Article ▸ Orthokeratology: An Update

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ABSTRACT

Orthokeratology is the reversible technique of reshaping the cornea by structural changes to the corneal epithelial cells. The effect is a reliable mode of myopia treatment which, despite an increase in higher order aberrations, provides good quality of vision for many patients. Orthokeratology may also have a positive effect on the accommodation/convergence system. An increased risk of microbial keratitis has been documented with orthokeratology. Patients must be informed of the risk of complications and maintain a thorough cleaning regime. Large scale evidence is mounting to support orthokeratology as an effective method of myopia control in children. The underlying rationale remains contentious, but the relative myopic shift of the peripheral retina is likely to be involved, possibly by influencing the focal/ambient visual system. The future may present methods to manage a larger range of refractive errors with orthokeratology and other myopia control techniques, such as modified spectacle lenses, dual focus soft contact lenses, or orthoculy (orthoC). However, at present, orthokeratology stands as being the most effective mode of myopia control. The purpose of this paper is to review the literature involving orthokeratology treatment since 2006.

Key words: aberrations, bacterial keratitis, myopia control, orthokeratology

Background

Orthokeratology treatment involves the use of rigid contact lenses to change the curvature of the cornea, resulting in a movement in refractive error towards plano.[1,2] It is believed that the concept of orthokeratology dates back to ancient China, when small weights were used on eyelids to reduce myopia. Modern day orthokeratology was developed by George Jessen in 1962.[3] Jessen fitted PMMA contact lenses that were flatter than the corneal curvature to flatten the cornea and reduce myopia. The lenses were worn during the day and were removed in the afternoon to provide clear unaided vision for a few hours.

In the late 1980's, with the development of rigid gas permeable materials to allow oxygen permeability and computerised corneal topographers to assist with lens design and fitting, overnight orthokeratology became a viable treatment for myopia. Reverse-geometry lenses have since been designed to improve the centration and refractive effect of the lenses.[4]

Swarbrick published a paper in 2006 that summarized the orthokeratology research at that time.[5] The purpose of this paper is to review the current literature involving orthokeratology treatment since 2006. The fitting techniques of orthokeratology are not reviewed.

Cornea

Orthokeratology creates a flattening of the cornea to reduce the overall refractive power of the eye. The corneal structural change is the result of a mid-peripheral thickening and a central thinning.[6] There is conflicting evidence on the time sequence of these changes, but ultimately the combined effect is responsible for the refractive change.[6,7]

Structural changes to the cornea can be observed after as little as 15 minutes of lens wear.[8] A study has shown that in the first 30 minutes, the corneal changes are almost universal irrespective of the refractive correction target.[9] After 30 minutes, the corneal changes are dependent on the refractive target of the custom made orthokeratology lens.

It is understood that a structural change of the epithelium is largely responsible for the corneal reshaping. Some studies have also shown mild stromal change,[7,10] although this has been more recently disputed/questioned[11] and may depend on the Dk/t (oxygen transmissibility) of the lens material.[12] Orthokeratology has no significant effect on the shape of the posterior cornea or the anterior chamber depth.[13,14]

The corneal epithelial cells change in both shape and size rather than an alteration in the cell layers:[7,11]

- The epithelial cells of the central cornea are compressed and flattened, but there is no loss or migration of the cells.
- These mid-peripheral epithelial cells are larger and more oval. The thickened mid-peripheral cornea maintains normal cell layers; however, there is a delayed surface cell exfoliation.

The use of orthokeratology lenses has not been shown to affect the microstructures of microvilli, microplicae, and desmosomes (intercellular junctions).[7] Fluorophotometry has been used to show that the permeability of the cornea is not compromised by the use of orthokeratology lenses.[15] Also, there are no significant short term effects[7] or long term effects (for at least three years)[16] on the endothelium.

