

Review

Modern scleral contact lenses: A review



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ABSTRACT

Scleral contact lenses (ScCL) have gained renewed interest during the last decade. Originally, they were primarily used for severely compromised eyes. Corneal ectasia and exposure conditions were the primary indications. However, the indication range of ScCL in contact lens practices seems to be expanding, and it now increasingly includes less severe and even non-compromised eyes, too.

All lenses that partly or entirely rest on the sclera are included under the name ScCL in this paper; although the Scleral Lens Education Society recommends further classification. When a lens partly rests on the cornea (centrally or peripherally) and partly on the sclera, it is called a corneo-scleral lens. A lens that rests entirely on the sclera is classified as a scleral lens (up to 25 mm in diameter maximum). When there is full bearing on the sclera, further distinctions of the scleral lens group include mini-scleral and large-scleral lenses.

This manuscript presents a review of the current applications of different ScCL (all types), their fitting methods, and their clinical outcomes including potential adverse events. Adverse events with these lenses are rare, but the clinician needs to be aware of them to avoid further damage in eyes that often are already compromised. The use of scleral lenses for non-pathological eyes is discussed in this paper.

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1. Introduction

Scleral contact lenses (ScCL) were linked to the first applications of contact lenses at the end of the nineteenth century [1,2]. However, corneal lenses and later soft contact lenses made ScCL nearly obsolete for a long period of time. The therapeutic advantages of ScCL continued to be reported in the peer-reviewed literature in the 1960s [3,4] but only a few specialized practitioners were fitting ScCL on a regular basis.

However, in the last few years, more companies have entered the ScCL market, and this was reflected in the research activity in this area. These lenses demonstrated therapeutic potential in their ability to successfully fit most patients with distorted corneas that were intolerant to other forms of vision correction including piggyback, hybrid or corneal gas permeable lenses [5]. For these reasons, these lenses are also known as “medically necessary contact lenses.” Tan et al. showed that 69% of their 517 eyes fitted with

ScCL had previously failed with other contact lenses [6,7]. Most of these patients would probably have been referred for a corneal transplant. Several reports show the potential of ScCL to delay or prevent surgery [8,9], which has an important impact on the costs involved in the health care of these patients [10]. Modern ScCL are an increasingly important part of the rigid gas permeable fittings in several countries.

2. Search criteria

A search was performed in PubMed on the 18th of November 2013 using different combinations of keywords as searching criteria. The outcomes are presented in Table 1. The most specific combination was represented by the junction of several keywords and reported a total of 102 papers, of which 86.7% were directly related to the field of ScCL. However, the sensitivity was quite low, retrieving only 36.7% of those references of interest. Instead, using a more generic combination of “scleral contact lens,” a total of 458 references were retrieved. In this case, despite a low specificity (only 36.7% of the references were relevant for the field of clinical application of ScCL), the sensitivity was higher because up to 68 papers

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Table 1
Different combinations of searching criteria, number of articles retrieved and specificity (% of articles directly related with the field) and sensitivity *assuming 162 as the 100% of interest.

Search criteria	N	% Related (specificity)	% Related not detected (sensitivity)*
"Scleral lenses"	2495	N.R	N.R
"Scleral contact lens"	441	36.7%	100%*
"Semiscleral contact lens" or "semiscleral contact lenses"	5	100%	96.9%
"Semiscleral lens"	5	100%	96.9%
"Mini scleral contact lens"	7	100%	95.7%
"Corneoscleral contact lens"	29	100%	82.1%
"Corneoscleral contact lens" or "Corneoscleral contact lenses"	29	100%	82.1%
"Scleral contact lens"	39	100%	75.9%
"Scleral contact lens" or "scleral contact lenses" or "scleral contact lenses" or "corneoscleral contact lenses"	98	86.7%	60.5%
"Scleral contact lens" or "scleral contact lenses" or "corneoscleral contact lenses" or "mini scleral contact lens"	102	83.3%	62.9%

N.R: not reported.

relevant to the field and not retrieved in the previous search were now obtained. Main confounders in the search were phakic lenses and vitreo-retinal surgery topics that included the words "scleral" and "lenses" simultaneously.

Using the combination suggested as the most sensitive and specific, almost 100 publications were retrieved. Fig. 1 illustrates the yearly rate of publications among those retrieved in the PubMed database during the last 50 years using this combination of terms.

3. Historical overview

The origins of contact lenses are intrinsically linked to scleral lenses. In fact, the first known contact lenses fitted to the eye were scleral lenses produced 125 years ago and made of blown glass shells [1]. The introduction of molding techniques for the glass lenses by Dallos in 1936 and the introduction of plastics for contact lenses in the 1940s by workers such as Feinbloom, Obrig and Gyofry were important breakthroughs for the development of this lens modality, according to Tan et al. [6].

