Is Ortho-k OK?

Fitting techniques and safety issues

Accelerated orthokeratology, frequently referred to as simply 'ortho-k', is a technique which utilises reverse-geometry rigid contact lenses to flatten the central corneal curvature, reduce the corneal eccentricity and with it the patient's myopia and with-the-rule astigmatism.

The corneal moulding effect is retained by the use of the lenses on an appropriate wearing schedule. This is generally during the night with daytime removal or during some of the waking hours with removal at night. Care is required to ensure that the topographic change produced is characterised by an area of central flattening approximately 4-5mm across with an area of concentric corneal steepening and no peripheral distortion. This article illustrates fitting techniques and describes the use of corneal topography in ensuring a satisfactory outcome. The issue of the mode of action will be addressed as well as safety issues.

Orthokeratology may be defined as "a temporary reduction in myopia by the programmed application of rigid contact lenses"[1]. However, orthokeratology is not a new idea. It was first described in 1962 by Jessen[2]. Slowly flattening lens fitting by either increasing the radius of curvature of the central base curve (BOZR), as described by Jessen[2] and Grant et al[3], or by reducing the optic zone diameter (BOZD), as described by Coon[4], reduction of myopia and improvement of unaided vision could be made.

The evaluations made by Polse[5], Kerns[6] and Coon[4] found that when compared with conventional rigid lens fitting, orthokeratology had, on average, little further beneficial effect in terms of myopia reduction. The average improvement in each study was a further reduction in myopia of -0.50 to -1.00D. However, the procedure was shown to be safe. Interestingly, five of the 31 subjects in the study by Polse et al[5] showed a reduction in myopia of 2.00D or more, leading them to state that if the corneal response variations could be better understood and controlled, then the technique could be of significance clinically.

The introduction of reverse geometry lenses as a result of collaboration between Wlogydla et al[7] in North America led to dramatic and rapid reduction of myopia and represented a major advance in the technique. This time the average reduction in myopia was 2.75D over four months[8]. Hence the term 'accelerated orthokeratology' is used frequently for modern orthokeratology. These lenses still have a flat central fitting, but the steeper secondary curve is designed to prevent the decentration which would otherwise occur with flat lenses. It is these reverse geometry designs which made rapid change in corneal shape possible.

Further refinements to accelerated orthokeratology practice followed. These are the introduction of a fitting philosophy based on matching the corneal sagitta to the lens sagitta[9]. For a given cornea, an analysis is carried out, of which reverse geometry lens design is most appropriate to ensure both a reasonably large area of corneal flattening and good lens centration. In addition, so-called 'night therapy' is now practised in most developed countries. Here the lenses are worn whilst sleeping and the desired outcome is that no visual correction is required during waking hours. Both this and daytime orthokeratology treatment using reverse geometry lenses now have FDA approval.

The interest among practitioners in the procedure differs around the world. Perhaps the European country where it has been most utilised is the Netherlands – it is estimated that approximately 8,000 patients have been fitted in the last few years.

The essentials of accelerated orthokeratology are the reduction of myopia by the application of appropriately fitted high Dk reverse-geometry gas permeable lenses which reduce the corneal eccentricity and flatten the apical radius of the cornea. The maximum realistic changes which are possible using contemporary designs are up to -4.00 dioptres of myopia and 1.50 dioptres of with-the-rule astigmatism (negative axis horizontal).

Corneal topography

An instrument which measures the corneal topography is essential to the practice of accelerated orthokeratology[1]. Such an instrument should provide:

- Manual editing to reduce the influence of artifacts
- Sequential difference maps to demonstrate effects of treatment (comparing pre and post treatment corneal topography maps)
- Apical radius and eccentricity data to help in lens selection
- Information about the periphery of the cornea, including amounts of peripheral corneal astigmatism

ABDO has awarded this article 2 CET credits (CL).

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Module 1 Part 6

Modern contact lens practice

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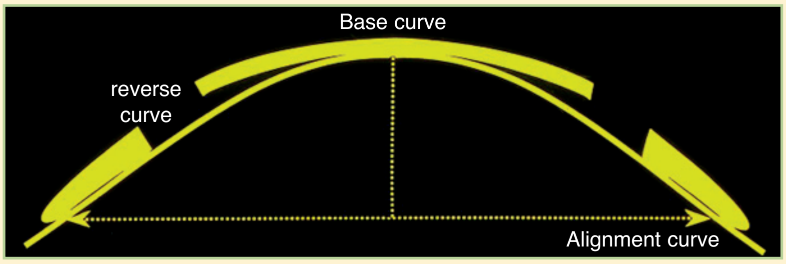


Figure 1a
Lens geometry build-up of an orthokeratology lens

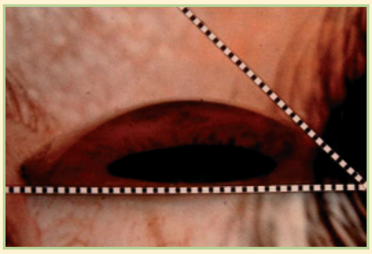


Figure 1b
Peripheral curve of the orthokeratology lens should be fitted in alignment with the slope of the peripheral cornea

As with any refractive procedure, it is essential to be sure that the topography is normal before starting an orthokeratology programme. Following the fitting and a subsequent daytime or overnight trial, the topography is measured again. The difference plot is examined to show the amount of change in the apical corneal power. This has been found to correlate to the refractive change[9]. The nature of the corneal shape change must be carefully scrutinised. This is very important because if the lens sits even slightly off centre, it will cause uneven peripheral steepening or compression. Neither of these is acceptable and can be present even with relatively good visual acuities and comfort.

