

Ortocheratologia Bibliografia

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Lee, T.T. and P. Cho

Discontinuation of Orthokeratology and Myopic Progression

Optom Vis Sci, 2010.

PURPOSE.: To report the effect of stopping orthokeratology (ortho-k) lens wear on the changes in refractive errors and axial elongation in a girl who has been wearing ortho-k lenses for myopic control for over 2 years. **CASE REPORT.:** A girl with a history of fast myopic progression enrolled in ortho-k treatment when she was 6 years old. She switched to spectacle wear after receiving ortho-k treatment for 38 months and then switched back to ortho-k lens wear. Refractive errors and axial lengths were monitored for 8 months with ortho-k lens wear, followed by about 6(1/2) months of lens discontinuation and spectacle wear, and finally another 6 months of resumed ortho-k lens wear. The residual refractive errors in the 8 months before discontinuation of ortho-k lens wear were not more than +/-0.25 diopter (D) and -0.50 D in spherical and cylindrical powers, respectively, and the average increases in axial length were 0.02 mm (OD) and 0.03 mm (OS) per month. Myopia increased by 0.75 D (OD) and 1.25 D (OS) during the lens discontinuation period, with corresponding axial elongations of 0.06 mm (OD and OS) per month. No significant changes were observed in axial elongation or residual refractive errors during the 6-month period of resumed lens wear. **CONCLUSIONS.:** When a child who had been wearing ortho-k lenses for myopic control for over 2 years ceased lens wear, small net amounts of axial elongation were observed during the subsequent months with spectacle wear. These changes took place at a faster rate relative to the ortho-k lens wear period. Ortho-k lens wear appeared to slow myopic progression for this child.

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Rah, M.J., J.J. Walline, L.A. Jones-Jordan, L.T. Sinnott, J.M. Jackson, R.E. Manny, B. Coffey, and S. Lyons

Vision specific quality of life of pediatric contact lens wearers

Optom Vis Sci, 2010. 87(8): p. 560-6.

PURPOSE: Several studies have shown that children are capable of wearing and caring for contact lenses, but it is not known whether the benefits outweigh the risks associated with contact lens wear. The purpose of this article is to compare the vision-related quality of life benefits of children randomized to wear spectacles or contact lenses for 3 years using the Pediatric Refractive Error Profile. **METHODS:** The Pediatric Refractive Error Profile was administered to 484 children who wore glasses at baseline. The children were then randomly assigned to wear contact lenses (n = 247) or spectacles (n = 237) for 3 years. The survey was administered at the baseline examination, at 1 month, and every 6 months for 3 years. **RESULTS:** During 3 years, the overall quality of life improved 14.2 +/- 18.1 units for contact lens wearers and 2.1 +/- 14.6 units for spectacle wearers (p < 0.001). In all scales except the visual performance scales (Distance Vision, Near Vision, and Overall Vision), the quality of life improved more for older subjects than younger subjects. The three scales with the largest

improvement in quality of life for contact lens wearers were Activities, Appearance, and Satisfaction with Correction. CONCLUSIONS: Myopic children younger than 12 years of age report better vision-related quality of life when they are fit with contact lenses than when they wear glasses. Older children, children who participate in recreational activities, children who are motivated to wear contact lenses, and children who do not like their appearance in glasses will benefit most.

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Gas permeable and soft contact lens wear in children

Optom Vis Sci, 2010. 87(6): p. 414-20.

PURPOSE: To compare children's reports of comfort, vision, and contact lens-related issues in gas permeable (GP) and soft (SCL) contact lens wearers. METHODS: Subjects were 116 8- to 11-year old children in the Contact Lenses and Myopia Progression Study. Aspects of contact lens wear were compared for children remaining in their original treatment group (either GPs or SCLs) for 3 years. Questionnaires were completed at every visit, as was visual acuity. Comparisons were made between the two groups using logistic regression or mixed linear models analyses as appropriate to examine the contact lens wearing experience. Additionally, children crossing over from GP wear to SCLs were compared with children remaining in GP lenses to determine the potential factors related to GP dissatisfaction. RESULTS: Seventy percent of GP wearers and 93% of SCL wearers wore their assigned lenses every visit. GP wearers wore their lenses significantly fewer hours per week than the SCL wearers (76.2 h/week vs. 86.8 h/week, respectively, $p = 0.003$). GP wearers had statistically significantly better visual acuity though the difference was not clinically meaningful ($p < 0.001$). Comfort was poorer among the GP wearers using the Ocular Pain subscale ($p < 0.001$) but did not differ using a subjective question about comfort. Symptoms were more frequent in GP wearers than SCL wearers ($p = 0.002$) and were related to reports of discomfort. Significant factors relating to crossing over from GPs to SCLs were lower wearing time with GPs and itching. CONCLUSIONS: Children are able to successfully wear GP and soft contact lenses. Long-term adaptation occurred more frequently to SCLs than to GPs. The amount of time GP lens wearers are able to comfortably wear their contact lenses and the amount of itching may help determine whether they will remain in that modality.

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Randomized trial of the effect of contact lens wear on self-perception in children

Optom Vis Sci, 2009. 86(3): p. 222-32.

PURPOSE: To determine whether contact lens wear affects children's self-perceptions. METHODS: The Adolescent and Child Health Initiative to Encourage Vision Empowerment Study was a randomized, singlemasked trial conducted at five clinical centers in the United States. Subjects were 8- to 11-year-old myopic children randomly assigned to wear spectacles ($n = 237$) or soft contact lenses ($n = 247$) for 3 years. The primary endpoint was the Self-Perception Profile for Children Global Self-Worth scale. Secondary outcomes included the Physical Appearance, Athletic Competence, Scholastic Competence, Behavioral Conduct, and Social Acceptance Self-Perception Profile for Children scales. RESULTS: Global self-worth was not affected by contact lens wear [analysis of variance (ANOVA), difference = 0.06; 95% CI, -0.004 to 0.117]. Physical appearance (ANOVA, difference = 0.15; 95% CI, 0.07 to 0.22), athletic competence (ANOVA, difference = 0.08; 95% CI, 0.01 to 0.15), and social acceptance (ANOVA, difference = 0.10; 95% CI, 0.03 to 0.17) were all greater for contact lens wearers. CONCLUSIONS: Although contact lens wear does not affect global self-perceptions of 8- to 11-year-old myopic children their physical appearance, athletic competence, and social acceptance self-perceptions

are likely to improve with contact lens wear. Eye care practitioners should consider the social and visual benefits of contact lens wear when choosing the most appropriate vision correction modality for children as young as 8 years of age.

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Corneal reshaping and myopia progression

Br J Ophthalmol, 2009. 93(9): p. 1181-5.

BACKGROUND/AIMS: Anecdotal evidence indicates that corneal reshaping contact lenses may slow myopia progression in children. The purpose of this investigation is to determine whether corneal reshaping contact lenses slow eye growth. METHODS: Forty subjects were fitted with corneal reshaping contact lenses. All subjects were 8 to 11 years and had between -0.75 D and -4.00 D myopia with less than 1.00 D astigmatism. Subjects were age-matched to a soft contact lens wearer from another myopia control study. A-scan ultrasound was performed at baseline and annually for 2 years. RESULTS: Twenty-eight of 40 (70%) subjects wore corneal reshaping contact lenses for 2 years. The refractive error and axial length were similar between the two groups at baseline. The corneal reshaping group had an annual rate of change in axial lengths that was significantly less than the soft contact lens wearers (mean difference in annual change = 0.16 mm, $p = 0.0004$). Vitreous chamber depth experienced similar changes (mean difference in annual change = 0.10 mm, $p = 0.006$).

CONCLUSION: Results confirm previous reports of slowed eye growth following corneal reshaping contact lens wear.

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A randomized trial of the effect of soft contact lenses on myopia progression in children

Invest Ophthalmol Vis Sci, 2008. 49(11): p. 4702-6.

PURPOSE: Soft contact lenses have been reported to increase the progression of myopia. The purpose of this study was to determine whether soft contact lenses affect the progression of myopia in children. METHODS: Children between the ages of 8 and 11 years with -1.00 to -6.00 D myopia and less than 1.00 D astigmatism were randomly assigned to wear soft contact lenses (n = 247) or spectacles (n = 237) for 3 years. Refractive error and corneal curvatures were measured annually by cycloplegic autorefractometry, and axial length was measured annually by A-scan ultrasound. Multilevel modeling was used to compare the rate of change of refractive error, corneal curvature, and axial length between spectacle and contact lens wearers. RESULTS: There was a statistically significant interaction between time and treatment for myopia progression (P = 0.002); the average rate of change was 0.06 D per year greater for contact lens wearers than spectacle wearers. After 3 years, the adjusted difference between contact lens wearers and spectacle wearers was not statistically significant (95% confidence interval [CI] = -0.46 to 0.02). There was no difference between the two treatment groups with respect to change in axial length (ANCOVA, P = 0.37) or change in the steepest corneal curvature (ANCOVA, P = 0.72). CONCLUSIONS: These data provide reassurance to eye care practitioners concerned with the phenomenon of "myopic creep." Soft contact lens wear by children does not cause a clinically relevant increase in axial length, corneal curvature, or myopia relative to spectacle lens wear. (ClinicalTrials.gov, NCT00522288.).

