Characterization of the geometric properties of the sclero-conjunctival structure: a review

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Abstract

● To revise the peer-reviewed literature on geometric properties of the scleral-conjunctival structure in order to define their clinical relevance and the potential relationship between their changes and myopia development or progression. A bibliographic search focused on the study of the geometry of conjunctiva and/or sclera as well as those studies evaluating the relationship between geometric changes in the scleral-conjunctival structure and myopia was carried out. Several studies have been performed with different diagnostic technologies, including optical coherence tomography, profilometry and Scheimpflug imaging, to detect geometric changes of the scleral-conjunctival tissue in different physiological conditions of the eye, after use of contact lenses and in different ocular pathologies. Likewise, these technologies have been shown to be a valuable clinical tool to optimize scleral contact lens fitting. Future studies should investigate new potential clinical applications of such technologies, including the evaluation of anterior scleral changes related to myopia, as well as to define standardized clinical standard operating procedures for obtaining accurate and reproducible clinical measurement of the scleral-conjunctival morphology.

● KEYWORDS: conjunctiva; sclera; profilometry; myopia; scleral topography

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INTRODUCTION

The conjunctiva is the transparent, thin membrane that covers a great portion of the anterior surface of the ocular globe and the internal surface of the eyelids. It has two segments: palpebral conjunctiva, which is the portion that covers the internal surface of both the lower and upper eyelids, and bulbar conjunctiva, which is the portion that covers the front part of the sclera, stopping at the junction between sclera and cornea[1]. These two portions of conjunctiva are continuous and have several relevant functions: to maintain the front surface of the eye lubricated and moist as well as the internal surface of the eyelids. Thus, they eyelids open and close without friction or inducing eye irritation, protecting the eye from dust, debris and infection-causing microorganisms. A great variety of small blood vessels are present in the conjunctiva that provide nutrients. Likewise, there are also special cells in this structure that secrete components of the tear film[1]. In spite of the large quantity of studies that have been performed about anatomical and histological aspects of this structure[2-4], there was a scarce peer-reviewed literature about their geometry which has been suggested to be mostly influenced by scleral geometry.

More than 80% of the surface of the eyeball is covered by the sclera, which is below the bulbar conjunctiva, extending from the optic nerve to the corneal area[5]. The junction area between cornea and sclera is called limbus. The thickness of the sclera is very variable, ranging from about 0.3 to 1.0 mm. The structure of this fibrous layer consists of collagen fibrils that are small fibers with an arrangement in irregular and interlacing bundles. This interweaving of fibers with random arrangement is the main factor accounting for the mechanical strength of the eyeball. As the sclera has a limited blood supply, it is almost inactive metabolically and can be considered as an avascular structure[5]. In conjunction with the intraocular pressure (IOP), the scleral structure is the main responsible for the maintenance of the shape of the eyeball, protecting the eye from damage, such as that produced by laceration or rupture.
as a consequence of an external trauma. This structure is also a sturdy attachment for the extraocular muscles allowing the movement and alignment of both eyes. As happened with the conjunctive, few studies have been conducted to analyse the geometry of this structure mainly due to the complexity of obtaining an in vivo measurement of such geometry. The objective of this study was to revise the peer-reviewed literature on geometric properties of the scleral-conjunctival structure in order to define their clinical relevance and the potential relationship between their changes and myopia development or progression.

METHODS
A bibliographic search was carried out using the Medline Mesh Database. The following publications were obtained and selected for these keywords: sclera, including the subgroups diagnosis, diagnosis imaging, growth and development: 41 articles; limbus cornea, including the subgroups diagnosis, diagnosis imaging, growth and development: 3 articles; corneoscleral topography: 6 articles; eye surface profiler: 8 articles. Furthermore, the following search equations were additionally used: sclera AND myopia: 74 articles; review AND myopia: 10 articles. From these 124 articles, 56 articles were confirmed to be repeated for the different search strategies used. Therefore, a total of 86 different articles were finally obtained.

