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# Applications of contact lens devices in the management of corneal disease

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**Abstract**

**Contact lens devices have a variety of therapeutic applications in the management of corneal diseases. A wide range of devices is available, some with very specific indications for use, including scleral lenses, silicone elastomer, collagen shields, large diameter corneal lenses, and silicone hydrogels. The traditional hydrogel contact lens is the most frequently used device and is indicated in at least 80% of cases. Common indications for use are relief of pain, promotion of corneal healing, mechanical protection and support, and control of corneal hydration, often a combination of effects being achieved. Visual improvement may be achieved but this is not the primary role of such devices.**
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## Introduction

In addition to optical indications, contact lens devices have a wide range of therapeutic applications in modern ophthalmology practice.[1,2] Such devices may be used to protect injured or diseased tissue, and to aid the return to a normal anatomical and functional state.

The principal and common indications for the use of such devices include:

- relief of pain,
- promotion of corneal healing,
- mechanical protection and structural support,
- control of corneal hydration,
- apposition of wound margins,
- maintenance of fornices, and
- drug delivery.

In clinical practice, a combination of effects is often achieved. Pain relief has been shown to be by far the most common indication for the fitting of a therapeutic contact lens device (TCLD).[3] Generally, any visual improvement is secondary.

In all situations where a TCLD is being indicated, the risk/benefit ratio must be considered. In many cases, the device will be worn on an 'extended wear' basis. The relative risks of extended wear are well documented[4] and indeed were noted in the early reports on the medical use of hydrogel lenses.[5]

A large range of devices are available for such application including:

- scleral shell,
- large diameter (limbal) corneal RGP lens,
- silicone elastomer lens,
- collagen shield,
- hydrogel lens, and
- silicone hydrogel lens.

## Scleral lenses

The application of scleral lenses in the management of corneal disease was described as early as 1882 when drug-impregnated shells were applied for the treatment of corneal abscess.

The major advantage of such lenses is that they cover the cornea and bulbar conjunctiva, and hence provide a robust protective mechanism to the ocular surface and will retain the tear film between lens and eye. They may be very useful for use in the very dry eye (eg in cicatrising disease, after chemical trauma) or where the ocular surface is particularly exposed or at risk from trauma because of irregular lid topography.

They can be difficult to fit and either an impression is taken of the eye or a fitting - set approach is taken. Generally, they are used in a 'sealed' format such that there is very little exchange of tear fluid. In recent years, gas-permeable materials have been used for the manufacture of scleral lenses.[6–8] This has greatly enhanced the success of their application and somewhat simplified their fitting. This type of

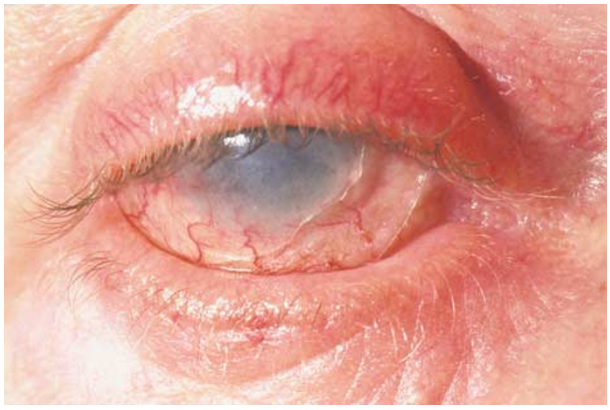

**Figure 1** Use of a sealed scleral lens in the management of Stevens Johnson syndrome. The lens protects the anterior eye and retains the limited tear film.

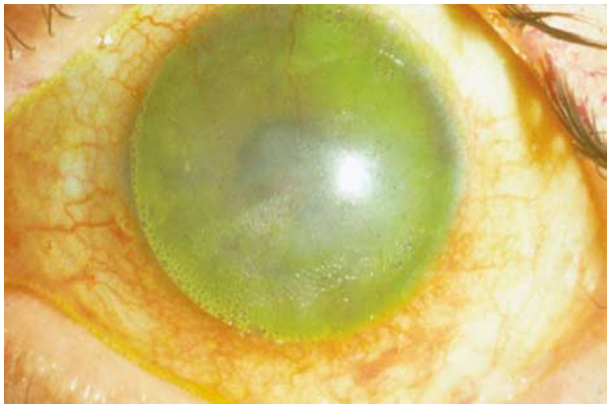

**Figure 2** Use of a large, limbal diameter rigid gas-permeable lens in the management of ocular cicatrising pemphigoid. The lens provides corneal protection and retention of the tear film.

TCLD is used on a 'daily wear' basis and arrangements must be made for safe lens handling by the patient or carer.