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Orthokeratology practice in children in a university clinic in Hong Kong

Clin Exp Optom, 2008. 91(5): p. 453-60.

PURPOSES: The aim of this study was to analyse clinical data of children undergoing orthokeratology (ortho-k) and to investigate patients'/parents' perspective on ortho-k via telephone interviews. METHODS: Clinical records of children undergoing ortho-k from a university optometry clinic were reviewed and the effects of ortho-k on refraction, vision and cornea were investigated. A telephone interview was conducted to solicit patients'/parents' perspective of the treatment. RESULTS: One hundred and eight files were reviewed. Median age of the children was nine years (range six to 15); mean (+/-SD) pre-treatment refractive sphere was -3.56 +/- 1.49 D and the median refractive cylinder was -0.50 D (range zero to -4.25 D). Significant refractive spherical reduction (58 per cent), improvement in unaided vision and corneal topographical changes were noted after only one night of wear. No significant change in astigmatism was found. Corneal staining was the most commonly observed complication with ortho-k and more than 80 per cent of patients were advised to apply ocular lubricants to loosen the lens before lens removal. Ortho-k was mainly undertaken for myopic control and about 90 per cent of the respondents reported good/very good unaided vision after ortho-k and ranked the treatment as satisfactory or very good. Lens binding and ocular discharge were the most frequently reported problems during the treatment. CONCLUSION: Under close monitoring, overnight ortho-k is effective and safe for reducing low to moderate myopia and the treatment is well accepted by the children.

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Benefits of contact lens wear for children and teens

Eye Contact Lens, 2007. 33(6 Pt 1): p. 317-21.

PURPOSE: Children are not offered elective contact lenses as a treatment option for refractive error nearly as often as teens are. The purpose of this report was to examine the benefits of contact lens wear for children and teens to determine whether children benefit as much as teens. If they do, children should routinely be offered contact lens wear as a treatment for refractive error. METHODS: Neophyte contact lens wearers were categorized as children (8-12 years of age) or teens (13-17 years of age). They completed the Pediatric Refractive Error Profile (PREP), a pediatric quality-of-life survey for subjects affected only by refractive error, while wearing glasses; then they were fitted with silicone hydrogel contact lenses. One week, 1 month, and 3 months after receiving contact lenses, the subjects completed the same PREP survey. Subjects also completed questions regarding wearing time and satisfaction with contact lenses during specific activities. RESULTS: The study enrolled 169 subjects at three clinical centers. Ninety-three (55%) of the subjects were girls; 78 (46%) were white; and 44 (26%) were Hispanic. After wearing contact lenses for 3 months, the overall PREP score increased from 64.4 for children and 61.8 for teens while wearing glasses to 79.2 for children and 76.5 for teens. The improvement from baseline to 3 months was significant for children and teens (P<0.0001 for both groups), but there was not a significant difference in improvement between children and teens (P>0.05). The areas of most improvement were satisfaction with correction, activities, and appearance. CONCLUSIONS: Contact lenses significantly improved the quality of life, as reported by children and teens using the PREP, and there was not a difference in improvement between children and teens. Contact lens wear dramatically improves how

children and teens feel about their appearance and participation in activities, leading to greater satisfaction with their refractive error correction. The improvement in quality of life after contact lens wear indicates that children should be offered contact lenses as a treatment for refractive error as routinely as teens.

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Safety and efficacy of overnight orthokeratology in myopic children

Optometry, 2007. 78(5): p. 225-31.

BACKGROUND: This prospective case series was conducted to describe the safety and efficacy of orthokeratology with the Emerald Contact Lens for Overnight Orthokeratology (Oprifocon A; Euclid Systems Corporation, Herndon, Virginia) among young myopes. **METHODS:** Twenty subjects (ages 10 to 16) were enrolled in the 6-month pilot study. Subjects were fit empirically with overnight orthokeratology lenses and evaluated at 1 day, 1 week, 1 month, 2 months, 3 months, and 6 months. **RESULTS:** Sixteen subjects completed the study. The mean baseline spherical equivalent refraction (SER) was -2.06 diopters (D) (+/-0.75). The mean SER at 6 months was -0.16 D (+/-0.38). The mean baseline uncorrected acuity was 0.78 (+/-0.28) logarithmic minimum angle of resolution (logMAR) equivalent (20/100 Snellen). The mean logMAR equivalent at 6 months was -0.03 +/- 0.12 (<20/20 Snellen). On average, 40% of eyes showed some type of corneal staining between the 1-week and 6-month visits. No serious adverse events occurred during the study. **CONCLUSIONS:** In contrast to previously published studies that reported maximum results at 2 weeks, subjects reached maximum reduction in myopia at the 1-week visit and, on average, obtained a 92.2% reduction in spherical equivalent refractive error at 6 months. This pilot study lends to a growing body of evidence that short-term correction of mild to moderate myopia with overnight orthokeratology is safe and efficacious in children and adolescents.

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Orthokeratology review and update

Clin Exp Optom, 2006. 89(3): p. 124-43.

Orthokeratology (OK) is a clinical technique that uses specially designed rigid contact lenses to reshape the cornea to temporarily reduce or eliminate refractive error. This article reviews the history of traditional daily-wear OK (1960s to 1980s) and discusses the reasons for the recent resurgence in interest in the new modality of overnight OK, using reverse-geometry lens designs (1990s to the present). The clinical efficacy of the current procedure is examined and outcomes from clinical studies in terms of refractive error change and unaided visual acuity are summarised. Onset of the effects of overnight OK lens wear is rapid, with most change after the first night of lens wear and stability of refractive change after seven to 10 days. Mean reductions in myopic refractive error of between 1.75 and 3.33 D and individual reductions of up to 5.00 D have been reported. There appear to be slight reductions or minimal changes in astigmatism with the use of reverse-geometry lenses and most patients are reported to achieve 6/6 unaided vision or better. The induction of higher order aberrations, in particular, spherical aberration, has been reported and this may affect subjective vision under conditions of low contrast and pupil dilation. Patient satisfaction with overnight OK has been reported as similar to or better than with other popular modalities of contact lens wear. Available evidence suggests that the corneal changes induced by overnight OK are fully reversible. The refractive effect in OK is achieved by central epithelial thinning and this has raised concerns about compromise of the epithelial barrier to microbial infection. Recent reports of microbial keratitis in the modality are reviewed and the overall safety of the procedure is examined critically. Recent research on stromal contributions to the OK effect, particularly relating to overnight oedema, is summarised. Emerging issues in OK, including myopic control, correction of other refractive errors and permanency of the OK effect, are discussed.

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Peripheral refraction in orthokeratology patients

Optom Vis Sci, 2006. 83(9): p. 641-8.

PURPOSE: The purpose of this study is to measure refraction across the horizontal central visual field in orthokeratology patients before and during treatment. **METHODS:** Refractions were measured out to 34 degrees eccentricity in both temporal and nasal visual fields using a free-space autorefractor (Shin-Nippon SRW5000) for the right eyes of four consecutively presenting myopic adult patients. Measurements were made before orthokeratology treatment and during the course of treatment (usually 1 week and 2 weeks into treatment). Refractions were converted into mean sphere (M), 90 degrees to 180 degrees astigmatism (J180), and 45 degrees to 135 degrees astigmatism (J45) components. **RESULTS:** Before treatment, subjects had either a relatively constant mean sphere refraction across the field or a relative hypermetropia in the periphery as compared with the central refraction. As a result of treatment, myopia decreased but at reduced rate out into the periphery. Most patients had little change in mean sphere at 30 degrees to 34 degrees. In all patients, the

refraction pattern altered little after the first week. CONCLUSION: Orthokeratology can correct myopia over the central +/- 10 degrees of the visual field but produces only minor changes at field angles larger than 30 degrees. If converting relative peripheral hypermetropia to relative peripheral myopia is a good way of limiting the axial elongation that leads to myopia, orthokeratology is an excellent option for achieving this.

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Microbial keratitis in overnight orthokeratology: review of the first 50 cases

Eye Contact Lens, 2005. 31(5): p. 201-8.