Selection Criteria From the 86 articles found, a total of 38 articles were specifically selected for the current study. The selection criteria were articles in English focused on the study of the geometry properties of conjunctiva and/or sclera as well as those studies evaluating the relationship between geometric changes in the conjunctival-scleral structure and myopia. Articles in Chinese, Russian and German were excluded as well as articles focused on computer assisted modelization. Finally, a total of 26 articles corresponding to scleral analysis in human patients were obtained (Table 1). Likewise, a total of 8 articles corresponding to scleral analysis in human cadaveric eyes or animals were obtained (Table 2).

RESULTS
Measurement Methods of the Scleral-conjunctival Geometry Different technologies have been used to study the geometry of the sclera (Table 3). Several experimental methods like the electron and light microscopy, uniaxial mechanical tests, second harmonic generation imaging and the histomorphometric analysis have been used with cadaveric eyes and/or animals to define the scleral-conjunctival geometry, its evolution with age and its relationship with different ocular pathologies. Despite the important and accurate information obtained with these experimental methods, these last are not clinically applicable. Norman et al. analysed the thickness of the sclera by micro-magnetic resonance imaging. This is an effective and accurate technique to obtain the scleral radius (SR), but it is an expensive technique and somewhat impractical for a general clinical use. The Scheimpflug camera technology has also been used to measure SR, but Tiffany et al. showed that this methodology is not the best for this measure as it reaches an average error of 9.2%. The most recent technologies of anterior segment optical coherence tomography (AS-OCT) allow obtaining a 3D reconstruction of the anterior segment, but the acquisition is always done through a sequence of multiple scans that cover a limited area of the anterior segment of the eye (Figure 1). This technology has been shown to be valid for a precise characterization of the corneoscleral limbal junction in different meridians, allowing an estimation of scleral toricity and helping in the selection of the most optimum design of scleral lens to fit in each specific case. Likewise, the optical coherence tomography (OCT) is also useful for the evaluation of the ocular response to scleral lens wear. However, these types of devices are not currently providing elevation maps of the whole anterior surface and do not include advanced modules of simulation of scleral contact lens fit. One problem associated to the measurement with this technology as well as with the rest of devices evaluating the sclero-conjunctival geometry is that the manual retraction of the eyelids to obtain a larger area of analysis may induce a distortion of the original front anterior segment shape due to the effect of traction of the extraocular muscles (flattening of the curvature of the anterior sclera) and a non-controlled pressure on the eyeball.

