The soft approach to RGPs
Part 1: realising great potential

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For many practitioners the rigid gas permeable (RGP) contact lens is often overlooked. Inexperience, popularity of disposable lenses, negative publicity, technology and patient discomfort are often cited as the main reasons for practitioner negativity towards RGP lenses. Nonetheless, whether an experienced practitioner, or a pre-registration optometrist, RGP contact lens fitting remains a vital core skill. This first article in a four-part series analyses the current situation in the market sector, discusses what role RGP lenses have in today’s practice, and considers various materials available and the lens care systems which are currently used.

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Learning objectives
Be able to demonstrate an understanding of the range of rigid lens materials, designs and care systems currently available, and be able to recall rigid lens classification nomenclature (Group 5.1.3)

Learning objectives
Be able to demonstrate an understanding of the nature and range of rigid lens materials, designs and care systems currently available, and be able to recall rigid lens classification nomenclature (Group 5.1.1)

About the author
Mark Tomlinson has been in optics for 34 years as a dispensing optician, contact lens optician and optometrist. He currently works as a part-time optometrist and is a practice academy consultant for Alcon, where he lectures on various CET topics including contact lenses. He has previously lectured widely to optometric audiences, including pre-registration students and peers on a local level.
Since their introduction in the late 1970s, the use of RGP contact lenses has declined dramatically. By 1991, the number of rigid lens wearers was approximately 500,000, representing 39% of the UK contact lens market. At the start of the new millennium, this number had reduced to 399,000, representing approximately 7% of the contact lens market. It was also around this time that some experts were forecasting that the demise of rigid lenses was imminent, and the use of these lenses would be non-existent by 2010. Analysis of market reports over the last decade, however, shows a different situation. There were 324,000 rigid lens users in 2008, suggesting that the rate of decline was much lower. The trend continued with 316,664 wearers in 2010, with an upturn in 2011 to 320,548 wearers of rigid lenses, representing 8.7% of the UK market in patient numbers and 4.5% in market value. These figures suggest that RGP contact lenses represent a small but still significant sector in the contact lens market, bearing in mind that the value of the rigid lens market according to ACLM is currently approximately £10.4m.

The reduction in RGP use has left many practitioners feeling less confident about fitting RGP lenses, where lack of comfort is undoubtedly a major contributory factor; patients want instant satisfaction from their new contact lenses, and are often not prepared to wait for a gradual acceptance of RGP lenses over a period of a few weeks. It is also true that a little more skill and clinical judgement is required to successfully fit RGP compared to soft lenses; this factor however should not deter practitioners from fitting patients with rigid lenses, as most clinical situations suggest that very little extra ‘chair time’ is required.

Why use RGPs?
The increase in popularity of soft lenses over the last three decades has obviously been instrumental in the reduced prescribing of RGP lenses; soft lenses are now the lens of choice for most practitioners. That may lead many eye care professionals to the conclusion that the need to keep up to date or even fit RGP lenses is a redundant skill which need not be readdressed.

So, what then are the benefits of fitting RGP lenses?
• RGP contact lenses can provide excellent superior optics to ametropic patients. The enhanced optical quality is provided by stable lens surfaces, even during the blinking process. RGP lenses have no water content and are, therefore, resistant to dehydration
• RGP lenses provide superior vision for astigmatic corneas, generally neutralising the astigmatism of the cornea, by the resultant tear lens. The rigid lens provides a new refractive surface to the front of the eye with the tear lens helping to overcome any corneal irregularities
• High myopia/hypermetropia – greater control can reduce the edge thickness of the lens which prevents inferior decentration. High Dk materials can also increase oxygen transmission for higher prescriptions
• Patients who find soft contact lenses difficult to handle may also find that they split or tear lenses. In these situations, the extra rigidity and smaller diameter provided by RGP lenses will often prove to be beneficial
• RGP fitting is currently a core competency requirement for the GOC and College of Optometrists
• Currently, internet sales of RGP lenses are of little threat to High Street practices
• Potentially, any patient who is a good and motivated candidate for contact lenses, generally, should be a good and motivated patient for RGP contact lenses. Ultimately, the patient has to be given the opportunity to try the contact lenses to determine the likelihood of a successful outcome.