A method of assessing corneal topography is essential if the practice of orthokeratology is to be carried out safely and successfully.

Lens designs

The basics of the lens design features can be broken into three components (**Figure 1a**). First, is the central (optical) zone. The radius of this is based upon the refractive power change intended. The tear film which is created behind this lens reflects the refractive change. In other words, patients are always able to see clearly with the lens on the eye: during the adaptation phase, during the night and sometimes simply when excellent vision is required (driving at night, for instance). A typical optic zone size of the lens is 6mm. The apical tear layer thickness will be approximately five microns.

The second curve to consider is the peripheral curve or alignment curve (**Figure 2b**). This curve actually represents the fitting curve and is responsible for centration of the lens, which is crucial in orthokeratology. It should be fitted in alignment with the slope of the peripheral cornea. The peripheral curves can be spherical or aspherical, or – as in some of the modern orthokeratology lens designs – a variable tangent to align the lens with the peripheral cornea. Tangents are straight lines not curves. Changing either alignment configuration or the tangent angle alters the sagittal height of the lens.

The major difference in design between most available lenses on the market today is the reverse zone. This connects the (fixed) optical zone with the alignment curve. The complexity of the reverse curve zones makes the three, four and five zone orthokeratology lenses which are currently available.

With orthokeratology, the aim is to create a tear layer thickness of about 5 microns over the apex of the cornea. If the exact sagittal height of the cornea were known, this would be an easy task. Unfortunately, corneal topographers are not able to give an exact estimate of corneal height. They will over or underestimate the sagittal height and practitioners should manually correct this based on fluorescein pattern evaluation or post-treatment topography data. Some topographers are better able to produce reliable and reproducible data[10] than others. Several corneal topography measurements should be performed to eliminate potential erroneous measurements and seek an average figure.

One potential way to evaluate the accuracy of the fit and the desired effect is to look at the fluorescein pattern. Evaluation of lens fit with fluorescein has been used ever since rigid lenses came onto the market. It has been proven to be highly useful in clinical practice, although the human eye is only able to detect fluorescein layers which are about 20 microns or thicker[11,12]. This means that everything thinner than 20 microns appears dark. Because of this, it is very difficult to fit orthokeratology lenses based on fluorescein evaluation alone. Analysing the corneal changes with a corneal topographer can be very beneficial in creating the desired lens fit in orthokeratology.

Figure 2a
Comparison of reverse geometry lens designs in overnight orthokeratology; subjective ratings at one month

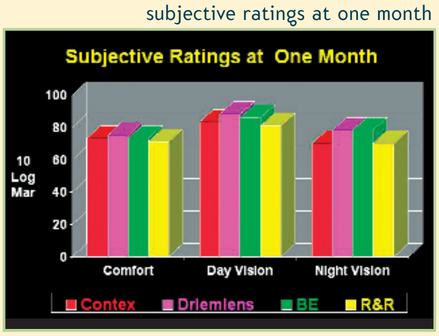
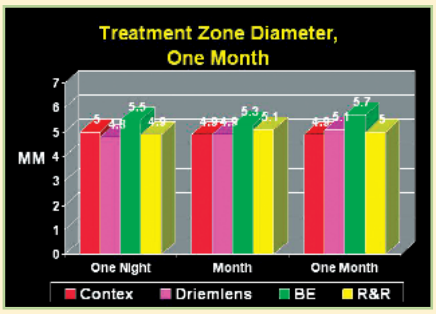


Figure 2b
Comparison of reverse geometry lens designs in overnight orthokeratology; treatment zone diameter



Manufacturers

Various designs are available from a number of sources. However, when various modern overnight reverse geometry lenses were compared[13] no dramatic differences in outcomes were noted (**Figures 2a and 2b**). The major difference is the fitting technique which is used. The study comparing the Contex, Driemlens, BE and Reinhart & Reeves designs found the subjective rating and unaided visual acuity not to be significantly different. The only slight difference which was found related to the treatment zone diameter: the BE lens showed a slightly larger result.

Patient selection

In general, suitable patients should have:

- Mild to moderate myopia (-0.75 to –4.00) where night therapy is to be used
- An adequate treatment zone diameter for their pupil size to avoid flare
- Mild (<1.50D) with-the-rule astigmatism and no against-the-rule or oblique astigmatism, as current designs tend to increase against the rule astigmatism and seem ineffective in reducing oblique astigmatism
- Central corneal (with the rule) astigmatism is easier to correct than limbus-to-limbus corneal astigmatism
- No contraindication to overnight lens wear such as diabetes
- A favourable response to a six-hour or an overnight tolerance trial in terms of physiology, refractive change and topographic change
- Realistic expectations. It is a fairly common misconception that at some point the usage of lenses can cease. Patients need to be reminded more than once that orthokeratology is currently a reversible process
- Although there is no age limitation in