Unlike OCT technology, the sMap3D system is based on multi-gaze profilometry using fluorescence staining for the detection of the ocular surface, with potentially less limitation by a scanty tear film, ocular surface anomalies, or corneal scarring or irregularities (Figure 2). The sMap3D measurements of scleral toricity and sagittal height (SAG) for a chord of 16 mm of diameter are repeatable, which suggests that they may be suitable to use for scleral lens fitting. This system has been shown to be accurate for measuring the actual surface topography (elevation of the ocular surface) even with irregular corneas, but could be more imprecise in the measurement of corneal power in normal corneas compared to systems based on Placido disc. Another potential problem with this technology is that in order to get accurate measurements of the scleral-conjunctival tissue, several images at different sight positions must be acquired and integrated using a computer program. Specifically, the measurement requires an image with a central sight, another with a downward sight and also with an upward sight with all the difficulties and potential deformations that this entails due to the pressure performed by the upper and lower eyelids over the eye and the eye muscles that deform the scleral structure by the tractions they produce during these measures.
<table>
<thead>
<tr>
<th>Method</th>
<th>Test subjects</th>
<th>Eyes</th>
<th>Patients</th>
<th>Technique</th>
<th>Scleral &amp; conjunctival thickness</th>
<th>Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCT</td>
<td>204 human eyes</td>
<td>204</td>
<td>102 patients</td>
<td>AS-OCT</td>
<td>AS-OCT</td>
<td>Age is the main factor influencing corneo-scleral profile.</td>
</tr>
<tr>
<td>OCT</td>
<td>48 patients</td>
<td>48</td>
<td>16 Asian, 16 Caucasian, and 16 Latino</td>
<td>AS-OCT</td>
<td>AS-OCT and MEsio-ocularographer</td>
<td>AS-OCT and MEsio-ocularographer</td>
</tr>
<tr>
<td>OCT &amp; MS300 topographer</td>
<td>50 patients</td>
<td>50</td>
<td></td>
<td>OCT &amp; MS300 topographer</td>
<td>OCT Extra peripheral corneoscleral data provide valuable data to analyse soft contact lens fit dynamics.</td>
<td>OCT Extra peripheral corneoscleral data provide valuable data to analyse soft contact lens fit dynamics.</td>
</tr>
<tr>
<td>Videokeratoscopy</td>
<td>19 patients</td>
<td>19</td>
<td></td>
<td>AS-OCT</td>
<td>AS-OCT</td>
<td>Stiff sclera in hyperopic and emmetropic eyes; biomechanically weakened scleral shell in most of myopic eyes.</td>
</tr>
<tr>
<td>OCT</td>
<td>30 patients</td>
<td>30</td>
<td></td>
<td>OCT</td>
<td>OCT</td>
<td>Ultrasonic biomicroscopy; OCT; SLO; Scanning laser ophthalmoscope; 3D: Three dimensions; ESP: Eye Surface Profiler; UBM: Ultrasound biomicroscopy; CCT: Central corneal thickness; AS-OCT: Anterior segment optical coherence tomography.</td>
</tr>
</tbody>
</table>
The Fourier domain profilometry with the Eye Surface Profiler (ESP) System consists of two blue-band projectors and a central camera with a yellow filter that captures an image of the front surface of the eye. The great advantage of this system is that it simultaneously analyzes an area of up to 20 mm diameter including more than 250,000 points, the supposed covering of all corneal tissue, limbus and large part of the sclera. This system allows obtaining a precise corneal-scleral topography (Figure 3). The full 3D scleral maps obtained with the

Table 2 Summary of the main findings of experimental studies in human cadaveric and animal eyes

<table>
<thead>
<tr>
<th>First author, year</th>
<th>No. of eyes</th>
<th>Method used for scleral measurement</th>
<th>Type</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norman[8], 2010</td>
<td>11 enucleated human globes</td>
<td>MRI</td>
<td>Human</td>
<td>Significant intra-individual and inter-individual variation in human ST related to axial length.</td>
</tr>
<tr>
<td>Shen[23], 2016</td>
<td>225 explanted human globes</td>
<td>Histomorphometric analysis</td>
<td>Human</td>
<td>An increase in scleral volume is associated to primary eye growth up to an age of 2 years.</td>
</tr>
<tr>
<td>Wang[28], 2018</td>
<td>18 rabbit globes</td>
<td>Electron microscopy and Instron 5566 universal testing machine</td>
<td>Animal</td>
<td>Changes in scleral mechanical properties facilitate the increase in axial length occurring in myopia.</td>
</tr>
<tr>
<td>McBrien[33], 2009</td>
<td>Postmortem human eyes</td>
<td>Different methods (review)</td>
<td>Human</td>
<td>Changes in scleral mechanical properties facilitate the increase in axial length occurring in myopia.</td>
</tr>
<tr>
<td>Wu[42], 2018</td>
<td>Mouse model of myopia</td>
<td>Single cell RNA sequencing</td>
<td>Animal</td>
<td>Myopia is promoted by HIF-1α signalling through myofibroblast transdifferentiation.</td>
</tr>
</tbody>
</table>

ST: Scleral thickness; MRI: Magnetic resonance imaging; RNA: Ribonucleic acid; HIF: Hypoxia-inducible factor.

Figure 1 Characterization of the corneo-scleral transition using OCT, showing that only a limited area of sclera can be visualized.

Figure 2 Characterization of the corneal-scleral surface with the sMap3D profilometer. A: Gaze images acquisition; B: 3 gazes stitched together; C: Normal 2D scleral elevation map; D: Keratoconus 2D scleral elevation map.