Gas permeable lens materials
Practitioners often poorly understand RGP lens materials, leaving the important decision of choosing the correct material and design of the final lens to the lens manufacturer. A comprehensive understanding of the development and variation between RGP materials can often help practitioners feel more at ease in fitting RGPs and know what remedial course of action to take when ‘trouble-shooting’ or refitting existing RGP patients with new lenses.

The original rigid contact lens, PMMA (polymethylmethacrylate, also known as Perspex), had very good optical characteristics; it also possessed stability and durability. The biggest drawback for long-term development was that PMMA did not possess oxygen permeability; thus, normal corneal physiology was compromised. CAB (Cellulose Acetate Butyrate) and TPX (Polymethylpentene) were also used to manufacture rigid lenses in the 1970s. However, their oxygen permeability, while slightly better than PMMA, was still not enough to maintain corneal integrity. In general, it was carbon-based molecules which formed the basis for these older lens designs.

Silicone acrylate (SA)
The first generation RGP contact lenses were made of silicone and methacrylic acid polymers, known as silicone acrylates.
The addition of silicone into the polymers provides exceptional oxygen permeability. Unfortunately, silicone contact lenses have a potential drawback; despite high oxygen permeability, the raw material is naturally hydrophobic, has poor wetting attributes, and rapid lipid deposition, leading to limited use of these lenses. By combining the attributes of PMMA with silicone, the lens achieved higher oxygen permeability; was also a better thermal conductor than PMMA and suffered from less warpage than CAB. The sacrifices, however, were decreased optical quality, decreased wettabillity, increased scratching and greater protein deposition.

**Fluorosilicone acrylate (FSA)**

In order to address some of the issues associated with SAs, the use of fluorosilicone acrylates was developed. This second generation of RGP lenses combined the silicone acrylate material with fluorinated monomers, giving the material significantly improved wetting characteristics, along with reduced protein deposition and improved oxygen transmission. In general, the silicone/fluorine part of the polymer gives the material its high oxygen permeability. Fluorine adds oxygen permeability (although not as high as silicone) and deposit resistance to the polymer. The permeability of fluorine is achieved by the mechanism of solubility whereby oxygen dissolves into the material and the fluorine literally soaks up the oxygen molecules like a sponge. Silicone relies on diffusion for its superior permeability, where it moves through the voids in the material. The methacrylate part of the polymer enhances optical quality and stability. The shortcomings of this material are generally down to its susceptibility to greater lipids and mucus.

**Hyperpurified delivery system (HDS)**

This material is a hyperpurified silicone, which has increased oxygen permeability for improved ocular health, as well as superior wetting properties. All this is achieved without compromising lens stability or machinability. HDS (Paragon Vision Services) is available in two versions with Dk of either 40 or 100 ISO barrers units.

**Fluorocarbons**

Fluorocarbons are composed of fluorine and methyl methacrylate with n-vinyl pyrrolidone added to improve surface wetting. The combination produces a lens with reasonably high oxygen transmissibility (Dk/t approximately 100), good wettabillity and resistant to proteins, but very flexible.

**Boston EO**

Boston EO has an innovative backbone known as Aerocon, which creates ‘space’ between the polymer chains, so as to provide oxygen permeability without the reliance of silicone. This allows about a 50% reduction of silicone, which creates a lens with better wetting properties and improved dimensional stability.

**Hybrid lenses**

‘Fluid-Surface’ (FS) technology employed in Hybrid FS ensures that any available moisture is bound on to the material surface. In contact with solution, the surface hydrophilic molecules bind with the solution to produce an extremely wettable lens surface.

