layers within which the drug is held, this can also help increase drug loading. Interactions with the tear film and blinking lead to drug release from these layers, with the slowest release originating from the innermost layers and the most rapid from the outer layers.[13]

- **Nanoparticle integration:** Nanoparticles, that have a high affinity for a specific drug, are incorporated throughout the contact lens. Some of these nanocarriers are biodegradable, therefore degradation will lead to drug release, others make use of external stimuli such as light or temperature changes to elicit drug release.[14]

- **Material ionic charge:** The ionic charges of a drug and lens influence drug loading and release. The lens material charge can be manipulated to align with the drug of choice.[13,15]

Challenges

Drug release profiles continue to be one of the fundamental issues with drug eluting contact lenses. If a drug which typically requires multiple timed doses is released too rapidly (a burst release), then the individual may need to replace their contact lens in time for their second dose, clearly negating any convenience benefits afforded by drug release lenses. A summary of some of the obstacles encountered by researchers is listed in Figure 1.

The present

Several different drugs, and many commercially available contact lenses,[16] have been assessed for their viability in contact lens drug release. Applications have been proposed for both anterior and posterior eye diseases,[17-19] each with differing levels of success. Not all attempts have been futile, products have reached late-stage clinical trials, but commercialisation has largely proven elusive. One product of note includes the antihistamine (ketotifen) releasing lens[16] which has demonstrated a positive impact on mean ocular itching scores compared to standard contact lenses.[20-21]

The future

As contact lenses that mediate drug release become more widely available, eye care professionals (ECPs) may begin to consider the clinical and commercial implications of this novel lens category on their own practice. As yet, data on practitioner and patient views towards drug eluting lenses remains limited and the early evidence is mixed.[22-25] Further work investigating safety, tolerability, and efficacy could help the understanding around the likely uptake by patients and practitioners.[26]

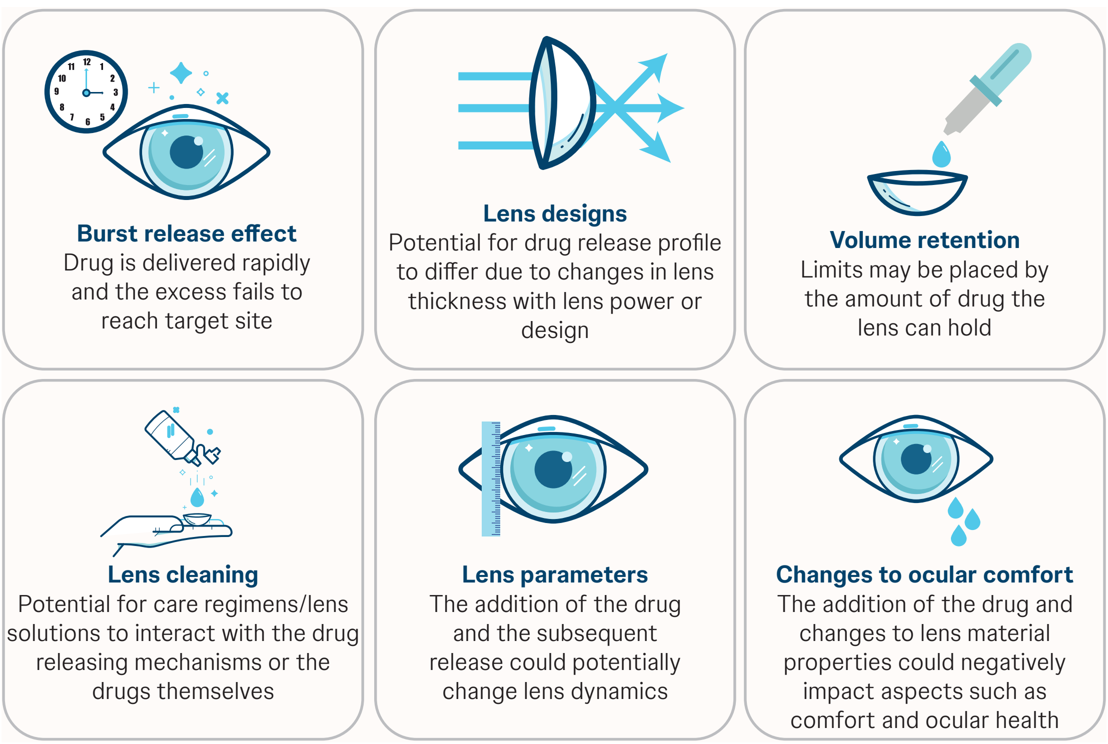

Figure 1. Obstacles faced by researchers investigating drug eluting lenses include issues relating to drug release kinetics, storage, drug stability, potential changes to lens dynamics, ocular comfort and visual experience.[2,6,7,13,14]

Smart Contact Lenses

Smart contact lenses have captivated the attention of audiences both within and outside the optometric profession. Whilst part of the enthusiasm may be attributed to the involvement of technology conglomerates such as Google, it is also likely part of a broader trend towards wearable health technologies.[27]

A paucity of published scientific literature can make it difficult to look beyond the press releases, but patents and clinical trial registrations can offer some clues to the direction in which the field is moving.