Figure 1 illustrates the use of a scleral lens in the management of Stevens Johnson syndrome.

### Large-diameter corneal RGP lens

Large-diameter corneal RGP lenses, as a consequence of their robustness, offer a similar application as the scleral lens. Clearly, they are far less occlusive to the ocular surface than a scleral lens. They may be suitable in situations where there is a dry ocular surface (eg ocular cicatricial pemphigoid, rheumatoid arthritis) and protection of the cornea is required. They are simpler to fit than scleral lenses and improvement in visual acuity may also result from their use.[9] A fitting set would normally be used for the evaluation of fit and a lens then custom-made for the patient.

Figure 2 illustrates the use of a large-diameter corneal lens in the management of ocular cicatrising pemphigoid.

### Silicone elastomer lens

The silicone elastomer lens was introduced to the market in the late 1970s as a consequence of the increasing evidence of the effects of chronic corneal hypoxia that resulted from PMMA and low water content hydrogel lenses of the time. Early trials showed great potential for their therapeutic application in the management of corneal disease.[10,11] Silicone elastomer has a high oxygen transmissibility and because it is not hydrophilic, lens parameters are independent of hydration and quality of the tear film. As a result of these specific properties, the silicone elastomer lens is considered to be a useful device

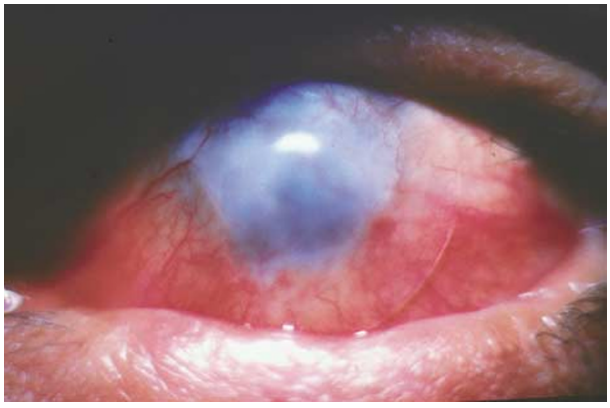

**Figure 3** Use of a silicone elastomer lens following a molten aluminium splash burn . In the very dry ocular environment the lens provides corneal protection and protects the cornea from the irregular scarred lids.

in the maintenance of corneal hydration (eg in Sjogrens syndrome) and when a very high oxygen transmission is required.[12,13] They are a relatively 'tough' device and will withstand the effects of irregular or keratinised lid margins.

However, the lenses are difficult to fit and tend to steepen unpredictably, resulting in a tight fit. This can result in great difficulties for the wearer , particularly in lens removal. Also, because of the nature of the chemistry of the elastomer, the lenses tend to attract a lot of surface deposits, particularly tear proteins and lipid, and need careful and regular cleaning. As a result, the lenses are generally worn on a 'daily wear' basis.

A fitting set is essential for the fitting evaluation.

Figure 3 illustrates the use of a silicone elastomer lens following a molten aluminium splash burn.

### Collagen shield

Collagen as a therapeutic lens material was first evaluated in the early 1980s.[14,15] Various reports showed encouraging results in their application as a corneal shield both as a device to protect the cornea and facilitate epithelialisation and also as a drug delivery system.[16,17] The devices, made from porcine collagen, are unique in that they dissolve *in situ* (being available with different dissolution rates from 6 to 72 h). These devices are therefore suitable only for relatively short-term use. Unfortunately, they are opaque in nature and hence are visually occlusive.

Such devices do not appear to have gained widespread usage.

### Hydrogel lens

In most ophthalmology services, hydrogel lenses provide the mainstay of TCLD application. Following the introduction of hydrogel polymers in 1960[18] and the development of a contact lens device from the polymer, numerous trials were conducted in the application of such devices for therapeutic purposes in the management of corneal disease.[19,20] Further refinements both in the development of different chemical makeup of hydrogels and also in the design and manufacture of lenses lead to further applications being developed. Such TCLDs are widely referred to as 'bandage lenses', although this term could equally be applied to certain other devices described in this paper.

Hydrogel materials consist of two components: a stable crosslinked polymer matrix and a rather less stable aqueous component that is able to exchange with the surrounding environment. The material therefore has a defined aqueous content dependent upon the precise chemistry of the material and also on other factors such as temperature and pH of the surrounding environment. Modern materials are available in a range of water contents from 38 to 80% water.