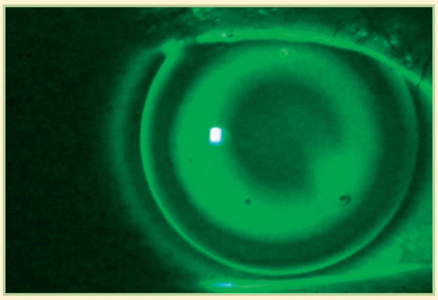


Figure 3
A well-fitted lens

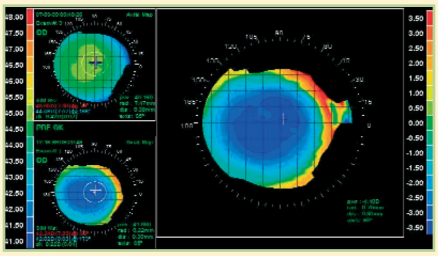


Figure 4
A perfect topographical difference map after lens fitting

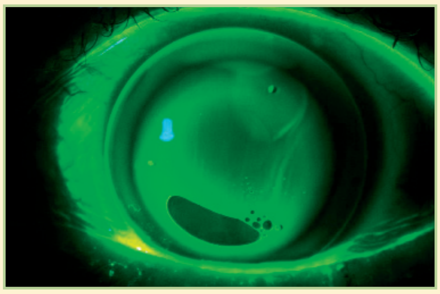


Figure 5
A tightly fitted lens

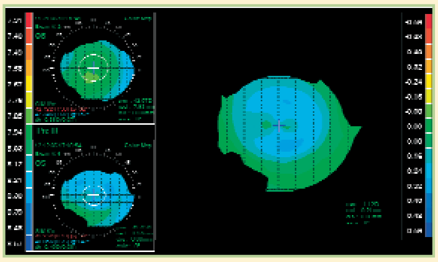


Figure 6
Central islands within the zone of flattening due to a slightly steep fitting

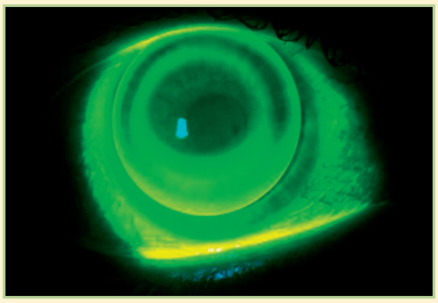


Figure 7
A flat fitting

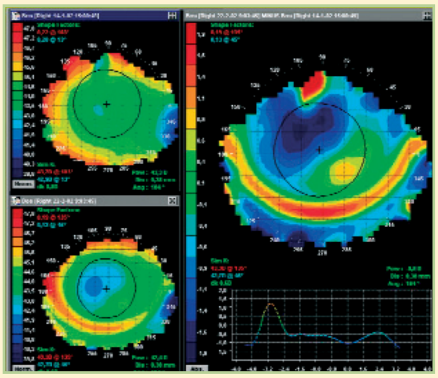


Figure 8
Difference map of an inferior zone of steepening (smiley face) induced by a flat fitting lens

orthokeratology, extra care should be taken towards hygiene and cleaning with all patients, particularly children

Fluorescein pattern

The correct pattern and tear layer profile is totally different to a conventional alignment fit (**Figure 3**). A well-fitting lens should display the following features:

- It must centre perfectly. This is the key to a good distortion-free result
- It should move 1-1.50mm on blinking depending on the overall size of the lens
- There is an apparent area of central touch 3-4mm wide, where the tear film is about 5 microns thick
- There is a surrounding wide annulus of fluorescein about 60 microns deep which forms the tear reservoir
- This is surrounded by a band of peripheral touch which supports the lens. This is about 0.75mm wide and should taper in from the tear reservoir out to the edge
- Finally, there is an edge band of fluorescein showing the same degree of edge clearance as a conventional lens (60-70 microns)
- Tears will be seen to flow through any fenestrations (if present)
- The final topographic pattern should comprise a well-centred zone of flattening about 5mm across with an annulus of peripheral steepening and no distortion. Detecting peripheral distortion is only possible with a corneal topographer and should refitting not improve the situation, then treatment should be discontinued (**Figure 4**)

Incorrect fitting

Figure 5 shows a tight fit. Features are:

- Wide area of central touch
- Narrower, shallower tear reservoir possibly with excessive bubbles. Peripheral touch band is wide and abruptly delineated from the tear reservoir
- Lens may decentre inferiorly
- Post-wear topography may reveal superior steepening or central islands (**Figure 6**)

Figure 7 shows a flat fit. Features are:

- Smaller area of central touch

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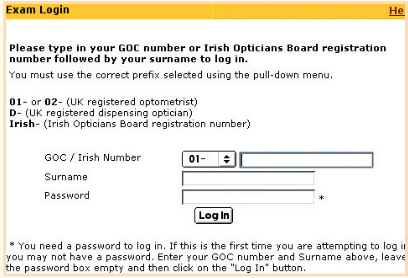

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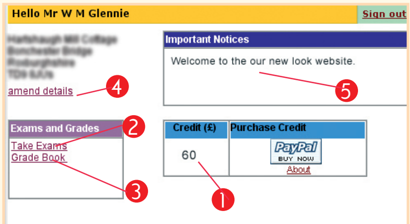

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Type of change	Mean (D)	Standard deviation (D)
ACP day 7	1.93	0.75
Regression	0.52	0.61
ACP day 30	2.23	0.57
Regression	0.43	0.44
ACP day 90	2.39	0.48
Regression	0.41	0.26

Table 1
The change in anterior corneal power and the speed at which that change reduced i.e. the regression

- Wide tear reservoir
- Peripheral touch band may be absent in areas or minimal
- May decentre superiorly and temporally
- Post-wear topography may reveal inferior steepening ('smile' pattern) and decentred flattening (**Figure 8**)
- There may be central staining with fluorescein

Patient responses

Initially, a suitable patient is given an overnight trial using well-fitting trial lenses. The typical patient will show only a very modest change in lens fitting when re-examined. The lens will be mobile (1mm movement typically) with a slightly less obvious tear reservoir. The myopia will have reduced by 70% of the intended correction with the associated increase in unaided vision. Topography will show a change in apical radius consistent with the change in refraction and a reduction in the eccentricity.