Methods by which smart contact lenses work

Contact lens developers can make use of various photometric, optical, and bio-sensors to detect changes in the eye or visual environment. For example, piezoresistive sensors or strain gauges, can be used to detect pressure changes[28] i.e., a potential application for measuring intraocular pressure; and microfluidic sensors to detect changes in biological components such as enzymes or antibodies within the tears i.e. a potential application in monitoring ocular infections and allergies.[29] Multifunctional lenses which can monitor more than one disease are also in development, and the use of newer materials[30] such as graphene is helping to move this field forwards.[31]

There are several lens subcategories which fall under the umbrella of the 'smart lens', a brief overview is provided below.

Disease Monitoring Lenses

Diabetes

Compared to blood testing, disease detection through tears and contact lenses offers a relatively less invasive approach, with the added potential of providing more comprehensive clinical data e.g., diurnal variations.[32]

To overcome the need for home finger-prick blood tests companies such as Microsoft and Google have tried developing contact lenses for monitoring tear glucose levels.[35]

Several approaches have been proposed[34-35] including use of graphene sensors;[31] and boronic acid based attempts to develop lenses which fluoresce in the presence of raised glucose.[36-37] Thus far, there seems to be little in the way of commercially available products.

Intraocular Pressure (IOP)

The Sensimed Triggerfish® contact lens is a FDA approved and CE marked device for measuring diurnal intraocular pressure fluctuations for periods of up to 24 hours, intended for use in individuals at risk of glaucoma.[38] A strain gauge sensor, embedded within the soft disposable contact lens, detects changes in corneoscleral shape. Information is then sent wirelessly to an adhesive external antenna, attached near the eye, before being passed onto a wearable portable recorder.[39] At the end of the recording period, the recorder data can be transferred to the practitioner. The intention is to monitor fluctuations in IOP; these are recorded in millivolts, unlike conventional IOP measurements which are recorded in millimetres of mercury, making it difficult to draw direct comparisons with conventional tonometry readings.[40]

Other novel proposals to measure IOP, using contact lenses, have included development of materials that change colour in response to pressure and moisture changes.[41]

Dry Eye

Dry eye related conditions are linked to the presence of various biomarkers within the tears.[42-43] There is potential to both detect and treat dry eye conditions using smart contact lenses.[41,44]

There have also been reports that biomarkers for Parkinson's disease, multiple sclerosis, and possibly for some types of cancers may be present in the tears,[45-48] thereby extending the diagnostic potential of smart contact lenses to beyond ocular conditions.[49]

Enhancing Vision

Accommodative

In addition to disease detection, smart contact lenses have been used to enhance vision, including proposals to develop accommodating contact lenses for presbyopes.

While several approaches have been put forth[50-52] one which is supported by growing research interest is the use of liquid crystal (LC) cells.[51-53] A small change in voltage brings about large changes in refractive index and thus lens power. Activation could potentially be via an external device e.g. a smartwatch, or possibly through deliberate blinking.[54-56]

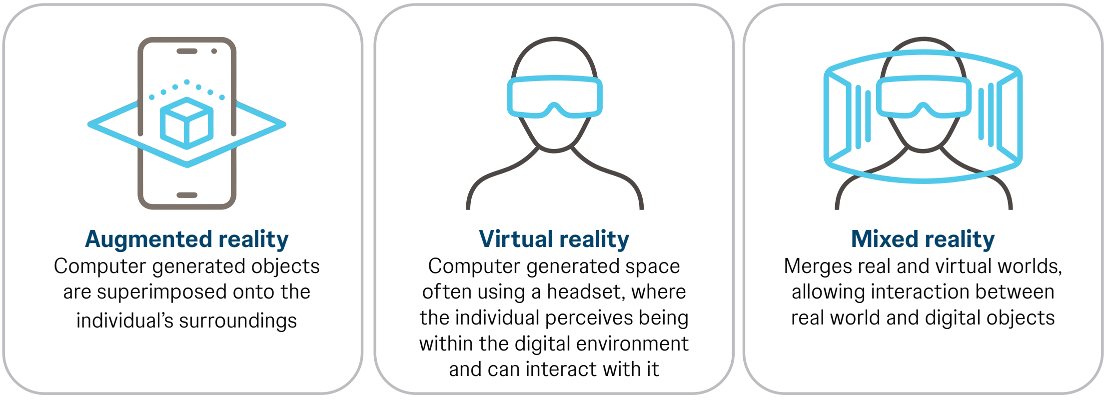

Figure 2. Augmented, Virtual, and Mixed reality definitions[62]