The speed of effect and recovery (after removal of the lenses) from orthokeratology varies from patient to patient and is dependent on corneal resistance.[7] A lower resistance

allows a faster response and a faster recovery. Currently, orthokeratology lenses are designed to have an effect lasting for at least 10-12 hours of functional vision.[17] Experience has shown that some patients can miss a night of orthokeratology lens wear and still maintain good distance vision. Generally, the cornea returns to its original shape within three days, although trace residual corneal flattening of the cornea can extend beyond two weeks following discontinuation of wear.[18]

Quality of Vision

In general, orthokeratology fulfils patients' expectations. In one study concerning quality of life, patients aged 21-37 years old treated with orthokeratology were generally not troubled by clarity of vision, near vision, distance vision, diurnal fluctuations, or activity limitations.[19] However, symptoms of glare were common, particularly for those with high pre-orthokeratology myopia, and this tended to affect night vision performance, particularly when night driving.[19,20] Children, who do not require vision for night driving, responded particularly well. In a 2008 study of 108 children undergoing orthokeratology treatment, 90% reported the treatment to be satisfactory to very good.[21]

Aberrations

It is known that orthokeratology affects more than just the central refraction of an eye. Many studies have investigated the effect of treatment on higher order aberrations and contrast sensitivity.

The generalised conclusions are:

- Contrast sensitivity is reduced[22-27] including at mesopic (low light) levels;[19,28]
- 3rd order and 4th order aberrations increase (namely coma and spherical, respectively);[22,24,25,27-31]
- Corneal asymmetry increases;[20,31]
- Decentration of lenses increases unwanted aberrations, decreases contrast sensitivity,[30,32] and is associated with monocular diplopia and glare.[33] Decentration tends to be temporal and is more common with greater initial astigmatism and smaller orthokeratology lenses;[33]
- With high myopic corrections, the amount of higher-order aberrations increases.[27,28,31,32] contrast sensitivity decreases,[27,28,32] and patient satisfaction decreases;[20,28,34]
- Some higher order aberrations decrease during the day (the most change being noted in the first half of the day);[17]
- Over the first 10 nights of wear, subjective vision improves with an increase in treatment zone size and a reduction in defocus, despite an increase in higher order aberrations;[35]
- After the first 1-4 weeks of wear (depending on study's review period), the manifest refraction and uncorrected vision do not fluctuate significantly for at least one year;[24,25,36]
- After the first 1-4 weeks of wear (depending on study's review period), the manifest third and fourth order aberrations and contrast sensitivity do not fluctuate significantly for at least one year;[24,25]
- Orthokeratology is reversible. Visual acuities, refractive error, higher order aberrations, and contrast sensitivity return near to baseline 1-8 weeks after discontinuation (depending on study's review period).[22,23]

Changes in Accommodative and Convergence Function

Orthokeratology may have a positive effect on the support of the visual system. McLeod found that there was no clinical or statistically significant difference in accommodation and convergence function with orthokeratology.[37] However, this was disputed by Brand in 2008, who found that orthokeratology can improve accommodation and convergence function in children.[38] Brand hypothesised that a reduction in the peripheral retinal hyperopic defocus alters the ambient visual function, resulting in normalisation of convergence and accommodation.

Both studies had small sample sizes and had no age matched control group comparison. The following differences in the design and method may also have influenced the results (Table 1):

Table 1: A comparison of studies done by McLeod and Brand

	McLeod	Brand
Patient entry criteria	Patients excluded if diagnosed with binocular vision dysfunction.	Patients not excluded if diagnosed with binocular dysfunction (amblyopia/ strabismus not accepted).
Patient age group	10-14 years old	11.0-36.8
Testing style	Mostly performed in phoropter	All performed in free space
Battery of tests	Near phoria Near vergence ranges Near point of accommodation Fused cross-cylinder Near relative accommodative range	Phoria distance and near Near vergence ranges Near point of accommodation Accommodation facility MEM

Other Associated Clinical Signs that Have Been Documented

(a) Corneal dimpling

Corneal dimpling may be seen after the first night of orthokeratology lens wear.[39] The best corrected visual acuity is usually unaffected, although it can be affected if the dimpling is central. It has been suggested that the tear film between

the cornea and orthokeratology lens is implicated in dimple formation.