For modern designs, especially where higher refractive changes are required, the central clearance may be very low. In these instances, neither the topographic data nor the fluorescein inspection of the lens fit is accurate enough to be sure that this minute clearance is correct. It is the topographic and refractive change which occurs on the trial that tells the practitioner whether the fit is adequate. If the adverse topographic outcomes shown above occur, then the ordered lens is modified to ensure that it functions correctly. The change in fitting will be very small because in orthokeratology changes in lens sagitta of only 10 microns produce noticeable changes in lens fitting. Thus the changes made may be minor, but they have a significant impact on the outcome.

The effects

Mountford[14] analysed the speed at which the refractive change diminished during the day for 48 patients on an overnight treatment programme using early reverse geometry lens designs at seven, 30 and 90 days after initial fitting. He measured the anterior corneal power (ACP) objectively using the EyeSys corneal topographer after the patients removed their lenses in the morning and then eight hours later. He had a control group of nine non-wearers. These showed no significant change in anterior corneal power (0.04D). The orthokeratology patients showed the results presented in **Table 1**.

Thus by one month, the majority of the measured change in corneal power (and therefore reduction in myopia) has occurred and by three months it wears off at an average rate of 0.41D over an eight hour period.

Individuals do show variations in the speed of the regression and these are presented in **Figure 9**, but the variation is most of the time not very different from average.

Other workers have looked at the refractive effect of orthokeratology using first generation lenses. Nichols et al[15] performed a trial using Contex design lenses on 10 subjects over a 60 day period. At the end of the study, eight subjects completed the trial and the authors demonstrated a mean reduction in myopia of 1.83D±1.23D without any complications. Similar results were obtained by Lui et al[16] where 14 orthokeratology subjects wearing Contex lenses were compared against a control group of conventionally fitted rigid gas permeable (RGP) lenses. A mean reduction of 1.50D±0.45D was found in the orthokeratology group and only 0.01D±0.2D in the control group. These refractive changes are smaller than those reported by Mountford[17] and Harris et al[8] and as seen in everyday practice. It is likely that this is because the sagitta based fitting approach was not adopted by these later workers.

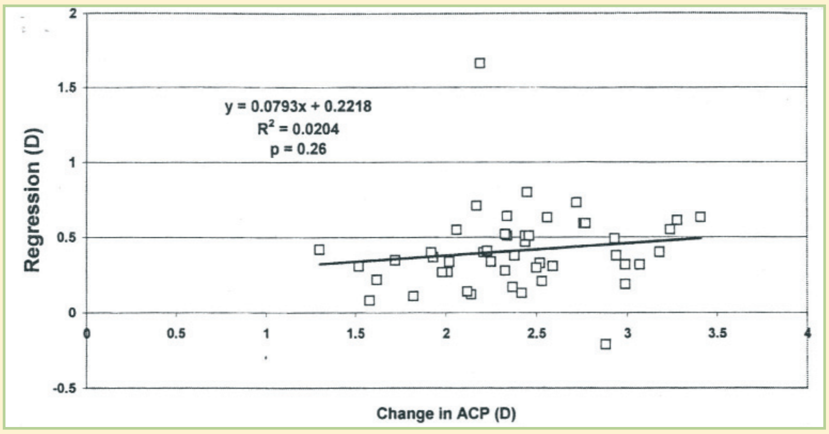

Figure 9
Regression plotted against anterior corneal power three months after fitting with single reverse geometry lenses[14]

Quality of vision

Typically, practitioners will use high contrast Snellen charts to measure the visual acuity after orthokeratology treatment. The study of Nichols et al[15] showed that there was a highly significant improvement in high contrast acuity using LogMAR charts. By the 30th day of their study, all subjects could see the equivalent of 6/7.5 or better unaided, representing a seven line increase in vision. There was a six line increase in low contrast vision. The corrected visual acuity should always be at least as good as the best corrected pre-fit visual acuity. This is usually the case, unless the cornea has been distorted by a poor fit which can be diagnosed by evaluating the corneal topography difference map. Patients rarely report visual problems provided their refractive error has been reasonably well negated by the treatment.

Comments about poor night vision and haloes or flare effects seem to be very rare in comparison with refractive surgery. This is actually surprising despite the relatively small treatment zones which are produced. There is, however, no peer-reviewed study published looking into the visual quality of orthokeratology patients. It is hypothesised that the gradual transition from central to peripheral zone (as opposed to the abrupt change after laser surgery procedures) is responsible for this effect.