**Surface treatments**

Surface treatments are used to improve the wettabillity of lens surfaces. There are three types of surface treatment, all of which change the lens surface chemistry so that surface wetting is greatly enhanced for better lens performance and longer lens wear. Manufacturers can also include a handling tint or a UV blocker.

The three treatments currently available are:
• Plasma treatment – used by Menicon RGP materials
• Graft polymerisation – used by Millennium lens
• Hydrolysable lens material – used by Contamac Hybrid F5 plus.

In summary, the most common monomers used in contact lens materials include:
• Methylmethacrylate (MMA), which contributes strength and hardness, but has poor oxygen permeability
• Silicone (Si), which increases oxygen permeability and flexibility, but has poor wettability
• Fluorine (FL), improves wettability and deposit resistance, to silicone-containing lenses.

RGP materials classification
BS EN ISO 18369-1: 2006/Dam1 sets out the new international standard method for the classification of contact lens materials. Each material is classified by a six-part code: Prefix, Stem, Series Suffix, Group Suffix, Dk range and Surface Modification code (see Table 1 for additional detail).

Oxygen permeability (Dk range)
This part of the code is a numerical designation which categorises the oxygen permeability in ISO Dk units at intervals considered significant in contact lens wear. For both lenses and materials, the oxygen permeability is measured according to ISO 9913-1 or 9913-2 (see Table 2).

Table 2 Oxygen permeability categorisation.

<table>
<thead>
<tr>
<th>Category</th>
<th>Traditional Dk units</th>
<th>ISO Dk units</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>&lt;1 Dk unit</td>
<td>&lt;0.75 Dk unit</td>
</tr>
<tr>
<td>1</td>
<td>1 to 15 Dk units</td>
<td>0.75 to 11.75 Dk units</td>
</tr>
<tr>
<td>2</td>
<td>16 to 30 Dk units</td>
<td>12 to 22.5 Dk units</td>
</tr>
<tr>
<td>3</td>
<td>31 to 60 Dk units</td>
<td>22.75 to 45.0 Dk units</td>
</tr>
<tr>
<td>4</td>
<td>61 to 100 Dk units</td>
<td>45.25 to 75.0 Dk units</td>
</tr>
<tr>
<td>5</td>
<td>101 to 150 Dk units</td>
<td>75.25 to 112.5 Dk units</td>
</tr>
<tr>
<td>6</td>
<td>151 to 200 Dk units</td>
<td>112.75 to 150 Dk units</td>
</tr>
<tr>
<td>7</td>
<td>Add new categories in increments of 50 Dk units</td>
<td>Add new categories in increments of 37.5 Dk units</td>
</tr>
</tbody>
</table>

hence, most deposits cannot penetrate these small fenestrations, but are limited to the lens surface. While microorganisms find it difficult to attach directly to the tightly-meshed lens surface, attachment occurs via the deposits on the lens surface, so cleaning and disinfection is an important part of the lens care regimen.

The earlier first generation SA materials are particularly prone to developing a hazy film of protein and lipids across the lens surface. FSA lenses develop less protein deposits, due to addition of fluorine to the material; however, they can still attract lipids and mucous layers. FSA lens materials have a relatively low surface tension which will encourage the spread of the tear film, which helps repel deposits. In order to maintain a consistent lower surface tension it is important not to store the lens dry.

Modern RGP solutions need to provide the following functions for healthy and successful lens wear:
• Wetting or conditioning
• Cleaning
• Disinfecting
• Storing or soaking.

Historically, there were often separate solutions for wetting, soaking and cleaning, and very often the need for additional enzyme (protein remover) tablets. Such a complex array of bottles is always going to discourage patient compliance, and corners will inevitably be cut.

Newer ‘combination’ systems such as wetting/soaking/disinfecting, improve the ease of compliance, and hence reduce complications and ultimately patient dropout.

Wetting/conditioning
Wetting/conditioning solutions have three principal uses:
• Minimise initial discomfort upon lens insertion
• Encourage an even distribution of tears over the lens surface upon application
• Acting as a buffer between the patient’s finger and the lens during application, to reduce contamination.