PURPOSE: Despite growing evidence for clinical efficacy of orthokeratology (OK) for the temporary reduction of myopic refractive error, there has been an increasing number of reports of microbial keratitis (MK) in association with overnight wear of OK lenses. This article analyzes the first 50 cases of MK reported in overnight OK, in order to define the spectrum of the disease and to identify possible risk factors. METHODS: All reported cases of presumed MK in overnight OK from 2001 onwards were included in the analysis. Demographic data of patients affected and lenses worn, and details of the disease process and possible risk factors were extracted from these reports. RESULTS: Most cases of MK in OK were reported from East Asia (80%) and most affected patients were Asian (88%). The peak age range was from 9 to 15 years (61%). Although *Pseudomonas aeruginosa* was the predominant organism implicated in this series of cases (52%), an alarmingly high frequency of *Acanthamoeba* infection (30%) was found. Inappropriate lens care procedures, patient noncompliance with practitioner instructions, and persisting in lens wear despite discomfort emerged as potential risk factors. CONCLUSIONS: The high frequency of MK in overnight OK in young Asian patients is likely to reflect the demographics of the OK lens-wearing population. The high frequency of *Acanthamoeba* infection strongly suggests that tap water rinsing should be eliminated from the lens care regimen for overnight OK. This study does not reveal the absolute incidence or relative risk of MK in overnight OK, and it is therefore premature to ascribe increased risk to this lens-wearing modality compared with other contact lens modalities.

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The longitudinal orthokeratology research in children (LORIC) in Hong Kong: a pilot study on refractive changes and myopic control

Curr Eye Res, 2005. 30(1): p. 71-80.

PURPOSE: Myopia is a common ocular disorder, and progression of myopia in children is of increasing concern. Modern overnight orthokeratology (ortho-k) is effective for myopic reduction and has been claimed to be effective in slowing the progression of myopia (myopic control) in children, although scientific evidence for this has been lacking. This 2 year pilot study was conducted to determine whether ortho-k can effectively reduce and control myopia in children. METHODS: We monitored the growth of axial length (AL) and vitreous chamber depth (VCD) in 35 children (7-12 years of age), undergoing ortho-k treatment and compared the rates of change with 35 children wearing single-vision spectacles from an earlier study (control). For the ortho-k subjects, we also determined the changes in corneal curvature and the relationships with changes of refractive errors, AL and VCD. RESULTS: The baseline spherical equivalent refractive errors (SER), the AL, and VCD of the ortho-k and control subjects were not statistically different. All the ortho-k subjects found post-ortho-k unaided vision acceptable in the daytime. The residual SER at the end of the study was -0.18 ± 0.69 D (diopetre) and the reduction (less myopic) in SER was 2.09 ± 1.34 D (all values are mean \pm SD). At the end of 24 months, the increases in AL were 0.29 ± 0.27 mm and 0.54 ± 0.27 mm for the ortho-k and control groups, respectively (unpaired t test; $p = 0.012$); the increases in VCD were 0.23 ± 0.25 mm and 0.48 ± 0.26 mm for the ortho-k and control groups, respectively ($p = 0.005$). There was significant initial corneal flattening in the ortho-k group but no significant relationships were found between changes in corneal power and changes in AL and VCD. CONCLUSION: Ortho-k can have both a corrective and preventive/control effect in childhood myopia. However, there are substantial variations in changes in eye length among children and there is no way to predict the effect for individual subjects.

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The Children's Overnight Orthokeratology Investigation (COOKI) pilot study

Optom Vis Sci, 2004. 81(6): p. 407-13.

PURPOSE: Innovations in contact lens materials and designs allow patients to wear contact lenses during sleep to flatten the cornea and temporarily to reduce myopic refractive error and improve unaided visual acuity. We conducted the Children's Overnight Orthokeratology Investigation (COOKI) pilot study, a case series, to describe the refractive error and visual changes, as well as the slitlamp observations associated with overnight orthokeratology in children, over a period of 6 months. METHODS: Twenty-nine 8- to 11-year-old children with myopia between -0.75 and -5.00 D and < -1.50 D corneal toricity were fitted with corneal refractive therapy contact lenses (Paragon Vision Sciences, Mesa, AZ). They were examined within 1 hour of awakening and about 6 hours later at 1 day, 1 week, 2 weeks, 1 month, 3 months, and 6 months after the first night of contact lens wear. At each visit, the logarithm of the minimum angle of resolution (logMAR) visual acuity, manifest

refraction, slitlamp examination, and corneal topography were performed. RESULTS: Twenty-three subjects completed the 6-month study. Three subjects decided not to wear contact lenses, two did not achieve acceptable fits, and one moved from the area. At the 6-month afternoon visit, the mean \pm SD uncorrected highcontrast visual acuity was $+0.08 \pm 0.15$ logMAR (Snellen equivalent, 20/24), and the mean \pm SD spherical equivalent refraction was -0.16 ± 0.66 D. The corneas of three-fifths of the subjects showed mild staining at the morning visit, and one-third of the patients showed mild corneal staining at the afternoon visit. The most common type of stain was central punctate staining. No subjects experienced lasting adverse visual effects from corneareshaping contact lens wear during the study period. CONCLUSIONS: Overnight cornea-reshaping contact lenses are efficacious for young myopic patients, and no children experienced a serious adverse event during the study.
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Walline, J.J., M.J. Rah, and L.A. Jones

The Children's Overnight Orthokeratology Investigation (COOKI) pilot study

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Influence of overnight orthokeratology on corneal endothelium

Cornea, 2004. 23(8 Suppl): p. S82-6.

PURPOSE: To evaluate the influence of overnight orthokeratology on the corneal endothelium. METHODS: Fifty-two eyes of 31 patients undergoing overnight orthokeratology for myopia were examined. They wore the lens every night and were followed up for at least 1 year. The corneal endothelium was examined with specular microscopy to calculate mean endothelial cell density, coefficient of variation of cell area, and percentage of hexagonal cells. Data obtained at 1-year follow-up examinations were compared with those at the baseline examinations using a paired t test. RESULTS: Orthokeratology significantly reduced manifest refraction from -2.32 ± 1.18 D (mean \pm standard deviation) to -0.16 ± 0.33 D ($P < 0.0001$) and improved uncorrected visual acuity from 0.77 ± 0.29 to -0.07 ± 0.10 logMAR ($P < 0.0001$). The endothelial cell density did not change significantly (2879 ± 231 cells/mm before and 2864 ± 260 cells/mm after treatment, $P = 0.252$). The coefficient of variation of cell area was 22.3 ± 2.7 at baseline and 22.1 ± 2.4 at 1-year posttreatment, which did not change significantly ($P = 0.537$). The percentage of hexagonal cells was $72.8 \pm 10.2\%$ pretreatment and $72.5 \pm 10.9\%$ posttreatment ($P = 0.800$). CONCLUSIONS: Overnight orthokeratology for 1 year did not influence the density or morphology of corneal endothelial cells.

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Asymmetrical increase in axial length in the two eyes of a monocular orthokeratology patient

Optom Vis Sci, 2004. 81(9): p. 653-6.

To report the myopia progression (change in axial length) of a boy in whom the progression was slower in the eye treated with overnight orthokeratology (ortho-k) than in the fellow eye with no visual correction. An 11-year-old boy was fitted with an ortho-k lens in his left eye in 1999 in a private practice. The refractive errors were OD -

0.25 - 0.75 x 168 and OS -2.50 - 0.50 x 170 before commencing ortho-k lens wear. He participated in one of our research studies and made yearly visits to our clinic in 2001, 2002, and 2003. Logarithm of the minimum angle of resolution (logMAR) visual acuity, refraction, ocular health, and axial length were assessed at each visit. At the visit in 2003, the unaided visual acuity was OD 0.40 logMAR and OS -0.04 logMAR. Between 2001 and 2003, there was a small increase in axial length in the left eye (0.13 mm) but a significant increase in the axial length (0.34 mm) with a corresponding increase in spherical equivalent refractive error (0.75 D) in the right eye. This case suggests that myopia progression may have been slowed down by ortho-k lens wear in the eye undergoing treatment of a boy undergoing unilateral ortho-k treatment.

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Chan, B., P. Cho, and S.W. Cheung

Orthokeratology practice in children in a university clinic in Hong Kong

Clin Exp Optom, 2008. 91(5): p. 453-60.

