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Review article

Modern scleral lenses: Mini versus large

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ABSTRACT

The evolution of scleral lenses has led to new formulations of scleral fitting concepts and designs. The diameters of modern scleral lenses have been overhauled too and they are smaller comparing to the original ones. Nowadays, prescription of mini-sclerals supposedly seems in major extension and it appears indeed the necessity of some practitioner to differentiate the smaller mini-scleral lenses from larger mini-scleral lenses empathizing that they are the "smaller" ones. Therefore, it is maybe, necessary a definition of mini-scleral lenses referring to the landing zone width in relation to the horizontal visible iris diameter (HVID) and the limbus extension. The choice of the total diameter is crucial for a successful fitting and it depends majorly on patient's topographic patterns and anatomic factors. However, there are other important criteria for the selection of the scleral lens diameter based on oxygen supply, bubbles formation, mechanical stress on a toric sclera, ocular surface disease protection, entity of the vault over the cornea and distribution of the lens weight on the sclera. The advantages of mini-scleral lenses are various nonetheless in some cases large lenses are necessary. This paper presents a review of the benefits and disadvantages of both mini and large scleral lenses analyzing the conditions in which it may be better to prefer one diameter to another. A suggestion may be that to start fitting the smallest lens as possible, depending on the dimension of HVID and limbus width and consider larger lenses only when issues occur.

1. Preliminary considerations

In the last ten years there has been an evolution of rigid contact lens polymers and a greater understanding of contact lens dynamics on the cornea that have led to new formulations of scleral lens techniques and designs, such as those with one or more reverse zones, toric front surface and multifocal ones. Likewise, the total diameter (TD) of the modern scleral lenses are reformed because they are smaller than their predecessors. Some lenses have TD greater than the horizontal visible iris diameter (HVID) about only 4.5 mm still maintaining a full corneal and limbal vault. Hence, comparing to the original scleral lenses, it was necessary to redefine them with a different terminology introducing the new term, mini-sclerals. Scleral Lens Education Society (SLS) developed and recommend an international nomenclature [1–3], adopted subsequently also by the Scleral Lens Italian Academy (AILeS), describing the rigid lenses based on the point where they rest on the ocular surface and not on their diameter (Table 1).

Despite the nomenclature suggested by SLS, some specialists still call mini-scleral lenses in different ways (i.e. smaller-diameter lenses [4–6], smaller scleral lenses [7], large diameter rigid-gas permeable (LRGP) [8], etc ….). These terms are to differentiate the "smaller mini-sclerals", that may have a diameter greater than HVID less than 3–4 mm still maintaining a complete corneal and limbal vault, referring particularly to their use in normal eyes, from the "larger mini-sclerals", that can be more than 4 mm, up to 6 mm, greater than HVID. In fact, according to the nomenclature, mini-sclerals can have a diameter larger than the HVID up to 6 mm. Hence they can be, in some cases, about 17.5–18.5 mm.

Certainly, a 6 mm TD greater than HVID (17.5–18.5 mm) can be definite mini-scleral lens referring to the earlier scleral lenses that had a TD greater than about 18 mm. However, supposedly, it seems that the majority of scleral lenses currently have diameters less than 18–20 mm. Thus, specialists may need the use of other terms to differentiate smaller mini-scleral lenses from larger ones. Therefore, to avoid confusion in terminology, it is may be necessary to redefine mini-scleral lenses and large scleral lenses.

The purpose of this article is first to propose a definition of mini and large scleral lenses. Afterward, to make a review of relative benefits and disadvantages of mini and large scleral lenses. For clarification, in this manuscript the use of the term "scleral lenses" is referred literally to full scleral lenses. This means that corneo-scleral lenses are not considered.

2. Definition of mini and large scleral contact lens

A scleral contact lens can be defined as a lens that rests only on the sclera [9]. Thus, contact lens bearing on the cornea and in a more circumferentially on the limbus cannot be called scleral lenses.

The definition of mini-scleral or large scleral cannot refer to the

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Table 1
The international nomenclature recommended by the Scleral Lens Education Society.

Description		Definition of Bearing Area
Corneal		Lens rests entirely on the cornea
Corneo-Scleral		Lens rests partly on the cornea, partly on the sclera
Scleral	Mini-Scleral Lens is up to 6 mm larger than HVID	Lens rests entirely on the sclera
	Large Scleral Lens is more than 6 mm larger than HVID	

absolute value of the lens diameter because of its size is strictly related to the patient's HIVD. Either HVID and limbus width influence strongly the size of the vaulting zone chord. The limbus range is notoriously about 1.0 mm [10]. Therefore, the parameters that can be varied, depending on the preferences of the practitioner, are the extension of the landing zone (or bearing) on the sclera and the last peripheral zone which does not touch the sclera. So it is clear that the definition of mini-scleral contact lens, or large scleral contact lens, depends substantially on the extension of the landing zone.