Typical fitting problems

- **Centration.** This is the key to successful orthokeratology involving all types of lenses. Assuming the fit is optimal, increase lens diameter and redesign the lens geometry to maintain an equivalent fit
- **Binding.** Overnight binding is very common, but lenses will usually release shortly after waking. If not, they must be freed before removal with a lubricant and pressure applied to the sclera below the lens, allowing tears to percolate behind the lens. Extra care towards potential contamination of the lubricant and the preservative should be taken (see 'Corneal staining')
- **Bubbles in tear reservoir.** Usually a sign that a lens is too steep, but can occur in well-fitting lenses and reduces over time. Reducing diameter may be effective when bubbling is excessive
- **Excessive or inadequate movement.** Increasing or decreasing the diameter after altering the B.O.Z.D to compensate is recommended

Mode of wear

Night therapy is now the generally favoured approach to modern orthokeratology. The patient wears the lenses at night and removes them in the morning, thus being free of daytime contact lens wear. This should be termed overnight, rather than extended, wear. The object is to achieve good vision all day without any correction and without significant regression of the effect during the day. If night therapy is not undertaken, then daytime wear is instigated following the trial and the wearing time reduced to the minimum which will sustain the refractive correction once this has been attained.

Aftercare

It is recommended that one re-examines the patient:

- After the first night of wear in the early morning with the lenses in
- Early morning after three to four days
- Early morning after one week with lenses removed that morning

The vision may be 6/6 at this stage. If all looks well, re-check weekly for two weeks and then monthly. If the fit is not perfect, then the lens is re-ordered.

Once the patient is about +0.25D in the afternoon following lens removal that morning, it is appropriate to consider reducing lens usage to every second night of wear. The patient is then seen in the morning following no wear the previous night. About one-third will be able to reduce wear to every other night within two months. It is important for consistency to schedule after-care checks at the same time of day. To correct the residual myopia during the day in the initial stages, daily disposable soft lenses can be used, or old spectacles worn. Some advocate day and night wear to accelerate the effect during the adaptation phase.

Once a satisfactory outcome has been reached, the corneal topography pattern is stable and the wearing pattern has been allocated, follow-up can take place at six monthly intervals.

In terms of success rate, the general finding among practitioners is that once a patient has successfully completed an overnight trial, the drop out rate is very modest: of the order of 15% over a three year period. However, in the authors' experience, only 40% of patients contacting the practice with an interest in orthokeratology fall within the suitability criteria and of these approximately 50% go ahead with the treatment once examined. On a positive note, those who do not go ahead, stay with the practice for alternative treatments.

How orthokeratology works

There is now no doubt that modification of the anterior surface power of the cornea is occurring during orthokeratology. The question is whether this is a result of bending of the cornea, stromal thickening, redistribution of the epithelial cells or because of a combination of these. Currently, the answer is not known with certainty, but the epithelial model seems to have most evidence in its favour.

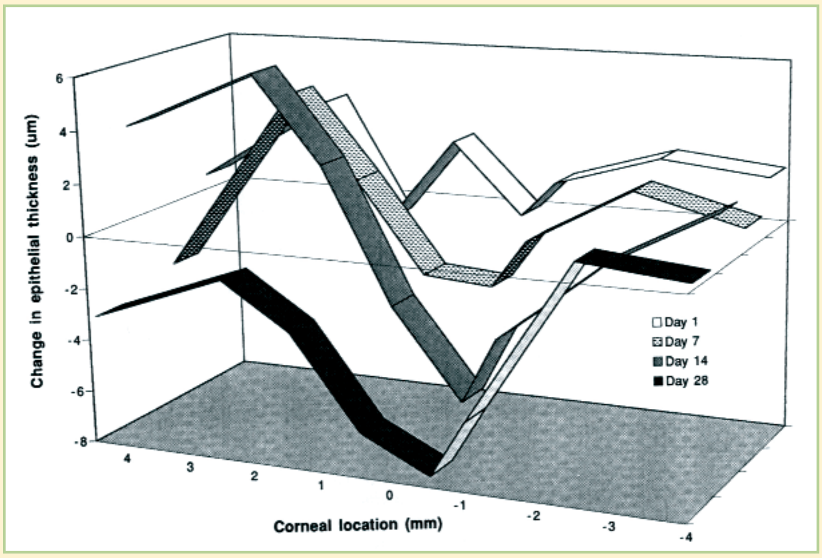

Figure 10
Topographical epithelial thickness changes in orthokeratology during one month[18]

Swarbrick et al[18] looked at the epithelial thickness, both centrally and peripherally in 11 eyes. They were fitted with the original Contex reverse geometry lens for daytime wear and followed for one month. There was an average reduction in myopia of 1.71 ±0.59 dioptres during that time. The data for epithelial thickness showed an average thinning centrally of 8mm. This was only statistically significant by day 28. There was epithelial thickening recorded in the periphery, but the changes were not statistically significant due to the inherent variability in the data. Overall, corneal thickness was shown to increase in the periphery perhaps indicating that it is the epithelium which is thinning centrally and thickening peripherally. The results for epithelial thickness with time are shown in **Figure 10**.

The relationship between the potential refractive change and the diameter of the flattened corneal surface was deduced by the application of Munnelyn's formula by Swarbrick et al[18] to the situation in a similar manner to its use in excimer laser refractive surgery. The assumption is that orthokeratology represents an epithelial change in which there is tissue compression centrally and expansion in the mid-periphery. It has been postulated by Caroline[19] that if the maximum amount of tissue thinning is 20 microns (epithelial thickness is 55 microns) and the minimum sized zone of flattening is 3.5mm, then the maximum predicted refractive change is -4.40 dioptres.