PURPOSES: The aim of this study was to analyse clinical data of children undergoing orthokeratology (ortho-k) and to investigate patients'/parents' perspective on ortho-k via telephone interviews. **METHODS:** Clinical records of children undergoing ortho-k from a university optometry clinic were reviewed and the effects of ortho-k on refraction, vision and cornea were investigated. A telephone interview was conducted to solicit patients'/parents' perspective of the treatment. **RESULTS:** One hundred and eight files were reviewed. Median age of the children was nine years (range six to 15); mean (+/-SD) pre-treatment refractive sphere was -3.56 +/- 1.49 D and the median refractive cylinder was -0.50 D (range zero to -4.25 D). Significant refractive spherical reduction (58 per cent), improvement in unaided vision and corneal topographical changes were noted after only one night of wear. No significant change in astigmatism was found. Corneal staining was the most commonly observed complication with ortho-k and more than 80 per cent of patients were advised to apply ocular lubricants to loosen the lens before lens removal. Ortho-k was mainly undertaken for myopic control and about 90 per cent of the respondents reported good/very good unaided vision after ortho-k and ranked the treatment as satisfactory or very good. Lens binding and ocular discharge were the most frequently reported problems during the treatment. **CONCLUSION:** Under close monitoring, overnight ortho-k is effective and safe for reducing low to moderate myopia and the treatment is well accepted by the children.

Chan, B., P. Cho, and J. Mountford

The validity of the Jessen formula in overnight orthokeratology: a retrospective study

Ophthalmic Physiol Opt, 2008. 28(3): p. 265-8.

PURPOSE: To investigate the validity of the Jessen formula, with a compression factor of 0.75, in determining the back optic zone radius (BOZR) of an orthokeratology (ortho-k) lens for myopic reduction [i.e. $BOZR = \text{flattest K} - (\text{target reduction} + 0.75)$]. **METHODS:** One hundred and twenty-three consecutive ortho-k patient files from the Optometry Clinic of The Hong Kong Polytechnic University were reviewed. Pertinent data at the preliminary visit and at the morning visit after 2 weeks of lens wear for 63 patients who fulfilled the

inclusion criteria were retrieved for analysis. All patients were either fitted with DreimLens (DreimLens Taiwan, Taiwan Macro Vision Group, Taiwan, China) or eLens (E&E Optics Ltd., Hong Kong SAR, China) designs. Only data from the right eye were analysed. The validity of the Jessen formula was evaluated by comparing the equation of the plot of myopic reduction attempted (based on the Jessen formula) and myopic reduction achieved (based on subjective refraction). RESULTS: The Jessen formula was found to underestimate the intended target of myopic reduction following ortho-k. The results suggested that the formula should be revised to $BOZR = \text{flattest K} - (1.23 \text{ target reduction} + 1.27)$. CONCLUSION: If the intention is to overcorrect the ortho-k patient by 0.75 D to allow for regression during the daytime, the Jessen formula with a compression factor of 0.75 is not valid to determine the BOZR of the ortho-k lens designs.

Cheah, P.S., M. Norhani, M.A. Bariah, et al.

Histomorphometric profile of the corneal response to short-term reverse-geometry orthokeratology lens wear in primate corneas: a pilot study

Cornea, 2008. 27(4): p. 461-70.

PURPOSE: To investigate the histological changes in primate cornea induced by short-term overnight orthokeratology (OK). METHODS: Nine young adult primates were used. One animal served as negative control. The remaining 8 animals wore reverse-geometry OK lenses for periods of 4, 8, 16, and 24 hours on 1 eye with the other eye as control. Central and midperipheral corneal thickness, as well as ultrastructural changes in corneal epithelium, stroma and endothelium in response to OK lenses, were evaluated. RESULTS: OK significantly reduced the thickness of the central cornea in all treatment groups. The central corneal thinning was both stromal and epithelial in origin. Substantial midperipheral corneal thickening was seen in 16-hour and 24-hour lens-wear groups and this effect was both stromal and epithelial in origin as well. Histology evidence indicated the primary epithelial response in the central cornea was compression of cells that resulted in wing cells becoming shorter and basal cells being squatted rather than lost or migration of cell layers. These pronounced cell shape changes occurred without compromising the structural integrity of the desmosomes. The thickened corneal epithelium has normal cell layers. The squamous cells have larger surface sizes and are composed of oval instead of flattened nuclei. This implied delayed surface cell exfoliation at the thickened midperipheral epithelium. Physical presence of OK lens over the cornea did not influence the microstructures of microvilli and microplicae, endothelium, and collagen distribution. CONCLUSIONS: The primate cornea, particularly the corneal epithelium, responds rapidly to the application of reverse-geometry OK lenses with significant epithelial cell shape alterations with short-term OK lens wear. This finding suggests that the corneal epithelium is moldable in response to the physical forces generated by the OK lenses.

Cho, P., S.W. Cheung, J. Mountford, and P. White

Good clinical practice in orthokeratology

Cont Lens Anterior Eye, 2008. 31(1): p. 17-28.

Overnight orthokeratology is becoming more and more popular especially in the Asia-Pacific region where the treatment is primarily used for myopic control in young children. Risk of complications in contact lens wear increases during overnight wear and may further increase when the treatment is used on children. The aim of this paper is to provide a comprehensive guideline for practitioners to improve their orthokeratology practice and minimize unnecessary or preventable complications. The fundamental requirement for starting an orthokeratology practice is to have proper education in the area and to equip the practice appropriately. Overnight trial fitting is recommended to confirm the physiological response prior to commencement of the treatment. Practitioners should provide adequate information, both oral and written, to patients before and after the commencement of treatment to avoid any legal dilemmas and to improve patients' compliance. Costs for the treatment should be transparent and provision of an emergency contact number is a must. Patients should be regularly recalled for aftercare visits and all communication with patients should be properly documented. In this paper, patient selection and the clinical procedures were discussed and a standard of practice in orthokeratology proposed. We believe that the key to providing a safe orthokeratology practice is to continually update knowledge in the field, and to practice to the highest professional standards.

Choo, J.D., P.J. Caroline, D.D. Harlin, et al.

Morphologic changes in cat epithelium following continuous wear of orthokeratology lenses: a pilot study

Cont Lens Anterior Eye, 2008. 31(1): p. 29-37.

PURPOSE: To investigate the sequence of morphologic changes over time in cat epithelium during continuous wear of orthokeratology lenses. **METHODS:** Four 2-year-old female cats were used; one served as a no lens wear control and three wore custom designed Paragon CRT lenses for myopic and hyperopic correction in the right and left eyes, respectively. Lenses were worn continuously and animals were euthanased after 4h, 8h and 14 days. Corneal tissue was fixed then stained with hematoxylin and eosin for histologic evaluation and measurement of epithelial thickness. **RESULTS:** Average epithelial thickness of control eyes in the centre (38 \pm 1 microm) and mid-periphery (3.0 mm from the centre, 38 \pm 2 microm) of the cornea was similar. Epithelial thickness in myopic corrected eyes showed progressive thinning in the centre and progressive thickening in the mid-periphery with increased lens wearing time. Hyperopic corrected eyes showed the opposite pattern of progressive epithelial thickening in the centre and thinning in the mid-periphery with lens wearing time. **CONCLUSIONS:** The epithelium appears to play a major role in the changes induced by orthokeratology lenses. The epithelial effects were dependent on time and lens design. Further studies are needed to determine the mechanisms responsible for these changes.

Gifford, P. and H.A. Swarbrick

Time course of corneal topographic changes in the first week of overnight hyperopic orthokeratology

Optom Vis Sci, 2008. 85(12): p. 1165-71.

PURPOSE: To investigate the time course of refractive and corneal topographic changes in overnight hyperopic orthokeratology (OK). **METHODS:** Ten young adult subjects were fitted with rigid hyperopic OK lenses (BE Enterprises, Capricornia) targeted to correct +1.50 D, in one eye only. The fellow eye acted as a non-lens wearing control. Lenses were worn overnight over a 7-day period and changes in subjective refraction and corneal topography were measured on lens removal (am) and 8 h after lens removal (pm). After a 2-week washout period, eight subjects repeated the study with the same lens design targeted to correct +3.50 D. Central corneal thickness was measured in this group using an ultrasound pachometer. **RESULTS:** There were statistically significant changes from baseline in all variables at all visits in lens wearing eyes. The central cornea steepened, and the mid-peripheral cornea flattened after one night of wear for both refractive targets, with greater effect and greater retention of effect by day 7. The +1.50 D refractive target was reached by day 7. However, the +3.50 D target was not reached, and showed greater variability in outcomes. There was no statistically significant change in central corneal thickness with the +3.50 D target lens at pm visits on days 1 or 7. **CONCLUSIONS:** The time course of refractive and corneal topographic changes in hyperopic OK is analogous to myopic OK. Most change in refractive and topographic variables occurs on day 1, with regression of effect during the day but greater retention of effect by day 7. Refractive outcomes were less predictable with the +3.50 D compared with the +1.50 D target lens. There was no change from baseline in central corneal thickness at pm visits despite significant retention of OK effect. This suggests that the primary corneal change in hyperopic OK may be mid-peripheral corneal thinning rather than central corneal thickening.