(b) Fibrillary lines

Fine, slightly curved fibrillary lines in the anterior stroma may be seen but have no known adverse consequences on vision or ocular health.[40] They have been documented in both otherwise normal and keratoconic corneae. Their origins are unknown.

(c) Reduced intraocular pressure readings

Tonometry requires an assumption about the central corneal thickness. Orthokeratology results in an artificially low reading of intraocular pressure (IOP) measurements due to the thinned central cornea. Non-contact tonometry is most influenced by a corneal thickness that is outside the expected norm.[41]

In a study of 90 eyes, the IOP readings were 13.5±2.5 mmHg before orthokeratology treatment and 12.4±2.7mmHg after 52 weeks.[42] While this is statistically significant and important to recognise, the author is of the belief that the effect is minor, especially for low corneal refractive changes, and it is unlikely that it would change the clinical management in view of glaucoma. To negate this effect and (presumably) obtain a more accurate interpretation of IOP readings affected by orthokeratology, central corneal thickness may be measured by pachymetry and taken into account when measuring IOPs.

(d) Lens binding and ocular discharge

Lens binding and ocular discharge are commonly reported problems during treatment.[21] These symptoms may be managed satisfactorily with ocular lubricants and lid hygiene.

(e) Corneal staining

A study has shown that on average, 40% of eyes undergoing orthokeratology treatment may show corneal epithelial staining; however, this was not associated with any adverse events.[43]

(f) Corneal sensitivity

Corneal sensitivity is reduced with extended orthokeratology lens wear, both centrally and peripherally.[44] This may dull symptoms and consequently delay the onset of treatment in the event of microbial keratitis.

Microbial Keratitis

Microbial keratitis associated with orthokeratology is well documented. Table 2 summarises the findings of many papers describing case studies of microbial keratitis associated with orthokeratology.

The common conclusions are:
1. Microbial keratitis is a potential vision-threatening complication of orthokeratology;
2. Patients must be made aware of the associated risk of microbial keratitis;
3. Vigilant cleaning of lenses and their accessories is crucial in reducing the risk of microbial keratitis;
4. Regular reviews of the cleaning regime may assist with compliance;
5. The most common pathogen is Staphylococcus aureus. Other implicated pathogens include Pseudomonas aeruginosa and Acanthamoeba;
6. The majority of the reported cases of microbial keratitis occurred in East Asia when regulations for orthokeratology were low; and
7. The use of tap water in the cleaning of lenses is now deemed inappropriate as a result of multiple cases of Acanthamoeba keratitis.

The large studies recently published investigating orthokeratology for myopia control (Table 3) did not report any adverse events. Lipson also concluded after a long-term study that there is no difference in safety with using orthokeratology lenses in children under 12 years compared with children over 12 years and adults.[58] These results suggest that these lenses can be safe for patients of all ages if used appropriately.

Risks of Microbial Keratitis Compared with Other Lens Modalities

A study using cats by Choo et al. which investigated the adhesion of Pseudomonas aeruginosa to orthokeratology and alignment fitted (AF) lenses showed that after 16 hours of wear (including time with eyes open and eyes shut), the orthokeratology lenses retained significantly higher amounts of bacteria than AF lenses.[59] The authors hypothesized that the possible causes were:
1. The lens design – the reverse curve zone of orthokeratology lenses may provide a reservoir for bacteria deposition; and/or
2. The corneal cellular response – the expansion or compression of the epithelial cells may cause a release of biochemical factors that affect bacterial adhesion.

However, results from Swarbrick's unpublished laboratory work have shown there was no difference in bacterial binding to the cornea with orthokeratology lenses compared with either RGP lenses or with no lenses.[60] She suggested that the overnight lid closure is possibly the key risk factor for the increased risk of microbial keratitis associated with orthokeratology. This theory is backed by Bullimore who has shown that the risk of microbial keratitis with orthokeratology is on par with other overnight contact lens modalities.[60] Regardless of the underlying reason, overnight orthokeratology lens wear

Table 2: Studies involving microbial keratitis associated with overnight orthokeratology.