Figure 3 Characterization of the corneo-scleral surface with the ESP profilometer.

The Fourier domain profilometry with the Eye Surface Profiler (ESP) System consists of two blue-band projectors and a central camera with a yellow filter that captures an image of the front surface of the eye. The great advantage of this system is that it simultaneously analyzes an area of up to 20 mm diameter including more than 250,000 points, the supposed covering of all corneal tissue, limbus and large part of the sclera. This system allows obtaining a precise corneal-scleral topography (Figure 3). The full 3D scleral maps obtained with the
<table>
<thead>
<tr>
<th>First author, year</th>
<th>No. and type of eyes</th>
<th>Method used for the scleral measurement</th>
<th>Geometric data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shen[23], 2016</td>
<td>225 explanted human globes</td>
<td>Histomorphometric analysis</td>
<td>Mean computed scleral volume 648±136 mm³; mean choroidal volume, being calculated from or a serrata to the posterior pole 44.1±14.1 mm³</td>
</tr>
<tr>
<td>Hall[24], 2013</td>
<td>204 patients AS-OCT and MS300 topographer</td>
<td></td>
<td>Nasal horizontal CSJ 173.9°±3.4°; temporal horizontal CSJ 177.0°±2.4°; superior vertical CSJ 178.1°±1.9°; inferior vertical CSJ 177.9°±1.6°; nasal horizontal SR 35.5±39.4 mm; temporal horizontal 22.4±12.7 mm; superior vertical 29.3±17.4 mm; inferior vertical 33.5±29.6 mm</td>
</tr>
<tr>
<td>Wang[26], 2018</td>
<td>18 ocular globes from white albinus rabbits Electron microscopy and Instron 5565 universal testing machine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Read[27], 2016</td>
<td>111 subjects aged between 10 and 31 years of age AS-OCT</td>
<td></td>
<td>Mean ST across all locations (270±90 μm), nasal meridians (506±72 μm), temporal meridians (504±93 μm); thickness at the scleral spur location: temporal (653±54 μm), nasal (606±42 μm)</td>
</tr>
<tr>
<td>Hall[29], 2011</td>
<td>50 patients Videokeratoscopy and OCT</td>
<td></td>
<td>Nasal horizontal CSJ 173.7°±3.1°; temporal horizontal CSJ 177.6°±1.6°; superior vertical CSJ 178.3°±1.7°; inferior vertical CSJ 177.74°±1.4°; nasal horizontal SR 45.0±41.4 mm; temporal horizontal SR 25.3±14.8 mm; superior vertical SR 43.1±32.2 mm; inferior vertical SR 42.2±30.1 mm</td>
</tr>
<tr>
<td>Woodman-Pieterse[30], 2018</td>
<td>40 patients (20 myopes and 20 emmetropes) AS-OCT</td>
<td></td>
<td>Anterior ST: at 3-mm location (543±67 μm), at 2-mm location (504±60 μm), at 1-mm location (512±52 μm); total anterior wall thickness: at 3-mm location (752±91 μm); at 2-mm location (730±87 μm); at 1-mm location (751±81 μm); mean change in anterior ST with accommodation: 6 D, mean change: −8±21 μm; 3 D, mean change: −6±20 μm</td>
</tr>
<tr>
<td>Consejo[31], 2017</td>
<td>44 eyes from 22 healthy adults ESP</td>
<td></td>
<td>Mean scleral change at the nasal area of 390±330 μm was found in the young group when using a 4.0 D stimulus. This modification was more prominent in myopic eyes (nasal part: 560±350 μm vs emmetropes nasal part: 220±120 μm)</td>
</tr>
<tr>
<td>Read[32], 2016</td>
<td>19 patients AS-OCT</td>
<td></td>
<td>Mean conjunctival thickness: 249±42 μm; mean diurnal amplitude: 69±29 μm; mean diurnal amplitude: 21±8 μm</td>
</tr>
<tr>
<td>Piñero[35], 2019</td>
<td>21 keratoconus eyes and 88 healthy eyes ESP</td>
<td></td>
<td>SR healthy eyes: 13.3±1.29 mm; SR keratoconus eyes: 13.4±1.21 mm (right eye 14.0±1.31 mm and left eye 12.69±0.53 mm)</td>
</tr>
<tr>
<td>Kuroda[36], 2017</td>
<td>14 patients AS-OCT</td>
<td></td>
<td>Significantly thicker conjunctival stroma/episclera could be observed in eyes with diffuse anterior scleral compared to healthy eyes (403.0 vs 288.0 μm); scleral stroma thickness did not differ significantly among anterior scleral inflammation and healthy eyes (464.7 vs 434.2 μm, P=0.11)</td>
</tr>
<tr>
<td>Mohamed-Noor[37], 2009</td>
<td>124 human (31 with OHT, 31 with POAG, 31 with NTG, and 31 normal individuals) UBM</td>
<td></td>
<td>ST: OHT 755.03±69.58 μm, POAG 738.45±66.83 μm, NTG 708.74±71.58 μm, Controls 724.45±73.27 μm</td>
</tr>
<tr>
<td>Oliveira[38], 2006</td>
<td>140 patients UBM</td>
<td></td>
<td>Mean ST: at 1 mm 699±65 μm, at 2 mm 510.5±62 μm, at 3 mm 506.9±65 μm; Caucasians 692.8±56.9 μm, non-Caucasians 718.0±62.4 μm</td>
</tr>
</tbody>
</table>