Gonzalez-Meijome, J.M., C. Villa-Collar, A. Queiros, et al.

Pilot study on the influence of corneal biomechanical properties over the short term in response to corneal refractive therapy for myopia

Cornea, 2008. 27(4): p. 421-6.

PURPOSE: To study the short-term corneal response to corneal refractive therapy for myopia and correlate it with corneal biomechanical properties as measured with the ocular response analyzer. **METHODS:** Eight eyes from 8 young subjects were fitted with a reverse geometry contact lens, attempting a myopic correction of -4.00 D. Corneal resistance factor and corneal hysteresis (CH) were measured before contact lens fitting with the ocular response analyzer. These parameters were correlated with the degree of change in apical curvature, simulated keratometry, and central corneal thickness after 3 hours of contact lens wear (effect) and 3 hours after lens removal (recovery). **RESULTS:** There was a trend toward a faster effect and faster recovery of the orthokeratologic effect for corneas with less resistance in terms of biomechanical properties. Corneal resistance factor did not correlate significantly, however, with any of the topographic and pachymetric parameters. Conversely, CH was significantly correlated with changes in steep keratometry (0.758; $P = 0.029$) and central corneal thickness (0.755; $P = 0.030$) during

lens wear and with changes in steep keratometry (-0.835; $P = 0.010$) during recovery. Overall, higher values of CH meant slower effect and recovery of the orthokeratologic effect. CONCLUSIONS: Short-term response of human cornea to corneal refractive therapy is correlated with the biomechanical properties of the cornea. Of the different theories supporting such involvement of corneal response to reverse geometry contact lenses, the most likely one seems to be the one assuming a faster response and faster recovery for corneas with lower resistance. Larger sample studies would be needed to clarify the involvement of corneal biomechanical properties on corneal response to orthokeratology.

Hiraoka, T., C. Okamoto, Y. Ishii, et al.

Time course of changes in ocular higher-order aberrations and contrast sensitivity after overnight orthokeratology

Invest Ophthalmol Vis Sci, 2008. 49(10): p. 4314-20.

PURPOSE: To investigate prospectively the time course of changes in ocular higher-order aberration and contrast sensitivity after overnight orthokeratology. METHODS: Data from 34 eyes of 17 patients who completed 1-year follow-up examinations were analyzed. The manifest refraction was -2.17 ± 0.86 D at baseline. Ocular higher-order aberrations for a 4-mm pupil were measured, and the root-mean-square (RMS) of the third-, fourth-, and total higher-order aberrations were determined. Contrast sensitivity was assessed at four spatial frequencies, and the area under the log contrast sensitivity function (AULCSF) was calculated. These examinations were performed before and 1, 2, 3, 6, and 12 months after commencement of the procedure. RESULTS: The treatment significantly increased third-, fourth-, and total higher-order RMS (all $P < 0.0001$, paired t-test). Log contrast sensitivity significantly decreased at all four spatial frequencies, and AULCSF was also significantly reduced after the treatment ($P < 0.0001$). To assess the time course of changes in these parameters, posttreatment data were analyzed by using repeated-measures analysis of variance. There were no significant fluctuations in manifest refraction; uncorrected visual acuity; third-, fourth-, and total higher-order RMS; and AULCSF (all $P > 0.05$). In addition, there was no significant variance in log contrast sensitivity at each spatial frequency during the 1-year follow-up period (all $P > 0.05$). CONCLUSIONS: The initial reduction in optical quality of the eye and quality of vision after the procedure is stable during the treatment period of at least 1 year, and the reduction does not worsen further after 1 month. Orthokeratology candidates should be fully informed of these changes.

Hiraoka, T., C. Okamoto, Y. Ishii, et al.

Recovery of corneal irregular astigmatism, ocular higher-order aberrations, and contrast sensitivity after discontinuation of overnight orthokeratology

Br J Ophthalmol, 2008.

AIMS: To prospectively examine the recovery of various parameters after discontinuation of overnight orthokeratology. METHODS: Thirty-four eyes of 17 subjects undergoing

orthokeratology for 12 months were examined. Refraction, corneal topography, wavefront aberrometry, visual acuity test, and contrast sensitivity test were performed at baseline, 12-month after commencement of the procedure, and 1 week and 1 month after discontinuation of the treatment. Asymmetry and higher order irregularity components were calculated by using Fourier analysis of the corneal topography data. Contrast sensitivity was assessed at four spatial frequencies, and the area under the log contrast sensitivity function (AULCSF) was calculated. RESULTS: Orthokeratology significantly reduced manifest refraction ($P < 0.0001$, Dunnett test), and significantly improved uncorrected visual acuity (UCVA) at 12 months after commencement of the procedure ($P < 0.0001$). Asymmetry and higher order irregularity components significantly increased ($P < 0.0001$, $P = 0.0032$, respectively), and third- and fourth-order aberrations also significantly increased ($P < 0.0001$). The treatment resulted in significant decreases in AULCSF ($P = 0.0004$). After discontinuing lens wear, all parameters, such as refraction, UCVA, asymmetry, higher order irregularity, third-order aberration, fourth-order aberration, and AULCSF fully returned to the baseline level within 1 month. CONCLUSION: This study confirmed that the effect of orthokeratology is completely reversible in light of optical quality of the eye and quality of vision as well as refraction and visual acuity.

Hiraoka, T., C. Okamoto, Y. Ishii, et al.

Mesopic contrast sensitivity and ocular higher-order aberrations after overnight orthokeratology

Am J Ophthalmol, 2008. 145(4): p. 645-655.

PURPOSE: To investigate mesopic contrast sensitivity and night driving ability in eyes undergoing overnight orthokeratology, and to analyze the relationship among mesopic contrast sensitivity, ocular higher-order aberrations, and myopic correction. DESIGN: Prospective, noncomparative, consecutive case series. METHODS: In 44 eyes of 22 subjects (mean age \pm standard deviation [SD], 24.0 \pm 3.2 years) with orthokeratology, ocular aberrations and mesopic contrast sensitivity were determined before and three months after commencement of the procedure. Mean spherical equivalent refraction \pm SD was -2.34 \pm 0.99 diopters at baseline. Mesopic contrast sensitivity with and without glare was assessed using the Mesotest II (Oculus, Wetzlar, Germany). RESULTS: Orthokeratology significantly reduced the log mesopic contrast sensitivity from 0.25 \pm 0.08 to 0.08 \pm 0.10 without glare ($P < .0001$, Wilcoxon) and from 0.21 \pm 0.11 to 0.07 \pm 0.10 with glare ($P < .0001$). The proportion of eyes that fulfilled the German standard recommendation level for night driving was 36%. The induced changes in log mesopic contrast sensitivity showed significant negative correlation with the changes in third-order ($r = -0.490$, $P = .0013$ without glare; $r = -0.362$, $P = .0177$ with glare; Spearman rank correlation coefficient) and fourth-order root mean square ($r = -0.586$, $P = .0001$ and $r = -0.306$, $P = .0450$, respectively). Furthermore, significant correlation was found between the amount of myopic correction and the induced changes in log mesopic contrast sensitivity ($r = -0.442$, $P = .0038$ without glare; $r = -0.464$, $P = .0024$ with glare). The induced changes in higher-order aberrations significantly correlated with the amount of myopic correction ($P < .0001$, Pearson correlation coefficient). CONCLUSIONS: Mesopic contrast sensitivity after overnight orthokeratology is deteriorated significantly as ocular higher-order aberrations increase, and these changes depend on the amount of myopic correction.

Kobayashi, Y., R. Yanai, N. Chikamoto, et al.

Reversibility of effects of orthokeratology on visual acuity, refractive error, corneal topography, and contrast sensitivity

Eye Contact Lens, 2008. 34(4): p. 224-8.

OBJECTIVES: To investigate the changes in corneal shape and optical performance during and after discontinuation of overnight orthokeratology for correction of myopia. **METHODS:** Both eyes of 15 subjects were fitted with overnight reverse-geometry orthokeratology lenses, which were then worn for >4 hr overnight for 52 weeks. Subjects were free of ocular disease and had a corrected visual acuity of > or =1.0. Refractive correction, uncorrected visual acuity, corneal topography, and contrast sensitivity (at 4 spatial frequencies) were measured under photopic conditions. **RESULTS:** Refractive error (spherical equivalent) and contrast sensitivity were decreased, whereas uncorrected visual acuity, the surface asymmetry index, and the surface regularity index were increased, 1 week after the onset of overnight orthokeratology and remained so during the 52 weeks of treatment. These parameters had largely returned to baseline values by 8 weeks after treatment discontinuation. **CONCLUSIONS:** Overnight orthokeratology improved uncorrected visual acuity and reduced refractive error but increased corneal irregularity and impaired contrast sensitivity. However, these changes in visual function and corneal shape were reversed after discontinuation of orthokeratology lens wear.