Study	Authors	Sample group	Results	Conclusion
Paediatric Ocular Surface Infections: A 5 year review of Demographics, Clinical features, risk factors, microbial results and treatment[45]	Wong, Lai, Chi, Lam	138 consecutive patients under 18 years old at a tertiary ophthalmic centre	There were 9 cases of Orthokeratology-related microbial keratits (18%).	Lid hygiene and good contact lens cleaning is important.
Bilateral Acanthamoeba keratitis after Orthokeratology[47]	Kim, Kim	Case study of one 22 yo female patient	Patient developed bilateral Acanthamoeba disciform keratitis.	Acanthamoeba keratitis can simultaneously affect both eyes during overnight orthokeratology.
Non-compliance and microbial contamination in orthokeratology[46]	Cho, Boost, Cheng	38 longstanding (>6 months wear) orthokeratology patients	Contamination rates: Lenses 29% Artificial tears 32% Lens case 34% Tweezers 46% Suction holder 58% The most common isolated pathogen was *Staphylococcus aureus*. Only 52% of participants reported a high level of compliance to the cleaning regime.	Regular education of the risk of microbial keratitis and reviews of the cleaning regime should be provided to patients to improve awareness and reduce contamination rates. Accessories should be replaced regularly.
Orthokeratology associated microbial keratitis[48]	Shehadeh-Masha'our, Segev, Barequet, Ton, Garzozi	4 cases of overnight orthokeratology-associated microbial keratitis	*Pseudomonas aeruginosa* was cultured from all 4 cases. Patients were treated with intensive topical antimicrobial treatment. The final visual acuities ranged from 20/25 to 20/200.	Infectious keratitis is a significant vision threatening complication of overnight orthokeratology. Patients need to be educated on the appropriate lens hygiene and symptoms of keratitis.
Safety of overnight Orthokeratology for myopia: a report by the American Academy of Ophthalmology[49]	Van Meter, Musch, Jacobs, Kaufman, Reinhart, Udell, American Academy of Ophthalmology.	Reviews of papers from 2005-2007	Over 100 cases of infectious keratitis associated with Orthokeratology have been reported.	Orthokeratology puts the patient at risk of developing vision-threatening complications that they may otherwise not encounter. Risk factors for various complications could not be determined.
Trends in microbial keratitis associated with Orthokeratology[50]	Watt, Swarbrick	123 cases of microbial keratitis associated with orthokeratology have been reported between 2001-2007	More than half of the cases were reported in 2001, all of which were from East Asia when regulation was limited. *Pseudomonas aeruginosa* (38%) and Acanthamoeba (33%) were implicated.	The frequency of Acanthamoeba keratitis shows the importance of eliminating tap water from the cleaning regime.
Good visual outcome after prompt treatment of Acanthamoeba keratitis associated with overnight orthokeratology lens wear[51]	Wong, Chi, Lam	1 case study of a 9 yo boy with Acanthamoeba keratitis associated with orthokeratology	Patient responded well to treatment with final best corrected visual acuity of 20/25	Orthokeratology can expose patients to a higher risk of keratitis. Patients should be advised.
Orthokeratology-related infectious keratitis: a case series[52]	Chee, Li, Tan	5 case reports of keratitis between 2001 and 2006 at Singapore National Eye Centre	*Pseudomonas aeruginosa* was cultured from all patients. Final visual acuities were 20/40 or better.	Orthokeratology should be used with caution.
Severe Acanthamoeba keratitis after overnight orthokeratology[53]	Robertosn, McCully, Cavanagh	1 case study in 2006	Acanthamoeba keratitis associated with orthokeratology resulted in severe permanent vision loss. Complications included secondary angle closure glaucoma and a mature cataract.	The risk of keratitis associated with orthokeratology may be reduced with better lens hygiene.
Pediatric microbial keratitis in Taiwanese children: a review of hospital cases[54]	Hsiao, Yeung, Ma, Chen, Lin, Tan, Huang, Lin	81 case studies of children (<16 yo) with microbial keratitis at Chang Chung Memorial Hospital, Taiwan.	33 (40.7%) cases of microbial keratitis were associated with contact lens wear, and of those, 8 were related to orthokeratology lenses.	The risk of keratitis should be evaluated before commencing orthokeratology.
Microbial keratitis in orthokeratology: the Australian experience[55]	Watt, Boneham, Swarbrick	33 questionnaires completed by 53% of the members of the orthokeratology Society of Australia.	Patients with microbial keratitis associated with Orthokeratology were predominately female Caucasian young adults. *Pseudomonas aeruginosa* and Acanthamoeba were implicated.	Tap water should not be used in the lens care regime.
Acanthamoeba keratitis related to orthokeratology[56]	Lee, Hah, Oum, Choi, Yu, Lee	4 cases of Acanthamoeba keratitis associated with orthokeratology in Korea	In all 4 cases, the patient had improperly used tap water in their cleaning regime.	Acanthamoeba keratitis should be considered as a diagnosis particularly for patients with over 1 year duration on contact lens wear.
Infectious keratitis related to orthokeratology[57]	Sun, Zhao, Deng, Zhang, Wang, Li, Luo, Jin	28 cases of microbial keratitis associated with orthokeratology in China from March 2000 – August 2001	All patients were in the age group 10-21 yo. Acanthamoeba and Pseudomonas accounted for 75% of the cases. There were 2 cases of fungal keratitis.	Infectious keratitis is a severe complication associated with orthokeratology.