Choo et al[20] were able to visualise the epithelial cell changes during orthokeratology. In myopic treatment, they found a decrease in epithelial cell layers centrally and an increase in cell layers mid-peripherally in cat's eyes (**Figures 11a and 11b**). For hyperopic orthokeratology (**Figure 12**) they found the reversed effect (reduction mid-periphery, increase centrally). This suggests a redistribution of epithelial cells.

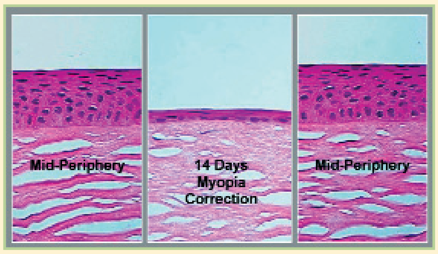

Figure 11a
Epithelial thickness change in myopic orthokeratology after 14 days in cats' eyes

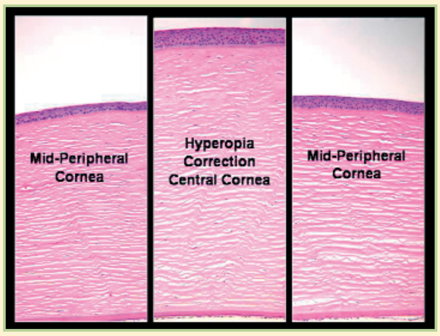

Figure 11b
Epithelial thickness change in hyperopic keratology after 14 days in cats' eyes

So there seems to be little doubt that there is an epithelial change during orthokeratology, but the exact nature of the epithelial change is still unknown. The two most popular theories are redistribution and compression. Many have questioned the ability of epithelial cells to loosen their tight bonds with other cells and to move around on the corneal surface – especially

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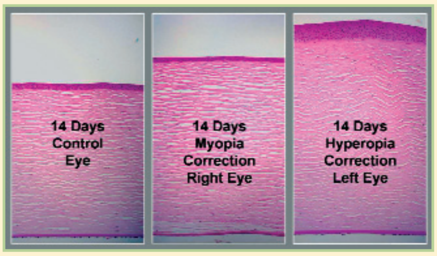


Figure 12
Stromal thickness increase in both myopia and hyperopia correction

Country	Number of reported cases
China	21
Taiwan	11
Hong Kong	7
Singapore	1
Australia	2
USA/Canada/UK	3
Europe (mainland)	1

Table 2
Reported occurrences of microbial keratitis

since the corneal changes seem to happen very shortly after lens insertion. Studies at the University of New South Wales[21] showed significant corneal flattening (0.61 ± 0.35D p=0.014) within 10 minutes of lens wear as a result of redistribution of corneal epithelium in response to tear film forces. In total, 70% of the refractive change seems to happen in the first night of wear. It seems hard to believe epithelial cells are able to redistribute within such a short time, and the short-term effect most probably has a compression component to it. After that, possibly a redistribution effect takes place or possibly hyperplasia of epithelial cells in the mid-periphery with a reduction of cells in the central part.

In addition to epithelial changes, stromal changes have also been found, but not over the entire surface. Research by Alharbi et al[22] suggests that the stromal changes are in the mid-periphery of the cornea. Looking at the results from their study, it can be seen that the total change in the central part of the cornea is exactly followed by the epithelial change they measured. Their data shows that in the mid-periphery, the stromal change fully explains the total corneal change.

Choo et al[20] came to the same conclusion with histological studies on cats' eyes: mid-peripheral stromal thickening in eyes corrected for myopia. Surprisingly, they observed the same effect in a cat cornea which was exposed to hyperopic orthokeratology. Whether the stromal changes are due to oedema or another mechanism is still unknown.

Matsubara[23] looked at corneal physiology in the corneal stroma and found that proteoglycans in the deep stroma are slightly increased centrally. He concluded that only very mild functional and morphological changes in rabbit cornea were present, and the significance seemed limited.

The focus when trying to explain the orthokeratology effect is primarily on the anterior corneal changes, but there could be some posterior involvement as well. Recent work of Owens et al[24] interestingly suggested there was some corneal bending involved in orthokeratology. Their work, in which they used the Orbscan scanning slit topographer to measure the posterior and anterior corneal change during the initial month of overnight orthokeratology, indicated some level of overall bending. Models of the central cornea suggest that a combination of oedema and moulding is likely to account for these posterior corneal changes.

Another recent study[25] looked at corneal aberrations in orthokeratology lens wearers. It was not a surprise to find that the treatment increased higher order aberrations (specifically spherical aberration) due to the reshaping of the anterior surface, as with laser refractive surgery. However, it was found that orthokeratology also increased internal optical aberrations. According to the investigators, this indicates that there has to be some kind of posterior flattening which is responsible for creating these changes.

Although the endothelium can be affected by contact lens wear, not a lot of research on orthokeratology has so far focused on this layer. However, those who did could not report any changes. Lin[26] found neither endothelium density changes nor morphological changes over a six month period in orthokeratology using high Dk/t lenses.