Lu, F., T. Simpson, L. Sorbara, and D. Fonn

Malleability of the ocular surface in response to mechanical stress induced by orthokeratology contact lenses

Cornea, 2008. 27(2): p. 133-41.

PURPOSE: To determine the malleability of the ocular surface by examining the acute effects of local mechanical stress on optical performance, corneal shape, and corneal/epithelial thickness after corneal refractive therapy for myopia and hyperopia (CRT and CRTH). **METHODS:** Twenty ametropes (spherical equivalent: -2.08 +/- 2.31 D) wore CRT and CRTH lenses in a random order on 1 eye (randomly selected). The lenses were worn for 15, 30, and 60 minutes (randomly ordered, with each period taking place on a different day). Refractive error, aberrations, corneal topography, and corneal/epithelial thickness (using OCT) were measured before and after lens wear. The measurements were performed on the control eyes at the 60-minute visit only. **RESULTS:** With both CRT and CRTH lens wear, significant changes occurred in many parameters from the 15-minute time point. The refractive error and defocus decreased after CRT lens wear (all $P < 0.05$) and increased after CRTH lens wear from baseline (all $P < 0.05$). Astigmatism did not change (both $P > 0.05$). Higher-order aberrations, including coma and spherical aberration (SA), increased after CRT and CRTH lens wear (all $P < 0.05$) from baseline, but the signed SA shifted from positive to negative after CRTH lens wear ($P < 0.05$). The central cornea flattened and the midperiphery steepened after CRT lens wear, whereas the central cornea steepened and paracentral region flattened after CRTH lens wear ($P <$

0.05). The central cornea swelled less than the midperiphery after CRT lens wear ($P < 0.05$), whereas the central cornea swelled more than the paracentral region after CRTH lens wear ($P < 0.05$). The central epithelium was thinner than the midperiphery after CRT lens wear ($P < 0.05$) and thicker than the paracentral region after CRTH lens wear ($P < 0.05$). Optical performance, corneal curvature, and epithelial thickness did not change from baseline in the control eyes (all $P > 0.05$). CONCLUSIONS: CRT lenses for myopia and hyperopia induce significant structural and optical changes in as little as 15 minutes. The cornea, particularly the epithelium, is remarkably malleable, with rapid steepening and flattening possible in little time.

Morgan, P.B. and N. Efron

The evolution of rigid contact lens prescribing

Cont Lens Anterior Eye, 2008. 31(4): p. 213-4.

Rigid contact lenses have long been known to be a versatile form of optical correction. However, as documented in this report of the results of annual prescribing surveys conducted over the past 12 years, there has been a steady decline in rigid lens fitting over this period. This is attributed to factors such as the initial discomfort of rigid lenses and the increased sophistication of soft lens materials and designs. There is an apparent trend for rigid lenses to be used more for 'specialist' fits, such as sophisticated toric designs, multifocals and orthokeratology.

Ng, L.H.

Corneal foreign body injury during overnight orthokeratology lens wear: a case report

Cont Lens Anterior Eye, 2008. 31(3): p. 158-60.

PURPOSE: A case of asymptomatic corneal foreign body injury during orthokeratology lens wear is reported. CASE REPORT: An 8-year-old Chinese female myopic child with 21 months of overnight orthokeratology lens wear experienced a corneal foreign body injury without symptoms. The foreign body was removed and the eye treated with prophylactic antibiotic and ocular lubricant. Orthokeratology treatment was resumed 4 weeks after initial detection and management and a small residual corneal scar remained. DISCUSSION: The mechanisms, differential diagnoses, management and role of neural sensitivity in corneal foreign body injury during orthokeratology lens wear are discussed. Clinicians should be aware that subtle corneal insult may be without symptoms during prolonged overnight orthokeratology lens wear.

Stillitano, I., P. Schor, C. Lipener, and A.L. Hofling-Lima

Long-term follow-up of orthokeratology corneal reshaping using wavefront aberrometry and contrast sensitivity

Eye Contact Lens, 2008. 34(3): p. 140-5.

PURPOSE: To evaluate changes in ocular wavefront aberrations and contrast sensitivity during 1-year follow-up of overnight orthokeratology. **METHODS:** Prospective study of 26 eyes that underwent orthokeratology with the BE lens design. Wavefront measurements were analyzed at baseline and after 1, 8, 30, 90, 180, and 365 nights of orthokeratology for a 6.5-mm pupil diameter. Contrast sensitivity 1 year after orthokeratology was compared to the baseline value under photopic conditions and mesopic conditions, with and without glare, in the spatial frequencies of 1.5, 3, 6, 12, and 18 cycles/degree. A P value of less than 0.05 was statistically significant. **RESULTS:** Higher-order aberration root-mean-square (HOA-RMS) increased statistically significantly from 0.41 +/- 0.12 microm to 1.04 +/- 0.32 microm up to night 8. Defocus (Z4) decreased until night 8 and then stabilized. Astigmatism (Z3 + Z5) did not change. There was a sevenfold increase in spherical aberration (Z12) until night 8, which subsequently remained unchanged (P<0.001). Coma (Z7 + Z8) increased until night 90 and then stabilized (P<0.001). Other Zernike modes showed stability at night 1, with the exception of quadrafoil (Z14) (P=0.048). Mesopic contrast sensitivity, with and without glare, at 18 cycles/degree, decreased but failed to reach statistical significance (P=0.922 and P=0.827, respectively). **CONCLUSIONS:** Most optical aberrations stabilized within the first week after beginning orthokeratology with BE lens. There was not a statistically significant reduction in contrast sensitivity 1 year after treatment.

Tsukiyama, J., Y. Miyamoto, S. Higaki, et al.

Changes in the anterior and posterior radii of the corneal curvature and anterior chamber depth by orthokeratology

Eye Contact Lens, 2008. 34(1): p. 17-20.

PURPOSE: To investigate the mechanism of the refractive effect of orthokeratology by using measurements of the anterior and posterior radii of the corneal curvature and anterior chamber depth with a Pentacam analysis system. **METHODS:** Nine women (18 eyes) with a mean age of 29.6 +/- 3.8 years and low to moderate myopia (≤ -4.00 diopters [D]) were recruited for a 53-week trial of overnight orthokeratology using RD171K lenses (hexafocon A). After wearing the orthokeratology lenses overnight, subjects were examined during the day. With a Pentacam analysis system, subjects were examined at 2, 4, 8, 12, 24, 36, and 53 weeks for the assessment of the anterior and posterior radii of the corneal curvature and anterior chamber depth. **RESULTS:** Myopic refractive error significantly reduced during the trial (P<0.001, analysis of variance). The mean refractive error was -2.85 +/- 0.46 D at baseline and significantly reduced to -0.28 +/- 0.65 D at 2 weeks (P<0.01, Bonferroni-Dunn post hoc test). At any week, no significant differences were seen in the central posterior radius of the corneal curvature (P=0.55, analysis of variance) or the anterior chamber depth (P=0.69, analysis of variance). The amount of change in the central anterior radius of the corneal curvature significantly correlated with the change in refractive error at 24 weeks (r=0.57, P<0.05, Pearson correlation coefficient). **CONCLUSIONS:** Overnight orthokeratology lens wear alters the anterior corneal shape rather than the posterior radius of the corneal curvature and the anterior chamber depth.

This finding suggests that the primary factor in the refractive effect of orthokeratology is change in the anterior corneal shape rather than overall corneal bending.

Van Meter, W.S., D.C. Musch, D.S. Jacobs, et al.

Safety of overnight orthokeratology for myopia: a report by the American Academy of Ophthalmology

Ophthalmology, 2008. 115(12): p. 2301-2313 e1.