These lenses could now be lathe-cut in a much more accurate manner to mimic the anterior shape of the eye. The use of oxygen permeable lenses, as first described by Ezekiel in 1983 [11], was another breakthrough, since these brought major improvements

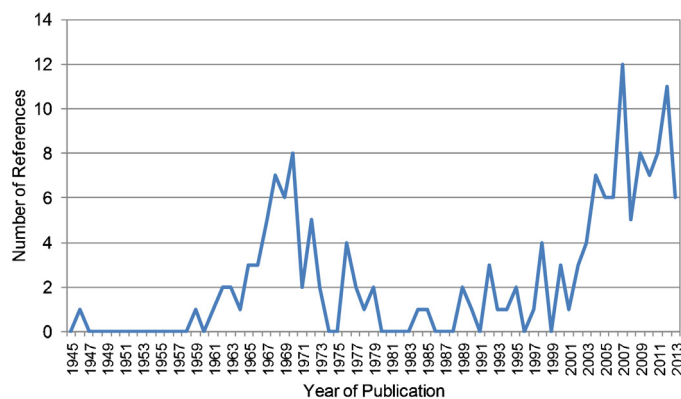


Fig. 1. Publication rate (yearly) in the field of scleral contact lenses as retrieved from the National Library of Medicine search engine (www.pubmed.com) by April 2013 using the following combination of keywords: "scleral contact lens" and after excluding the non-related references ($n = 162$).

in ocular health. Lyons et al. developed the impression-molded process for fitting rigid gas permeable ScCL in the late 1980s [12]. The subsequent development of the smaller, corneal gas permeable lenses and later of soft lenses temporarily stopped further development of ScCL fitting. But the ScCL is now fully back on the agenda as an option for more challenging eyes, with many ScCL designs currently available to practitioners including back toric, quadrant specific and bifocal lens designs.

A few years ago, only a handful of very specialized lens fitters around the world were capable of fitting ScCL successfully, and only a few manufacturers were making ScCL. Now many contact lens manufacturers offer ScCL designs. Improved manufacturing processes allow for better design, more reproducibility and decreased costs. Additionally, better lens materials contributed to better ocular health, longer wearing time and ease of lens fit. Recently introduced special websites and organizations are devoted to ScCL. Conferences and the ophthalmic literature are frequently reporting on ScCL fitting. It is in the interest of the patient that more practitioners familiarize themselves with the ScCL modality to provide best optical correction and fit available for the more challenging eyes.

4. Scleral lens designs

4.1. Oxygen supply to the cornea

ScCL are presently manufactured in highly oxygen permeable rigid gas permeable materials [13]. Current materials allow high levels of oxygen to pass through the lens compared to early PMMA lenses [14]. Despite this, ScCL create a stagnant, thick tear layer depending on the lens type. Typically, the larger the lens design, the more tear clearance behind the lens is – or can be – created. Corneal edema is not commonly reported in ScCL wear. Pullum and Stapleton looked at central corneal swelling in four normal subjects wearing sealed scleral contact lenses for three hours. The lenses used were of Dk 32, 59, and 115 with thicknesses of 0.15, 0.30, 0.60, and 1.20 mm. For a scleral lens thickness of 0.6 mm in a material with a Dk of 115, the mean central corneal swelling induced was less than 3%, they concluded [14]. But according to theoretical estimations, tear film layers thicker than 250 μm may induce edema under open eye conditions [15], in combination with a given thickness (350 μm) and the maximum Dk value of the rigid gas permeable lens material available (Dk 150). Following this estimation, as well as clinical experience, overnight wear of ScCLs should not be considered. Exceptions include if the state of the condition allows no other alternative, and the limitation of hypoxia is accepted as a risk factor [16]. Post-radiotherapy complications, Stevens–Johnson disease, and congenital or post-surgical lid defects have been some of the conditions contemplated by Tappin et al. for overnight ScCL wear [17], or persistent epithelial defects as reported by Rosenthal et al. [18].

4.2. Classification and nomenclature

Several different classification schemes for ScCL have been used in recent years, which have induced a similar diversity of names assigned to the different large diameter rigid gas permeable lenses. Van der Worp [19] and Jedlicka et al. [20] used similar criteria for mini-scleral (15.0–18.0 mm) and large-scleral/full-scleral lenses (18.1–25.0 mm and over), but not for the smaller semi-scleral and corneo-scleral lenses.

Recently (August 2013), the Scleral Lens Education Society (SLS) has recommended internationally recognized nomenclature for describing scleral lenses according to size and fit characteristics. Below is the recommendation of the SLS, which is summarized in

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