Table 3: Studies providing evidence that orthokeratology reduces myopic progression.

Study	Details of Study	Findings
Corneal Reshaping and Yearly Observation of Nearsightedness (CRAYON) study [64]	2-year study in the USA in 2007 compared 28 children (8-11 yrs old) undergoing orthokeratology with an age-matched control group of 28 children wearing soft or rigid gas permeable contact lenses.	Axial length and vitreous chamber depth were significantly slowed in the orthokeratology group by an annual average of 0.16mm and 0.10mm, respectively.
Myopia Control with Orthokeratology contact lenses in Spain (MCOS) study [65]	A prospective study in Spain compared 31 children with orthokeratology to 31 well matched children with single vision spectacle wear.	There were no changes in best-corrected visual acuity or significant adverse health effects from orthokeratology wear.
Controlling Astigmatism and Nearsightedness in Developing Youth (CANDY) [66]	20 myopic children not treated with orthokeratology were compared to 28 myopic children treated with orthokeratology.	Myopic progression of 0.36D per year in normally corrected myopia reduced to 0.03D per year with orthokeratology lens wear.
Overnight Orthokeratology lens wear slows axial eye growth in myopic children (ROC) [67]	14 children of Eastern Asian ethnicity wore an overnight orthokeratology lens in one eye and a conventional daily wear rigid (RGP) lens in the other for 6 months. The lens-eye treatment was reversed for a second 6 month period.	Axial length initially decreased with orthokeratology then returned to baseline at 6 months, whereas eyes with an RGP lens increased in axial length over the same 6 month period.
Corneal reshaping inhibits myopia progression (CRIMP) [68]	10-year retrospective study in Australia compared 32 children (under 18 yrs) utilizing orthokeratology with 32 well matched children utilizing spectacle correction.	An 86% slowing in myopia progression was found (- 0.29D change in control group and -0.04D change in orthokeratology group). 70% of orthokeratology wearers did not experience myopia progression.
Influence of overnight orthokeratology on axial elongation in childhood myopia [69]	Compared the axial elongation of 42 myopic children in Japan using orthokeratology lenses compared with 50 well matched children wearing spectacle lenses over a 2 year period.	Axial myopic lengthening has been shown to be retarded by 36% with orthokeratology over a 2 year period. The axial length increased by 0.39mm and 0.61mm in the Orthokeratology and control groups, respectively.
Stabilization of Myopia by Accelerated Reshaping Technique (SMART) study [70]	5-year longitudinal study still in progress in USA. Large scale (>150 patient multicentre evaluation) study comparing children (8-14yrs) using orthokeratology and soft contact lenses.	3rd year report: 85% reduction in myopia control; the orthokeratology test group progressed by -0.15D compared with the soft contact lens control group, which progressed by -1.02D).
Retardation of myopia in Orthokeratology (ROMIO) [71]	2-year study still in progress.	First year results showed a 41% retardation of axial length with orthokeratology compared with control group.