OBJECTIVE: To review the published literature to evaluate the safety of overnight orthokeratology (OOK) for the treatment of myopia. **METHODS:** Repeated searches of peer-reviewed literature were conducted in PubMed (limited to the English language) and the Cochrane Central Register of Controlled Trials (no language limitations) for 2005, 2006, and 2007. The searches yielded 495 citations. The panel reviewed the abstracts of these articles and selected 79 articles of possible clinical relevance for review. Of these 79 full-text articles, 75 were determined to be relevant to the assessment objective. **RESULTS:** No studies were rated as having level I evidence. Two premarket applications to the Food and Drug Administration were rated as having level II evidence. There were 2 studies rated as having level II evidence. The main source of reports of adverse events associated with OOK was 38 case reports or noncomparative case series (level III evidence). **CONCLUSIONS:** The prevalence and incidence of complications associated with OOK have not been determined. Complications, including more than 100 cases of infectious keratitis resulting from gram-positive and gram-negative bacteria and *Acanthamoeba*, have been described in case reports and case series representing observations in undefined populations of OOK users. Data collection was nonstandard. Risk factors for various complications cannot be determined. Because OOK puts patients at risk for vision-threatening complications they may not encounter otherwise, sufficiently large well-designed cohort or randomized controlled studies are needed to provide a more reliable measure of the risks of treatment and to identify risk factors for complications. Overnight orthokeratology for slowing the progression of myopia in children also needs well-designed and properly conducted controlled trials to investigate efficacy. Because of variations in orthokeratology practice, a wide margin of safety should be built into OOK regimens. **FINANCIAL DISCLOSURE(S):** Proprietary or commercial disclosure may be found after the references.

Burns-LeGros, D. and H. Wagner

Paragon corneal refractive therapy lens prescribed for daily wear in a post-radial keratometry patient

Eye Contact Lens, 2007. 33(1): p. 50-3.

PURPOSE: To present a case in which the Corneal Refractive Therapy (CRT) lens, a reverse-geometry contact lens designed specifically for overnight orthokeratology, was prescribed for daily wear in the treatment of a patient after radial keratotomy. **METHODS:** Case report. **RESULTS:** The CRT lens provided adequate visual acuity and satisfactory

daily wearing time without an adverse physiologic response. CONCLUSIONS: This case illustrates an off-label use of the CRT lens to facilitate lens centration and provide a functional vision correction that enhanced a patient's ability to participate in activities of daily living. Although further study regarding the long-term safety and efficacy of this lens modality is needed, the findings suggest that these lenses provide a viable vision correction for patients who are dissatisfied with their postsurgical vision, particularly when satisfactory visual acuity cannot be achieved through conventional means.

Chalmers, R.L.

What have pre- and postapproval studies shown about contact lens-related inflammatory events?

Eye Contact Lens, 2007. 33(6 Pt 2): p. 388-91; discussion 399-400.

INTRODUCTION: Clinical studies that occur before and after the regulatory approval of contact lenses differ in many aspects, including breadth, length, and subject inclusion and exclusion criteria. METHODS: A sample of published studies conducted in North America was reviewed to outline these differences and show their impact on rates of corneal complications with lenses. RESULTS: In postapproval studies of silicone hydrogel lenses, subject age and refractive error have been more diverse than in pre-approval trials, for example, 42% of lens wearers in a postapproval study of a single vision contact lens being older than 40 years. Inclusion of subjects in a wider age range in that study showed that lens wearers older than 50 years were at an increased risk for corneal infiltrates. Few adolescents were included in the first pre-approval trials of tisiptocon A overnight orthokeratology lenses, although many teenagers are prescribed the lenses in practice and may be at a higher risk for corneal infections with the device. The range of spectacle refractive error in a large postapproval registry of lotrafilcon A patients ranged from -16.00 to +7.00 diopters, significantly greater than that in pre-approval studies. A nonrandomized postapproval study showed that patient selection resulted in older patients with a higher degree of ametropia receiving silicone hydrogel lenses compared to younger patients with lower ametropia being fitted with hydrogel lenses. CONCLUSIONS: Postapproval studies give an organized view of the type of patients who will eventually make up the wearing population and their success or limitations with new types of contact lenses.

Chee, E.W., L. Li, and D. Tan

Orthokeratology-related infectious keratitis: a case series

Eye Contact Lens, 2007. 33(5): p. 261-3.

PURPOSE: To describe five patients who developed infectious keratitis after the use of overnight orthokeratology contact lenses. METHODS: Retrospective case report of five patients with infectious keratitis seen in Singapore National Eye Centre between 2001 and 2006. RESULTS: Five children between the ages of 9 and 14 years, who wore their lenses for an average of 1.5 months before developing orthokeratology-related infectious keratitis, were seen and treated at the Singapore National Eye Centre. All five patients had cultures

that were positive for *Pseudomonas aeruginosa*. They were treated with fortified cefazolin (50 mg/mL) and gentamicin (14 mg/mL) and responded well, with resolution of the infectious keratitis. Although most patients had a best-corrected visual acuity of 20/40 or better after the resolution of the acute infection, they all showed a central or paracentral residual scar. CONCLUSIONS: Because of the safety issues involved, orthokeratology should be used with caution in children.

Cheung, S.W., P. Cho, W.S. Chui, and G.C. Woo

Refractive error and visual acuity changes in orthokeratology patients

Optom Vis Sci, 2007. 84(5): p. 410-6.

PURPOSE: To evaluate the refractive error and visual acuity (VA) at various contrast levels in the two eyes of overnight orthokeratology (ortho-k) subjects, and to compare their postortho-k VA with the best corrected VA of spectacle-wearing control subjects matched for age, gender, and initial refractive error. **METHODS:** Distance postortho-k uncorrected and best corrected logMAR VA at four different contrast levels of 31 ortho-k (test) subjects (aged 7-35 years old) and the best corrected VA of 31 spectacle-wearing (control) subjects were measured and compared using the Waterloo Four-Contrast LogMAR VA Chart, which incorporated four sets of letters at different contrast levels: 90%, 48%, 21%, and 7%. Noncycloplegic manifest refractive error was measured in both eyes. **RESULTS:** The mean \pm SD percentage reductions in spherical equivalent achieved in the current study were 92% \pm 11% in the better eye and 84% \pm 14% in the worse eye of the test subjects. Postortho-k uncorrected VAs were significantly correlated with the residual overall blurring strength (length of the vector representing the residual refractive error) in both eyes at all contrast levels. The mean postortho-k uncorrected VA in the better eye were 0.00 \pm 0.11, 0.08 \pm 0.11, 0.21 \pm 0.12, and 0.46 \pm 0.13 with the 90%, 48%, 21%, and 7% contrast charts, respectively. These were comparable to the best corrected VA of the better eye of the control group with the 90% (-0.03 \pm 0.07) and 48% contrast charts (0.03 \pm 0.09), but worse than those of the control group with the 21% (0.13 \pm 0.10) and 7% (0.35 \pm 0.13) contrast charts. Postortho-k VA, with the four different contrast charts, improved by 0.07 to 0.12 log units in the better eye and 0.15 to 0.18 log units in the worse eye after correction of the residual refractive error; the improved VA was comparable to the best corrected VA of the control group. **CONCLUSIONS:** Postortho-k visual outcomes were compromised primarily due to the presence of residual refractive error. Although the uncorrected postortho-k VA was comparable to the best corrected VA of the spectacle wearers at high-contrast levels, it was worse at low-contrast levels and caused a significant between-eye difference at all contrast levels. Therefore, we suggested that monocular VA at high- and low-contrast levels should be evaluated for ortho-k patients.

El Hage, S., N.E. Leach, W. Miller, et al.

Empirical advanced orthokeratology through corneal topography: the University of Houston clinical study

Eye Contact Lens, 2007. 33(5): p. 224-35.

PURPOSE: Traditionally, orthokeratology has used diagnostic lenses to determine the best fit. The purpose of this study was to determine the efficacy of fitting empirically from corneal topography, without the use of diagnostic lenses. **METHODS:** Twenty-nine subjects, 18 to 37 years old, with myopia of 1.00 to 4.00 diopters (D) and astigmatism of no more than 1.50 D, were entered into this 6-month study. Corneal topography, scanning slit topography and corneal thickness (Orbscan), confocal microscopy, ultrasound corneal thickness, aberrometry, and biomicroscopy were used to assess corneal changes. Unaided logMAR high-contrast visual acuity, subjective refraction, and questionnaires were used to monitor vision and symptoms. Follow-up visits were scheduled after 1 day, 1 week, 2 weeks, 1 month, 3 months, and 6 months. **RESULTS:** For 6-month data, unaided logMAR acuity improved from 0.78 +/- 0.26 in the right eye and 0.75 +/- 0.22 in the left eye to 0.06 +/- 0.18 in the right eye and 0.04 +/- 0.16 in the left eye. Myopia decreased from -2.55 +/- 0.87 D in the right eye and -2.47 +/- 0.89 D in the left eye to +0.45 +/- 0.74 D in the right eye and -0.17 +/- 0.69 D in the left eye. Shape factor, using corneal topography, increased from 0.85 +/- 0.13 in the right eye and 0.85 +/- 0.15 in the left eye to 1.28 +/- 0.32 in the right eye and 1.30 +/- 0.29 in the left eye. Both eyes showed a decrease in lower-order aberrations (i.e., defocus) and an increase in higher-order aberrations (i.e., spherical aberrations and coma). **CONCLUSIONS:** Myopia reduction after 1 week was clinically insignificant from the 1-month results, indicating that the full effect is achieved by 1 week. Neither total nor epithelial corneal thickness varied significantly from baseline measurements.