Digital Smart Lenses

Augmented reality, mixed reality and virtual reality, are terms found more often amongst tech blogs than the optical press (see Figure 2), but this has gradually been changing over the past decade. Frequent reports of smart glasses and contact lenses detail prospective features which include displaying of digital alerts such as text messages, weather information, and the potential to capture images and video recording. Several tech giants such as Sony and Samsung have been granted patents relating to smart contact lenses;[57-58] with the most recent press releases reporting on a collaboration between Menicon and Mojo vision.[59]

In addition to the entertainment and novelty aspects, smart lenses also possess the potential to help aid navigation, object detection, and to magnify aspects of the visual environment; all potentially useful applications for individuals with visual impairment.

The delays in these, sometimes theoretical, products reaching the market are a likely mix of technical and regulatory challenges. The microelectronics need to be small and lightweight enough to not impede oxygen permeability, positioned to avoid negative impact on vision, whilst retaining lens dynamics and comfort. An added challenge is displaying the digital images in such a way that is both visible, but not obstructive.[60-61]

The future

Most smart contact lenses remain in a developmental stage. While newer materials and technological advances may overcome any technical hurdles,[31] such as the challenges posed by including a power supply within a thin lens, wider discussions about privacy, safety, and the role ECPs might play, will all need to take place.

Myopia Management With Contact Lenses

It is reported that almost half the world's population will be myopic by the year 2050;[63] but a statistic of greater significance to practitioners in the UK and Ireland is that Western Europe is expected to reach this unfortunate milestone around a decade earlier.

In fact, by the year 2030, an estimated ~45% of the population in Western Europe will have already become myopic.[63]

Axial myopia is attributed to a discord between increasing axial length and the refractive capabilities of the cornea and crystalline lens.[64] Typically, a 1mm increase in axial length equates to approximately ~2.5 to 3D of myopia,[65-66] but differences can exist between different demographics. Earlier onset is often linked to greater risk of progression to higher levels of myopia.[67] For most individuals, progression will stabilise by the late teens,[68-69] however, an unlucky minority may continue to progress beyond this point.[68-69] As myopia and axial length increase, so too does the risk of developing sight threatening disorders.[70] Hence, inhibiting the onset of myopia, or at least minimising the risk of high myopia, could yield significant benefits.

The reasons underlying escalating myopia prevalence are believed to be multifactorial. Exposure to a myopigenic environment (a lack of time outdoors, near work, pursuit of higher education),[71-73] may increase an individual's risk of developing myopia, elements of which may be further compounded by an existing genetic predisposition.[74]

Theories of myopia development and progression are wide-ranging, but the design of many myopia inhibiting contact lenses relies, in some way, on the concepts of relative peripheral hyperopia (see Figure 3) and/or accommodative lag.

Methods of myopia management using contact lenses

Whilst time outdoors may deter the onset of myopia, for individuals who are already myopic various myopia inhibiting solutions are now available. Current solutions include spectacle lenses, contact lenses, and on the horizon is the potential for myopia specific pharmaceutical preparations.

Rigid gas permeable corneal lenses

Some older texts advocated the use of rigid corneal lenses to manage myopia, while this practice has now largely fallen out of favour it still persists in some parts of the world.[75] There is, however, limited evidence of a genuine treatment effect.[76] Any positive impact is thought to be linked to a mechanical flattening of the cornea rather than a slowing of axial elongation.[76]

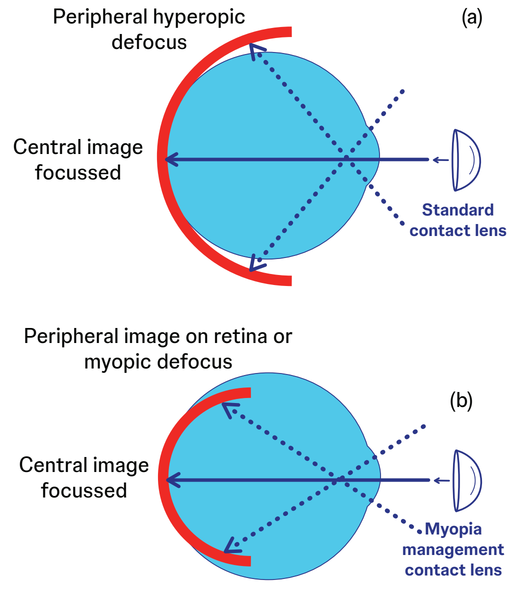

Figure 3. (a) Peripheral hyperopic defocus, relative to the central retina, is believed to influence central axial growth. Image shell falls behind retina for the peripheral region **(b)** Reducing this hyperopic defocus is believed to inhibit myopia progression. Not everyone agrees with this theory but, in general, optical lens designs for myopia management based on such theories appear to yield positive outcomes.