increases the risk for infection, and therefore, good cleaning and hygiene is essential.

Myopia Control

Orthokeratology is becoming a popular form of optical correction, particularly for children.[61] Its popularity for children may be linked to the theory that orthokeratology can reduce myopic progression. Large amounts of anecdotal evidence to support this claim are widely available, including case studies of subsequent myopia progression when treatment is stopped.[62]

Prior to 2006, the Longitudinal Orthokeratology Research In Children (LORIC) study was the only major study that gave credibility to the claim.[63] However, since 2006, multiple studies have provided strong evidence that orthokeratology can reduce myopic progression. These studies are summarised in Table 3. The studies show that orthokeratology can reduce myopic progression by 85-93.5% and slow axial elongation.

(a) How does Orthokeratology reduce myopic progression?

Twin studies have shown a strong genetic component in myopia; however, many studies also support the argument of environmental influences.[72] A well-recognized theory is that ocular growth and refractive development are regulated by visual feedback. Experimental evidence has shown that a local vision-dependent retinal mechanism can profoundly influence refractive development.[73] Furthermore, research now strongly supports the idea that predominately the peripheral optic error, or defocus, controls central refractive development.[73,74]

Lens-induced relative peripheral hyperopia in Rhesus monkeys causes central axial myopia, and it has been proposed that this relationship is true for other primates, including humans.[75] To test this theory, short term responses of human eyes to lenses were analysed. It was shown that small but significant temporary compensatory changes in axial length of human eyes have been found to occur in response to ±3D lenses after 60 minutes.[76] It is possible that more permanent myopia control seen with orthokeratology also works by this model.

Eyes with axial myopia are relatively more prolate shaped than are emmetropic or hyperopic eyes; consequently, they typically exhibit relative peripheral hyperopia in the horizontal meridian compared with the fovea.[77,78] Orthokeratology reduces myopia in the central 20[79] to 25[80] degree field, and it causes a contrasting relative myopic shift in the peripheral field.[79-81] It has been hypothesised that the reduction in the relative peripheral hyperopia is involved in the myopia control in children.[79,80] Mutti has recently questioned this rationale,[82] but the large amount of evidence still suggests that it is possible.

(b) A behavioural aspect

Our bodies, including our visual systems, are designed to perform best in a dynamic spatial (three-dimensional) environment. Repetitive and/or sustained movements can eventually alter the position to which the system returns at rest. This is both efficient and economical; however, it can result in undesired adaptations. Studies have shown a correlation between myopia and amount of near work, as well as with a lack of outdoor activity.[72]

It has been shown that a near visual stress response can be manipulated by plus lenses at near, optometric vision therapy, and environmental changes. Palassis hypothesized that the success is due to the effect that these techniques have on the focal/ambient visual systems.[83] Brand has proposed that the focal/ambient visual system is also influenced by orthokeratology.[38] He hypothesized that the peripheral retinal defocus secondary to orthokeratology alters the ambient visual function to affect accommodative convergence positively. Near work stress may cause visual re-organisation to result in myopia. It may therefore be extrapolated that the reduction of myopic progression seen with orthokeratology may also be a result of changes in the focal/ambient system.

(c) Why doesn't myopia control work with LASIK?