In summary, it is still not totally clear what tissue change is responsible for the orthokeratology effect. Overall bending seems unlikely, although it has gained some recent attention. Epithelial changes are very likely to occur, at least in the central portion. Redistribution or compression, a combination of these or some unknown mechanism is the proposed cause of the epithelial effect. A stromal involvement is possible, probably in the midperiphery only.

Safety

Whatever the mechanism of orthokeratology might be, in conclusion it is fair to say that it works in terms of myopia reduction. The overriding concern which remains is how safe is it? To evaluate safety, hypoxia (bacterial binding), corneal staining and corneal iron rings will be discussed.

Hypoxia

Bacterial binding to the corneal epithelium is more likely under hypoxic conditions[27] and bacterial binding is considered a risk factor for corneal infection. Oxygen availability is reduced by one-third, from 21% to 7%, in a closed eye situation and hyper Dk/t lenses should be used for any lens which is worn during the night, even though the eye is exposed to the full oxygen tension during the course of the day.

So theoretically, when applying these lenses with enough oxygen they should be relatively safe. However, when looking at reported case reports of infections around the world another picture seems to arise – 46 cases of corneal infection have been reported in total worldwide (**Table 2**)[28]. The majority of these cases are in Asian countries, where the circumstances in terms of hygiene, training, equipment (no topographer, no slit lamp) and lens material (reports of PMMA use) are questionable. Many of the cases in Asia involve children, so extra diligence in relation care and hygiene in younger individuals seems wise. However, it should be remembered that in China alone more than 400,000 patients were fitted with orthokeratology lenses with the majority being children, meaning these numbers of incidents should be considered in relation to the large numbers of wearers.

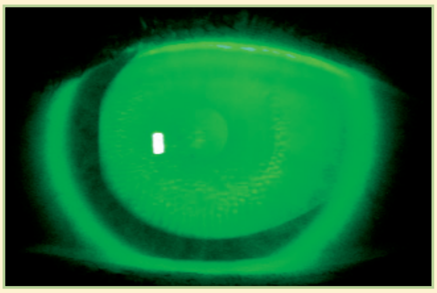
In the Netherlands, only one case of corneal infection has been reported. Based on this information only (with obvious limitations), the corneal infection rate is 1.67:10,000 to date, which is in line and not higher than with conventional contact lens wear.

Corneal staining

Another risk factor for corneal infections is corneal staining, which should be avoided as much as possible. However, complete absence of corneal staining in lens wear, including orthokeratology, is rarely achievable. Any corneal staining should not exceed grade one (CCLRU/Efron grading scale), and it should be noted as to whether the staining disappears during the course of the day. Chronic lens binding can cause severe corneal staining as well as retrolental debris. In addition, extra care should be taken over the contact lens solutions used. Exposure to the preservatives is increased since immediately after lens insertion the eyelid is closed.

Corneal dimples (**Figure 13**) are commonly seen with orthokeratology and are caused by air bubbles under the lens resulting in a golf ball pattern. When fluorescein is applied to the tear film, these dimples pool with fluorescein, mimicking real corneal staining with damaged corneal cells. As far as is known, dimples do not damage epithelial cells and are no more

Figure 13
Dimple veiling



prone to bacterial binding than normal cells. It is only if vision is compromised that action should be taken to avoid occurrence of cornea dimples. To put corneal staining in orthokeratology into perspective, one should be aware of the fact that one of the main causes of corneal staining in conventional RGP lens wear (3 and 9 o'clock staining) is not present in overnight OK lens wear.

Corneal rings

Corneal iron rings have been reported in cases of pterygium, filtering blebs, foreign bodies, LASIK, PRK, intra-corneal rings, keratoplasty, keratoconus and also in orthokeratology. In orthokeratology (**Figure 14**), the ring is located close to the area where the reverse curve rests on the cornea and it is thought that they develop because of a stagnant tear film in that area and additionally, that epithelial cells are more prone to iron uptake in the initial reshaping phase. Occurrence of iron rings may be related to the degree of reshaping. Cho et al[29] and Barr et al[30] have reported some cases of corneal rings in orthokeratology, but apart from the presence of the rings bilaterally, the corneal integrity and topography were stable and clinically unremarkable. They concluded that although this is an interesting finding, it does not affect visual acuity nor does it appear to be adverse in nature and they do not progress.

The future

At present, orthokeratology seems able to induce up to four dioptre changes to the corneal shape. It seems to be a safe reversible way of effecting a reduction in myopia. New lens designs are emerging for hyperopia and astigmatism.

However, the fact that it is not a permanent change dissuades many patients from having a course of treatment. Researchers in Texas, USA, are currently looking at means of making the shape changes of orthokeratology permanent. They are using an enzyme called sodium hyalonuridase (Vitrase) to temporally soften the corneal stroma. A well-fitted orthokeratology lens then reshapes the cornea and once a satisfactory outcome has been achieved, another currently non-specified enzyme is injected into the cornea to 'fix' the outcome. Initial reports have been variable, but if this technique is shown to be efficacious and safe it should attract a substantial new group of patients to the procedure.

Anecdotally, many orthokeratology practitioners feel that their young patients do not experience an increase in myopia and that therefore the procedure has some form of stabilising effect on juvenile-onset myopia. Currently, studies are underway to confirm these anecdotal findings, but no proof has been found to date. If this is substantiated, it would obviously add further to the appeal of orthokeratology. Currently, the interest in it is highest in the Far East, where many parents are told that there is a retarding effect on myopia progression. This can only increase interest if scientific confirmation is given.