Orthokeratology in myopia

Orthokeratology (OK) has long been used as a reversible non-surgical alternative to refractive surgery. Lenses are worn at night to temporarily reshape the cornea providing temporary relief from refractive error during the day.[77-78] While in this article OK is referred to in the context of correcting myopic refractive error, the technique has also been used to correct hyperopic, presbyopic, and astigmatic errors.

OK affords freedom from spectacles and contact lenses during most waking hours, however, towards the end of the day corneal shape may begin to recover, causing a regression effect[76-77] of around ~0.50-0.75D. To counter this, a small amount of overtreatment is often incorporated.[78]

OK (or reverse geometry) lenses are unlike the rigid corneal lens designs intended for daily wear. There is a greater need for high oxygen transmissibility; stability, to ensure the same part of the cornea is treated consistently and, of course, a requirement to temporarily reshape corneal geometry.[79] The latter is achieved through use of a flat central base curve and the incorporation of a secondary lens curve which is relatively steeper than both the central and peripheral curves. This arrangement creates a tear reservoir or 'reverse zone' which facilitates lens stability whilst permitting rapid changes to corneal shape.

During lens fitting and aftercare appointments the cornea is closely monitored. Corneal staining, and lens binding are common complications associated with OK,[79,80] but amongst the most serious potential complications is microbial keratitis; the risk of which increases due to overnight lens wear.

It is now well established that use of OK inhibits axial length increase and therefore impedes myopia progression.[76,81]

While the mechanisms underlying this inhibitory effect are unclear, some researchers have attributed it to a redistribution of corneal cells, in which there is central corneal flattening, compared to relative steepening more peripherally.[82] In line with the theories of peripheral hyperopia; changes to corneal morphology could, therefore both reduce central myopia and induce peripheral myopic defocus.[83] Others suggest an increase in higher order aberrations[84] or changes to accommodative response may also play a role.[85]

The introduction of OK lenses specifically for myopia management may signify the growing interest of manufacturers in this area of practice. Yet, questions remain, including a need for further clarity and consensus around a potential rebound effect, the underlying mechanisms for the myopia inhibition effect, and a need for longer-term data in some population groups.[79]

Soft contact lenses for myopia management

Until recently a lack of licensed soft lens products, for myopia management, led some ECPs to off-label prescribing of multifocal lenses intended for presbyopia. While these lenses generated pockets of impressive data, a published review of myopia management, that was limited to randomised controlled trials (RCTs), concluded bifocal soft contact lenses were of little benefit.[76] Nevertheless, since this landmark review was undertaken, several key RCTs of soft lenses for myopia management have now been published, demonstrating an impressive slowing of both axial elongation and myopia using dual focus and extended depth of focus lenses.[86-87]

Evidence is still emerging, and recent work has shown how manipulation of the lens add can lead to further improvements in outcomes.[76] Future developments may give rise to a broader range of myopia management options including greater soft lens provisions for myopic astigmats.

The future

Myopia management is an area of active development, and while many of the previous barriers to uptake have now been addressed, gaps in the knowledge base remain. Not all practitioners will wish to undertake myopia control, but it is important for all to remain informed of the options so that patients can be appropriately advised.

In the future, there may be potential for contact lens ECPs to expand myopia management offerings through combination treatments, such as combined contact lens and low-dose atropine use.*

*Low dose atropine is currently not approved by any regulatory body for myopia control. Its use is considered off-label and is subject to local regulatory, legal and professional requirements that the ECP must understand and comply with to cover all aspects of off-label prescribing in their country. There is no intention for J&J to promote any off-label use and/or treatment.

Summary

The field of contact lenses continues to be an active area of development. In addition to this brief overview of new contact lens applications, additional opportunities and efforts to broaden contact lens practice are gradually reaching fruition, for example, a growing interest in telehealth,[88] dry eye treatments,[89] and innovations in ocular imaging.[90-91]

When keeping abreast of changes in the field, ECPs should be cognisant of relevant professional guidance. Regulatory steps to bring a product to market exist, amongst other reasons, to establish product and patient safety.

Key points

- In the recent past, new lens categories such as myopia management and photochromic lenses have been added to the practitioner's armoury.
- Early evidence is encouraging, however, as is the case for any new lens category, gaps in the knowledge base remain.
- Contact lenses of the future may be able to combine both detection and treatment of disease, but presently most remain in a developmental stage.

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