Lubricating and rewetting solutions are comprised of either wetting agents or viscosity-increasing agents, and are used to make RGP lens surfaces more hydrophilic to cushion the lens on application. The most common wetting agents are polyvinyl alcohol (PVA), which has both lipophilic and hydrophilic groups, and methylcellulose, a wetting agent which adds greater viscosity than PVA, to improve the cushioning effect.

Cleaning
Daily lens cleaning is important for removing deposits, such as lipids and mucous, and decreasing the number of potential organisms attached to the lens surfaces; this enhances the disinfecting action of the soaking solution. RGP cleaners usually have either detergent agents (surfactants), abrasive particles, friction enhancers or alcohol-based solutions as the methodology.

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for preparing the lens surface prior to storage and disinfection. It should be noted that particular care might be needed when using abrasive cleaners. In these agents, particles are added to increase the cleaning effect when rubbing the lens. Consequently, patients should be discouraged from rubbing the lens between the thumb and finger. Instead, the lens should be placed in the palms of their hand, and rubbed (after adding two to three drops of solution) in a circular motion; this method will minimise scratching and warpage of the contact lens.

Generally, the most efficient cleaners are separate from the conditioning and storage solutions, as opposed to the all-in-one multipurpose system; therefore, as practitioners we must decide on an individual basis whether increased patient convenience is worth compromised cleaning function.

Soaking
In general, soaking solutions have two main functions:
• To prevent the lenses form dehydrating when being stored in the lens case, which enables consistent surface wettability
• Provide this in a sterile, bactericidal environment.

It is also important to note that sterilisation is not the same as disinfection:
• Disinfection – defined as the destruction of micro-organisms, but not necessarily bacterial spores. Disinfection is a critical step in the care of any RGP contact lens. Incorrect disinfection has been shown to be a significant contributory factor in the aetiology of microbial keratitis
• Sterilisation – defined as the total removal of all living micro-organisms including spores. RGP lenses are highly unlikely to be 100% sterile.

Historically, rigid lenses were disinfected with either benzalkonium chloride, thimerosal or chlorhexidine gluconate. When formulating a disinfecting or preservative solution, there is a fine balance between a solution strong enough to effectively kill bacteria, yet gentle enough so as not to cause toxic reaction to the eye. Solution manufacturers have now generally moved towards using formulations using polyhexanide or polyquaternium-1 (polyquad) as the principal disinfecting agent.

Protein removal
Proteins from the tear film loosely attach to the surface of a RGP contact lens within a few minutes of lens application. Lysozyme is the main protein within the tear film, and one of its primary functions is to combat microbial activities on the surface of the eye. Oxidation, heat, ultra violet light exposure and drying can denature or alter naturally occurring proteins. Over time, these denatured proteins become more aggressively bound to the surface of the lens affecting the transparency and integrity of the lens surface. This may in turn also challenge the body’s immune system, causing the patient to produce an increase in antibodies which, in turn, can cause ocular side effects such as irritation, redness and itching.

Protein removal should be done frequently, so as to prevent the protein from becoming ‘denatured.’ Denatured protein is inherently difficult to remove, due to the fact that enzyme-based protein removal systems are far less effective on denatured protein.

When RGP contact lenses are not being worn, it is best if the patient keeps their lenses hydrated, preventing residue from drying up and building on the lens surfaces.

Conclusion
RGP contact lenses have come a long way over the last 30 years; however, there is little doubt that these lenses are not utilised in everyday practice, mainly because of initial discomfort. It is worth remembering that correct choice of vocabulary will enhance patients’ acceptance of RGP lenses, and words such as ‘rigid,’ ‘hard,’ ‘uncomfortable’ or ‘painful’ should be avoided. Practitioners should be proactive in maintaining their skills and knowledge with RGP lenses; the necessary confidence and opportunities will follow.