LASIK surgery works on a similar but permanent principle to orthokeratology to correct for myopia by flattening the central cornea and steepening the peripheral cornea. However, unlike with orthokeratology, myopia progression is common with LASIK if performed on a child who has an unstable myopic refraction.[84] Consequently, LASIK is generally recommended for patients over the age of 18 years, and the myopic refraction should be stable for at least 12 months. It has been hypothesized that the reason for the success of myopia control with orthokeratology that is not seen with LASIK surgery is related to the greater relative peripheral myopic increase in the corneal power created by a narrower optic zone and higher mid-peripheral steepening.[84]

(d) Can similar results be achieved with specialised spectacles or soft contact lenses?

Recent clinical trials involving Chinese children in Australia (at the Vision Cooperative Research Centre, Sydney) tested three designs of spectacle lenses (including Zeiss MyoVision lenses) that optically decreased the degree of relative peripheral hyperopia while maintaining full correction of the central refractive error.[85,86] The study showed a mild reduction in myopia progression over 12 months. The Zeiss MyoVision spectacle lenses, worn by a subgroup of children aged 6-12 years old with a family history of parental myopia, showed the best reduction of myopic progression (30%).

The Vision Cooperative Research Centre also studied the use of silicone hydrogel contact lenses designed to reduce relative peripheral hyperopia.[85] The rate of myopia progression was reduced by 54% over the six month study period. These results suggest that the modified soft contact lenses were more effective in myopia control compared with the modified spectacle lenses. The reasoning provided was that the treatment zone in the contact lenses remained centred during eye movements and was positioned closer to the line of sight.

Myopia control with dual focus soft contact lenses has also been studied recently in New Zealand.[87] They found that the myopic progression was reduced by 30% or more in 70% of the 40 children aged 11-14 years old compared with the fellow control eyes that used a single vision distance lens.

While the effect of these modalities is positive in myopia control, the results fail to match the 85-93.5% reduction in myopia progression seen with orthokeratology (Table 3). Further design changes may influence these findings, but to date, orthokeratology remains the most successful technique in managing myopic progression.

Hyperopia

Hyperopic orthokeratology is less effective than myopic orthokeratology. It has been postulated by Swarbrick that this is due to its limited mechanism of corneal reshaping. Hyperopic orthokeratology relies primarily on a para-central thinning of the cornea rather than a combination of the para-central thinning and central thickening which would be the reverse of myopic orthokeratology.[88] With less change achievable, the hyperopic prescriptions that can be corrected are minimal. Results can be relatively reliable up to +1.50 but become less predictable for a +3.50 target.[89] Better visual acuities are achieved with larger central steepened zones.[90] As with myopic orthokeratology, refractive change commences within the first hour of wear.[91] Most of the refractive change may be achieved in the first night of lens wear, and the stability of refraction improves in the first week of wear.[89]

Beyond Orthokeratology

The concept of orthoculogy (orthoC) has recently been proposed.[92] It involves changes in the lens (and sclera in high myopia cases) instead of altering the cornea as with orthokeratology. Flat rigid contact lenses are worn for up to two minutes. The draw from the contact lenses on the meniscus stimulates a neuromuscular response to re-establish distance focus by altering the curvature of the crystalline lens. After removal of the contact lens, the crystalline lens compensates by flattening out to rectify distance focusing.

Conclusion

Orthokeratology is becoming increasingly popular, particularly with children for whom the benefit of myopia control has become evident. New large, well-controlled studies have demonstrated that myopic progression may be slowed by 85-93.5% with orthokeratology.

Other techniques that have been developed to arrest myopic progression include soft dual focus contact lenses and modified spectacle lenses which aim to reduce peripheral hyperopic defocus. To date, these have not proved to be as successful as orthokeratology. Further research may provide a better understanding of how orthokeratology reduces myopia progression and may lead to improved techniques, including the possibility of orthoculogy.

Overall, orthokeratology is an effective mode of optical correction with the advantage of myopia control in children. Provided the risk of microbial keratitis is kept to a minimum

by vigilant care, orthokeratology is an appropriate option in myopia management, particularly in children.

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