Oxygen supply to the cornea is an important factor when considering a TCLD and with hydrogel materials this is controlled essentially by water content and thickness. Oxygen supply is directly proportional to the water content and inversely proportional to thickness. Although lens thickness tends to increase with water content, most authorities recommend a higher water content to increase oxygen supply.[21]

Debris and deposits on hydrogel TCLDs may be a problem particularly in extended periods of wear. These problems tend to increase with higher water content lenses and also with materials having a more ionic chemistry.[21]

Selection of an appropriate hydrogel TCLD is determined, in part, by an understanding of the primary ocular disorder, the precise aim of use of the device and the anticipated duration of wear. Thinner, low water content lenses are tougher and are more appropriate to situations requiring mechanical protection and support. Higher water content lenses are the lens of choice when dealing with a very sick or fragile cornea or for extended periods of wear.

#### *Fitting and assessment*

For a high proportion of cases a lens of relatively 'standard' parameters will fit quite satisfactorily.. With the development of readily available and economical 'planned replacement' lenses, trials of their use as therapeutic devices have indicated significant success in up to 80% of cases fitted.[22,23]

The required back optic zone radius of the lens is generally determined empirically, as keratometry is often not possible. Usually it is not necessary to carry out precise corneal measurement —because of the relative thinness and 'draping' effect of modern lenses.

The lens is generally applied directly onto the cornea and an adaptation period of up to 30 min is recommended to allow stabilisation in terms of lacrimation, temperature, etc. If the patient is very photophobic and has marked blepharospasm it is useful to use topical local anaesthesia.

Assessment of fit involves:

- observation of corneal coverage,
- lens centration,
- lens movement of blink and manual displacement, and
- avoidance of 'fluting' of lens edge.

In cases of markedly irregular corneae a standard lens may not fit satisfactorily. In a busy corneal service it is recommended that a range of different lenses is maintained for use in these circumstances.

Follow-up of the case will depend primarily on the aim of use and the ophthalmic condition being treated. Contact lens fit is unlikely to alter greatly with time, unless corneal topography changes (eg associated with anterior chamber reformation after injury or glaucoma surgery) . Often the lens is used only for a short period of time but in some situations the regime is maintained for prolonged periods.

The indications for use of a hydrogel TCLD are extensive and diverse.[24] Figures 4–9 illustrate a number of applications.

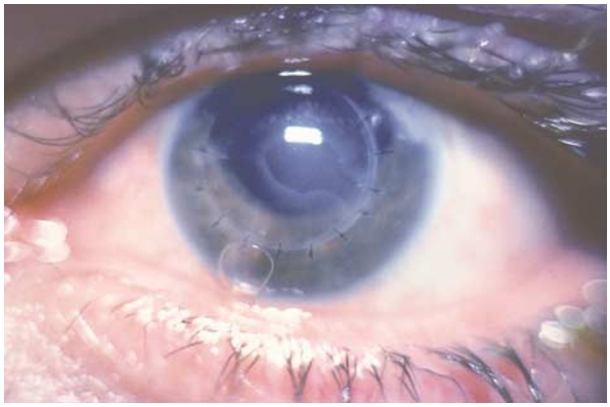

**Figure 4** Use of a high water content hydrogel lens in the management of poor epithelialisation following penetrating keratoplasty.

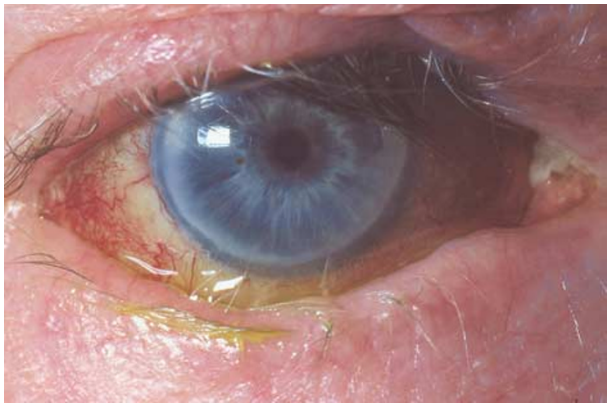

**Figure 5** Protection of the cornea in trichiasis using a low water content hydrogel lens.

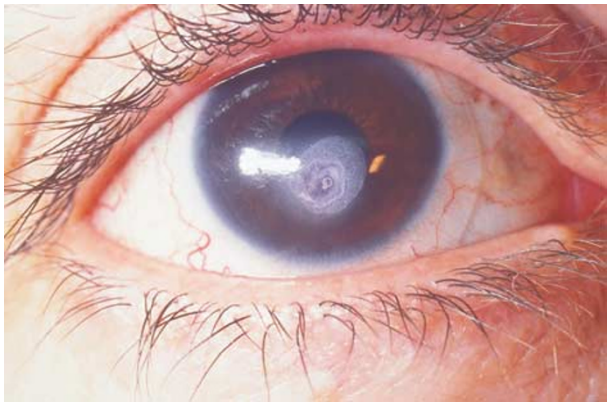

**Figure 6** A 'disposable' hydrogel lens used in conjunction with cyanoacrylate glue in the management of corneal perforation associated with rheumatoid arthritis.