Conclusion

In summary, accelerated orthokeratology is one of several possibilities which may be offered to the patient with moderate myopia and low with-the-rule astigmatism who seeks freedom from spectacles or conventional contact lenses. It is a minimally invasive, reversible technique which appeals to patients who are unsure as to whether they wish to opt for refractive surgery, or who are too young for surgery to be considered. Many patients choose this technique because dry eye and other comfort-related issues present with their existing lenses which do not exist in orthokeratology. They find overnight orthokeratology more comfortable and altogether more satisfactory than conventional contact lens wear.

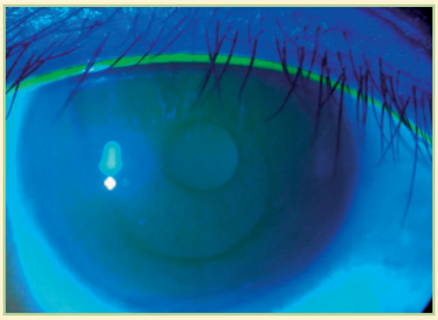


Figure 14
Corneal iron ring

About the authors

David Ruston is Director of Professional Affairs for the UK and Ireland at Johnson & Johnson Vision Care. Until recently, he was in full-time specialist contact lens practice in central London. He helped found the British Orthokeratology Society and served as its Secretary. He is co-author of the textbook Orthokeratology Principles and Practice.

Eef van der Worp has been working at the Hogeschool van Utrecht in different positions since 1994, serving as the Head of the Contact Lens Department for over seven years. He is the Vice President of IACLE Europe and Chairman of the cornea and contact lens section of the Dutch Optometric and Contact Lens Association. Currently he is in the process of a PhD project on corneal topography, RGP lens wear and corneal desiccation at the University of Maastricht.

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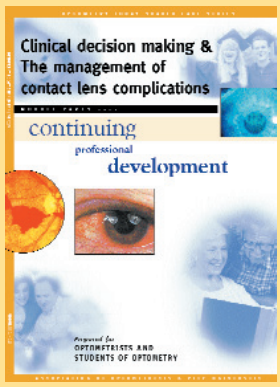
References

Email nicky@optometry.co.uk or visit www.optometry.co.uk/references.



David Ruston BSc, FCOptom, DipCLP, FAAO
and Eef van der Worp BOptom, FAAO, FIACLE

MCQs

Module 1 Part 6 of Modern contact lens practice

Is Ortho-k OK? – Fitting techniques and safety issues

Please note there is only ONE correct answer

1. The mechanism of orthokeratology was first described in the early:
a. 1960s
b. 1970s
c. 1980s
d. 1990s

2. Up to what level of myopia can usually be corrected in most patients?
a. -2.00D
b. -3.00D
c. -4.00D
d. -5.00D

3. What kind of corneal astigmatism is best corrected with orthokeratology?
a. Against-the-rule corneal astigmatism
b. With-the-rule astigmatism
c. Oblique astigmatism
d. Limbus to limbus corneal astigmatism

4. Which of the following is the most important fitting characteristic in terms of successful visual outcome?
a. Adequate movement
b. Adequate diameter
c. Adequate edge lift
d. Good centration

5. A 'smiley' face corneal topography outcome is NOT characterised by:
a. a superiorly decentered lens
b. a steep fitting relationship
c. a wide tear reservoir
d. a smaller area of central touch

6. The average regression in dioptres after eight hours of cessation of orthokeratology is on average about:
a. 0.40D
b. 0.80D
c. 1.20D
d. 1.50D

7. When, and under what conditions, is the first aftercare visit after fitting orthokeratology lenses?
a. After the first night, early morning, with the lenses in
b. After the first night, during the course of the day, with lenses in
c. After the first night, early morning, without lenses
d. After the second night, early morning, with the lenses in

8. What are possible remedies in case of lens binding?
a. Forceful blinking
b. Use of a lubricant
c. Pressure applied to the sclera below the lens
d. All of the above

9. There seems little doubt about epithelial changes in orthokeratology. Less obvious is the involvement of the stroma. If any, what stromal change seems to occur?
a. Central thickening
b. Central thinning
c. Mid-peripheral thickening
d. Mid peripheral thinning

10. What mechanism at this stage is most likely to cause the epithelial changes in orthokeratology?
a. Compression
b. Redistribution
c. Neither a or b
d. Both a and b

11. Which of the following types of corneal staining is NOT typical in overnight orthokeratology lens wearers?
a. 3 and 9 o'clock staining
b. Toxic reactions to contact lens solutions
c. Chronic lens binding
d. Flat fitting lenses

12. Corneal topography is crucial in assessing the orthokeratology effect. What is corneal topography used for?
a. To evaluate corneal eccentricity pre-treatment
b. To evaluate amount and type of corneal astigmatism pre-treatment
c. To evaluate the effect of the trial lens
d. All of the above

An answer return form is included in this issue. Paper entries ONLY should be completed and returned by January 12 to:
CET initiatives (c4938f), *OT*, Victoria House, 178-180 Fleet Road, Fleet, Hampshire, GU51 4DA.

Please note that model answers for this *Pay-As-You-Learn* series will not be available until January 14, 2005. This is so that readers submitting answers online can join at any time from now until that date and take part in any or all of the six articles as they are published. Paper entries will be marked on the normal monthly basis.