CSJ: Corneo-scleral junction; SR: Scleral radius; AS-OCT: Anterior segment optical coherence tomography; ST: Scleral thickness; ESP: Eye Surface Profiler; OCT: Optical coherence tomography; UBM: Ultrasound biomicroscopy; NTG: Normal tension glaucoma; OHT: Ocular hypertension; POAG: Primary open angle glaucoma.
anterior eye height data obtained with this device in an invasive and precise mode by processing the tridimensional device also allows characterizing the anterior limbus in a non-invasive manner. With a specific estimate of the axial length, these scleral maps can be used to obtain a precise measurement of the SR modulus of the scleral tissue. Looser arrangement of scleral collagen fibrils has been observed in the posterior sclera compared to those that are present in equatorial and anterior sclera during the growth and development process, with the posterior sclera also showing a large number of small diameter collagen fibrils. Thus, the posterior scleral elastic modulus was found to be lower than that of the equatorial and anterior sclera. Considering that the structure of the anterior and equatorial sclera tends to be more stable than that of the posterior sclera, it may be more likely to change in some scleral-related diseases or alterations, such as in high myopia and scleral ectasia. These experimental findings are consistent with the results obtained by Read et al. in human subjects aged between 10 and 31 years.

Scleral and conjunctival thickness experience significant age and gender-related variations as well as changes according to the measurement location. Refractive error, however, does not appear to significantly influence the anterior scleral (or conjunctival) thickness in this population of young subjects. Concerning the corneoscleral junction, Tan et al. demonstrated that the angle and topography of the corneoscleral junction is different between ethnic groups (Asian, Caucasian, and Latino). Caucasians showed significantly higher angle and rougher surface of the corneoscleral junction than Asians and Latinos. Some differences among ethnic groups have been found, although these ethnic differences are not the same for all quadrants. The nasal quadrant has a much more pronounced corneoscleral angle and/or rougher corneo-scleral junction than Asians and Latinos. Some differences among ethnic groups have been found, although these ethnic differences are not the same for all quadrants. The nasal quadrant has a much more pronounced corneoscleral angle and/or rougher corneo-scleral junction (CSJ) profile. These results agree with the results obtained from Hall et al. who found a tendency of mean CSJ angle to be sharpest at the nasal area, becoming progressively flatter at the temporal, inferior, and superior areas. Steepest mean scleral curvature was also observed in the temporal sclera, with more similar curvature in the superior, inferior and nasal scleral planes.