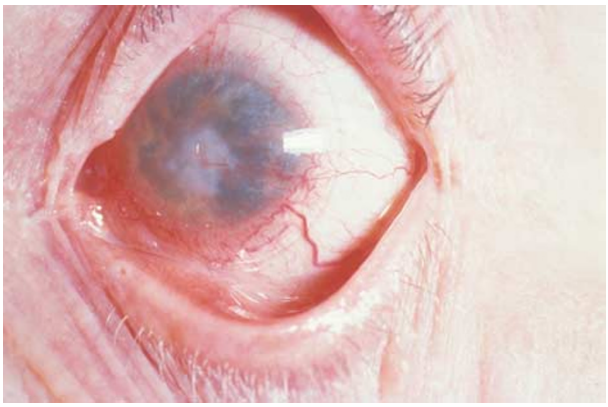

**Figure 7** The application of a hydrogel lens for pain relief in bullous keratopathy resulting from anterior migration of silicone oil in retinal detachment repair.

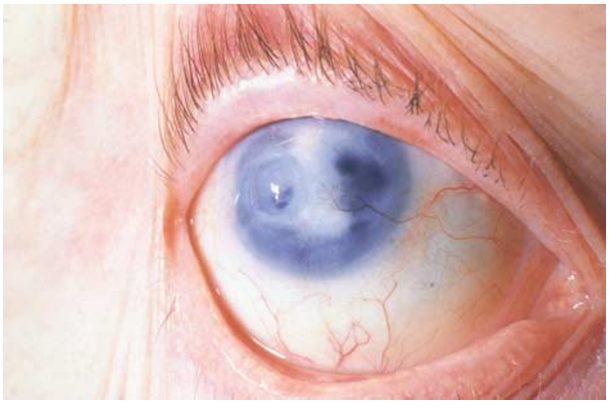

**Figure 8** A thick hydrogel lens may be used to provide mechanical support — this case illustrates a descemetocoele secondary to herpes zoster keratitis. Irregular corneal profile in such cases can often prevent satisfactory lens fitting.

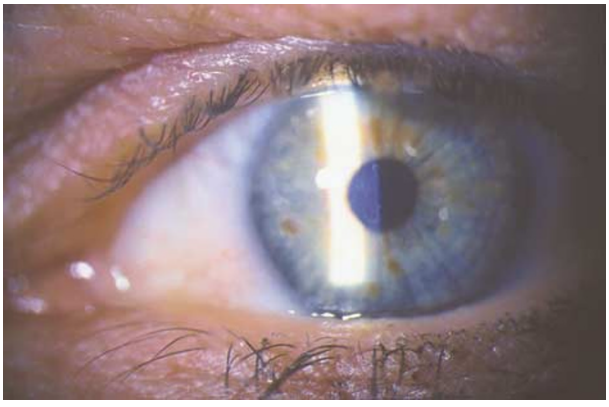

**Figure 9** Pain relief in corneal epithelial dystrophy may be achieved by the use of a high water content hydrogel lens.

### Silicone-hydrogel lens

A recent development in contact lens material technology has been that of the introduction of the silicone-hydrogel hybrid.[25] This is a soft hydrophilic lens with a significant silicone content. The effect of this is to produce a flexible lens with high oxygen transmission, greatly in excess of the standard hydrogel lens. The implication of this high transmissibility factor is that for extended wear of the device, the critical oxygen transmissibility level needed to limit overnight corneal oedema is satisfied.

The material has a relatively low water content (between 24 and 36%, depending on the product), which reduces the likelihood of dehydration and attraction of surface deposits, particularly compared with high water content ionic hydrogel lenses. The material is also thicker and stiffer than a standard hydrogel. Early reports of the therapeutic application of the silicone-hydrogel lens have been encouraging.[26]

### Complications of TCLDs

The use of all types of TCLD is not without serious risk.

The range of potential complications is similar to that posed to any contact lens wearer but potentially to a far more severe degree. The clinician must assess each situation on its own merits and ensure that the patient has access to medical back-up in the event of problems and that the patient is aware of the potential complications that might arise.

### Conclusion

Despite the significant advances in medical and surgical management of corneal disorders, a wide range of conditions are still managed using TCLDs. The hydrogel lens remains the most widely used, but in certain situations the other types of device described in this paper may be of significant benefit.

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