Which should be the minimum value of the landing zone extension is controversial [2,3,11]. For a "mini-scleral" lens a minimum landing zone width may be arbitrarily considered about 1.0 mm and a maximum landing zone width 1.5 mm. The minimum limit about 1.0 mm may be based on the hypothesis that smaller width can represent a risk factor of discomfort and/or vessel compression and/or bulbar indentation. However, the crucial value for the subdivision between mini and large scleral lens is the maximum limit which may be considered 1.5 mm. This maximum value is based on the hypothesis that larger width may interfere with a more asymmetrical sclera. In effect, the outcomes of a recent report [12] appear to indicate that scleral asymmetry starts at the more symmetrical limbus and increases in asymmetry towards the extraocular muscles, but it is not clear yet at which distance from the limbus the scleral asymmetry starts. With higher values of landing zone width this enters in the field of "large scleral" lens (Table 2).

Thus the calculation of total diameter of a scleral lens can be achieved following this formula:

TD = HVID + limbus width (×2) + landing zone width (×2) + last - peripheral zone width (×2)

For example, if HVID is 11.5 mm and the lens has the maximal width of the landing zone, 1.5 mm and one last peripheral curve width 0.25 mm, then, that can be specified as a mini-scleral contact lens and is characterized by the following total diameter:

$TD_{max} = 11.5 + 2.0 + 3.0 + 0.5 = 17.0$ mm.

3. Characteristics of mini and large scleral lenses

As the prescription of scleral lens is constantly expanding, better understanding of the advantages and disadvantages of various fitting characteristics relating to lens diameter would be crucial to prevent complications and maintain ocular health although increasing visual acuity.

The choice of the total diameter is crucial for an optimal fitting and it is the first step in a scleral lens application. The TD is also important because it determines the lens sagittal height. The selection of the TD depends majorly on patient's topographic patterns such as: regular cornea or steep cone, pellucid marginal degeneration (PMD), keratoglobus and prominent graft; and anatomic factors such as: HVID, asymmetric or irregular sclera and lids interaction. Furthermore, individual practitioner preference, regional and national differences, and even cultural characteristics may have important influences in TD selection [3]. However, there are also other criteria for choosing the lens diameter based on oxygen supply, bubbles formation, mechanical stress on a toric sclera, lens handling, ocular surface disease protection and distribution of the lens weight on the sclera. The characteristics of mini and large scleral lenses are numerous and both have advantages and disadvantages.

Table 2
Formula to calculate scleral lens total diameter (TD). Classification of mini-scleral and large scleral lens.

TD Scleral = HVID + limbus width × 2 + landing zone width × 2 + last peripheral zone width × 2 Classification	
Mini-Scleral	Large Scleral
Landing zone ≤ 1.5 mm	Landing zone > 1.5 mm

3.1. Mini-scleral lenses

The benefits of mini-scleral lenses are manifold. Small scleral can be thinner [11], may need lower clearance [3–5,7] and avoid the interaction with an asymmetric sclera [7,11]. The reduced mass and less movement on the eye, compared to large lenses, may make a contact zone more tolerable [11].

3.1.1. Mini-scleral lenses are thinner

The lens thickness depends on the back vertex power and material of the lens and on the program developed by the lab. Thus, sometimes it is not possible to change lens thickness because it does not depend on the fitter. However, mini-scleral can be made thinner than large scleral because lens rigidity is greater with small diameters [11]. Thus, they may provide a better Dk/t for the cornea. In some cases, in which the endothelium is compromised such as in post-corneal grafts, it is necessary to have more oxygen [3], and that could be possible with a small thin lens.

Several researchers evaluated the oxygen transmissibility of contact lenses and the critical Dk/t levels necessary to avoid corneal edema [13–18]. Holden and Mertz [13] found that a Dk/t of 24×10^{-9} (cm mlO2)/(s ml mmHg) was required to avoid hypoxia for daily wear, and a Dk/t of 87×10^{-9} (cm mlO2)/(s ml mmHg) was necessary for extended wear. However, a revision of such criteria was proposed by Fonn and Bruce [14] to at least 125×10^{-9} units for extendent-wear. Harvitt and Bonanno [15] found that a Dk/t of 35×10^{-9} units was needed for alleviating hypoxia throughout the entire corneal thickness for open eye lens wear and 125×10^{-9} units for closed eye lens wear. Papas [16] found that a Dk/t of 125×10^{-9} units was indispensable to prevent limbal injection for continuous wear. Morgan et al. [17] indicated Dk/t levels of about 20×10^{-9} units for the central part of soft lens and 33×10^{-9} units for the peripheral part to avoid corneal edema in daily wear. A study [18] conducted to evaluate the critical level of Dk/t for daily wear corneal contact lenses stated that a Dk/t of 20×10^{-9} units or greater was necessary to avoid corneal edema. Corneal lenses provide additional oxygen to the cornea through the lid-activated pump. The exchange of post-lens tear fluid is between 10 and 30% per blink, and it depends on lens fitting and blinking characteristics [19,20].

Furthermore, numerous recent reports [21–30] have examined the corneal response following short-term mini-scleral lens wear, in which there is the post lens fluid layer thickness additional to lens thickness. Studies showed [21–26] a relatively low corneal swelling, on average typically below 4% even if lens and clearance thickness varied between a study and another. This amount of corneal swelling is within the range of physiological swelling that occurs with closed eye conditions. However, the results of these reports contradict theoretical models