Besides all this research, there are also some scientific evidence about changes occurring in the scleral-conjunctival structure with accommodation. Woodman-Pieterse et al. were the first in providing evidence of the presence of a significant anterior scleral thinning associated to the process of accommodation. These changes were found to be especially significant at 3 mm posterior to the scleral spur in myopic eyes. These regional differences may be associated with regional variations among refractive error groups of the thickness of ciliary body reported previously by other authors, regional differences in the ciliary muscle contraction with accommodation, or differences in the scleral response to these mechanical forces. Another research group have also demonstrated recently that the scleral shape experiences changes with accommodation, being more pronounced these changes in myopic eyes compared to emmetropes. All these evidences suggest that the geometry of the anterior sclera may change due to the action...
of ocular muscles (extraocular and ciliary muscles) during the accommodation process. In eyes that can accommodate, the mechanical effects of accommodative convergence dominate over those induced by the ciliary muscle, although both effects can occur simultaneously. Considering the location of the ‘anchor point’ of the main extraocular muscles responsible for accommodative convergence on the sclera, a more significant change could be expected in the horizontal meridian than in the vertical. The uniform effect of the ciliary muscle is present but somehow ‘masked’, as the not uniform contribution of extraocular muscles is more relevant[31].

Read et al[32] provided the first evidence of diurnal variations of anterior scleral and conjunctival thicknesses. This confirms that studies requiring precise measures of the thickness of these anatomical layers should be performed considering a specific period of day to take the measurements. Most of changes in these thicknesses occurred in the early morning immediately after waking, with a larger magnitude for those occurring in the conjunctiva. Thickness changes at other times of the day were of lower magnitude and not representing in most of cases a statistically significant change.

Concerning myopia, loss of scleral tissue and subsequent scleral thinning have been found to occur rapidly during axial myopic development[33]. However, this initial tissue loss experience a progress without significant alterations to the collagen fibril diameter distribution associated. In the long term, an increased number of small diameter collagen fibrils is present in the sclera of highly myopic eyes, which is consistent with findings in humans and is likely to contribute to the weakened mechanical properties of the sclera[31]. Additionally, corneal and scleral shapes have been found to be correlated in eyes with astigmatism, which suggests that astigmatism is not restricted to the corneal structure and could be be considered a property of the entire eye globe[34].

In the field of ocular pathology, some studies have been conducted to characterize changes occurring in the scleral-conjunctival geometric profile in different diseases. Piñero et al[35] detected in moderate and advanced stages of keratoconus a significantly more asymmetric anterior scleral-conjunctival geometric profile rather than in healthy eyes. These results suggest that a potential geometric alteration exists in both the diseased cornea and the anterior sclera of the moderate and advanced stages of keratoconus. Kuroda et al[36] demonstrated that the swelling of diffuse scleritis occurred within the episclera rather than in the scleral stroma. Since OCT visualises the morphology of the episclera and sclera, it can be useful for evaluating inflammation activity and therapeutic effects in diffuse scleritis. Mohamed-Noor et al[37] reported a correlation between central corneal thickness (CCT) and scleral thickness (ST) among eyes with normal tension glaucoma (NTG), but no correlation was seen among groups of eyes with ocular hypertension (OHT), primary open angle glaucoma (POAG) and controls. Likewise, Oliveira et al[38] demonstrated that the CCT only correlated with the ST at the scleral spur, with no relationship to axial length or refractive error. This study did not support the hypothesis that a thin CCT was a surrogate marker for abnormal scleral or laminar thickness as an independent cause of increased glaucoma risk.

**Anterior Sclero-conjunctival Geometric Changes and Myopia** Several studies have been conducted in the last years to analyse alterations of scleral structure in myopia due to an increasing interest of clinicians and researchers in this issue. These researches are crucial for new developments in scleral surgery and emerging minimally invasive therapies to treat scleral-related vision disorders and to reverse myopia-associated scleral extracellular matrix (ECM) remodelling events. It should be considered that the sclera does not behave as a static container of the eye content, being a dynamic tissue, with capacity of altering its ECM composition due to visual environmental changes to regulate ocular globe size and refraction[39].

Scleral changes in myopic eyes have been linked to altered expression of several genes, such as matrix metalloproteases (MMPs), fibroblast growth factor receptor-1 (FGF receptor-1), collagen (predominantly type-I), tissue inhibitors of MMPs (TIMPs), transforming growth factor β (TGFβ), and integrins[40]. Myopia has been linked to a reduction in the collagen subtype ratio (V/I), with some speculations about the relevance of this reduction on the alterations of the fibril diameter in myopic eyes. The active form of an enzyme associated with the breakdown of collagen and proteoglycans, MMP-2, is highly present in myopic scleras as well as reduced levels of TIMP-1. Furthermore, myopia development has been linked to the downregulation of collagen binding integrin subunits α1, α2, and β1 as well as TGFβ isoforms, particularly TGFβ1. Likewise, the upregulation of FGF receptor-1 have been also associated to the eye elongation development. Two second messengers have been implicated in studies based on the guinea pig model. In form deprivation myopia, scleral cyclic AMP and cyclic GMP levels have been also found to be increased[40]. Myopic eyes are characterized by scleral ECM remodelling, but the initiators and signalling pathways underlying scleral ECM remodelling in myopia are not well understood.

According to Harper and Summers[41], therapies promoting a slow ECM loss in the human sclera, through stimulation of proteoglycan and collagen synthesis, MMP activity inhibition, or collagen crosslinking procedures may be adequate therapeutic approaches to reduce the progression of myopia. The retinaldehyde dehydrogenase 2 (RALDH2) has been
identified as a visually regulated enzyme, being a potent scleral ECM remodelling regulator through its synthesis of all-trans-retinoic acid. This is another relevant evidence for creating new approaches to slow or prevent the myopia progression in children. Wu et al have demonstrated that hypoxia-inducible factor-1α (HIF-1α) signalling promoted myopia through myofibroblast transdifferentiation. In addition, HIF-1α-associated molecular changes can be prevented by antihypoxic treatments, thus avoiding myopia progression. These findings defined the relevance of hypoxia in scleral ECM remodeling and their relationship with myopia development. Scleral hypoxia identification in myopia is not only a concept for understanding the mechanisms of myopia development, but also promotes the design and development of new viable therapeutic approaches to control myopia progression in humans.

Despite all this evidence of structural scleral changes related to myopia, there are no scientific studies to this date reporting and defining the real relationship between anterior scleral-to-conjunctival geometry and myopia. Hu et al demonstrated that the average axial length/horizontal corneal radius of curvature ratio in eyes with pathological myopia decreased significantly after posterior scleral reinforcement. More studies are required to characterize this relationship between the geometry of the sclero-conjunctival and that corresponding to the posterior sclera.

CONCLUSION

Several studies have permitted to evaluate the accuracy of different diagnostic technologies for the measurement of the morphogeometric properties of the scleral-conjunctival structure, including OCT, profilometry and Scheimpflug imaging analysis, in different physiological condition of the eye as well as different ocular pathologies. The scleral-conjunctival geometry is an important parameter to define the SAG of the scleral lens to fit as well as its most adequate landing zone. Likewise, the measurements provided by these technologies allow the practitioner to define the level of peritoricity required if necessary, in each specific case. However, this is not the only potential use of this type of analysis, being also useful for the confirmation of some diagnoses and for the control of the development and treatment of different pathologies and myopia. All this research has been complemented with experimental studies demonstrating important morphological differences in myopic eyes compared to control eyes as well as morphological modification of the sclera during the myopia development. The use of profilometry, OCT and Scheimpflug imaging for the analysis of the sclero-conjunctival geometry should be studied further in order to find new potential clinical applications for this type of analysis as well as to define standardized clinical standard operating procedures for obtaining accurate and reproducible clinical measurement of the scleral-conjunctival morphology. Likewise, more studies are needed to characterize the relationship between the scleral-conjunctival morphology and posterior scleral geometry in order to define the potential usefulness of the measurements obtained with the technologies prescribed to monitor and predict myopic changes.

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Corneo-scleral topography and biomechanics