Hiraoka, T., C. Okamoto, Y. Ishii, et al.

Contrast sensitivity function and ocular higher-order aberrations following overnight orthokeratology

Invest Ophthalmol Vis Sci, 2007. 48(2): p. 550-6.

PURPOSE: To evaluate relationships among contrast sensitivity function, ocular higher-order aberration, and myopic correction in eyes undergoing overnight orthokeratology for myopia. **METHODS:** A prospective study was conducted in 46 eyes of 23 patients undergoing orthokeratology. Inclusion criteria were spherical equivalent refraction between -1.00 and -4.00 diopters (D), refractive astigmatism up to 1.00 D, and best-corrected visual acuity of 20/20 or better. Ocular higher-order aberrations and contrast sensitivity function were determined before and 3 months after initiation of the procedure. We measured three indices of contrast sensitivity function: contrast sensitivity, low-contrast visual acuity, and letter contrast sensitivity with the CSV-1000 charts (Vector Vision Co., Greenville, OH). Area under the log contrast sensitivity function (AULCSF) was calculated from the contrast sensitivity data. **RESULTS:** Orthokeratology significantly improved logMAR uncorrected visual acuity ($P < 0.0001$; paired t-test) but significantly increased ocular higher-order aberrations ($P < 0.0001$) and decreased contrast sensitivity function, including AULCSF ($P < 0.0001$), low-contrast visual acuity ($P = 0.0025$), and letter contrast sensitivity ($P < 0.0001$; Wilcoxon signed-rank test). The induced changes in AULCSF, low-contrast visual acuity, and letter contrast sensitivity by orthokeratology showed significant correlation with changes in third-order (Pearson $r = -0.430$, $P = 0.0026$; $r = 0.423$, $P = 0.0031$; and Spearman $r(s) = -0.351$, $P = 0.0186$, respectively), fourth-order ($r = -0.418$, $P = 0.0035$; $r = 0.425$, $P = 0.0029$; and $r(s) = -0.566$, $P = 0.0001$, respectively), and total higher-order ($r = -$

0.460, $P = 0.0011$; $r = 0.471$, $P = 0.0008$; and $r(s) = -0.434$, $P = 0.0036$, respectively) aberrations. The induced changes in contrast sensitivity function and higher-order aberrations significantly correlated with the amount of myopic correction ($P < 0.01$). CONCLUSIONS: Orthokeratology significantly increases ocular higher-order aberrations and compromises contrast sensitivity function, depending on the amount of myopic correction.

Hsiao, C.H., L. Yeung, D.H. Ma, et al.

Pediatric microbial keratitis in Taiwanese children: a review of hospital cases

Arch Ophthalmol, 2007. 125(5): p. 603-9.

OBJECTIVE: To study the clinical and microbiological characteristics of pediatric microbial keratitis in Taiwan. METHODS: The medical records of 81 eyes with microbial keratitis in 78 children aged 16 years or younger who were diagnosed and treated at Chang Gung Memorial Hospital, Taipei, Taiwan, from July 1, 1998, through December 31, 2002, were retrospectively reviewed. Predisposing factors, microbial culture results, clinical course, and visual outcomes were analyzed. RESULTS: Predisposing factors were contact lens wear (33 cases [40.7%]), trauma (17 cases [21.0%]), ocular disease (12 cases [14.8%]), and systemic disease (9 cases [11.1%]). Eight of the 33 contact lenses were rigid gas-permeable lenses that were worn overnight for orthokeratology. Forty-seven (58.0%) of the 81 eyes were culture positive. The most common isolates were *Pseudomonas aeruginosa* (21 eyes [44.7%]) and *Staphylococcus aureus* (9 eyes [19.1%]). Twelve (14.8%) of the 81 eyes required surgical intervention. Of the 68 eyes that had a best-corrected visual acuity available at the last follow-up, 33 eyes achieved best-corrected visual acuity of 20/25 or better. CONCLUSIONS: Predisposing factors for pediatric infectious keratitis vary with age. In the teenage years, the most predominant risk factor is contact lens wear. Infectious keratitis resultant from overnight orthokeratology lenses should receive particular attention. Parents of children who consider overnight orthokeratology should evaluate the benefit of temporary myopia reduction and the risk of infection. Identification of predisposing factors and microorganisms may be helpful for early recognition and treatment of pediatric microbial keratitis.

Johnson, K.L., L.G. Carney, J.A. Mountford, et al.

Visual performance after overnight orthokeratology

Cont Lens Anterior Eye, 2007. 30(1): p. 29-36.

PURPOSE: To investigate visual performance after overnight orthokeratology in terms of changes from baseline values, regression of the orthokeratology effect over time, and evaluation of the best-corrected vision after treatment. In particular, to evaluate any residual visual deficits over the duration of a day due to the abnormal corneal topography induced by orthokeratology treatment. METHOD: One eye of each of six subjects was fitted with custom designed BE orthokeratology lenses (Capricornia, Brisbane, Australia), with the fellow eye acting as a control. Unaided vision, subjective sphero-cylindrical

refraction, high contrast high luminance visual acuity, low contrast high luminance visual acuity, high contrast low luminance visual acuity and letter contrast sensitivity were measured at baseline and after one night (Day 1) and eight nights (Day 8) of lens wear. Except for baseline, data were collected after overnight lens wear immediately after lens removal, and again 3, 6 and 9h after lens removal. At each time point throughout the day, the visual performance measures were evaluated with the initial refraction of the day (the 0h refraction) and also using the optimum subjective refraction at each measurement time. This method was used to evaluate the practical visual performance to be expected after orthokeratology treatment and the residual visual deficits arising from any induced corneal changes after correction of defocus. RESULTS: As expected, orthokeratology lens wear significantly changed unaided vision and refraction from baseline. However, it did not significantly affect visual acuity in different contrast conditions, or contrast sensitivity. The spherical component of refraction was the only parameter to exhibit regression over each day ($p=0.021$), with more stability demonstrated on Day 8 than Day 1 ($p=0.012$). There were no statistically significant changes of best-corrected acuity from baseline in the differing contrast and luminance conditions. CONCLUSION: Apart from the predicted improvements in unaided vision and reduction of the myopic refractive error, orthokeratology treatment was not found to significantly change any other aspects of visual acuity and contrast sensitivity. All visual performance measures exhibited stability over a 9-h period. Spherical refractive error changed significantly on Day 1 but became stable after a week of treatment. These results indicate that the corneal topography changes induced by orthokeratology do not induce changes in aberrations that are large enough to significantly diminish visual performance.

Kang, S.Y., B.K. Kim, and Y.J. Byun

Sustainability of orthokeratology as demonstrated by corneal topography

Korean J Ophthalmol, 2007. 21(2): p. 74-8.

PURPOSE: To determine the sustaining effects of orthokeratology. METHODS: This study enrolled 58 eyes with moderate myopia. LK-DM lenses (Lucid Korea Dream Lens) were fitted daily for at least eight hours on an overnight regimen. The effects of orthokeratology and its sustainability throughout the day were recorded twice; immediately after removal in the morning and eight hours later. Sustainability was measured by comparing the changes from morning to afternoon for best uncorrected visual acuity, apical corneal power, keratometric values, spherical equivalent and induced astigmatism. RESULTS: UCVA demonstrated improved values at all follow up periods. Fluctuations during the day stabilized after 4 weeks of lens wear. K values averaged a mean of 42.4 mm at baseline, and reduced to 40.9 mm by week 12. Unaided logMAR visual acuity changed from 0.94 ± 0.14 at baseline to -0.11 ± 0.17 by week 12. The sustainability of orthokeratology, defined as the difference between morning and afternoon values of unaided logMAR visual acuity, increased from -0.82 on day 1 to -0.11 on week 12. CONCLUSIONS: UCVA and spherical refractive error did not change to a significant degree after 4 weeks. Although statistically insignificant minute fluctuations during the day were observed up to week 12, these fluctuations decreased to a statistically significant level after week 4.

Knappe, S., O. Stachs, and R. Guthoff

[Corneal changes after wearing orthokeratology contact lenses: an investigation using in vivo, confocal laser scanning microscopy]

Ophthalmologe, 2007. 104(8): p. 681-7.

BACKGROUND: Wearing orthokeratology contact lenses (OCL, Hecht-see free; Hecht, Germany) overnight can change corneal refraction by up to -4.5 dioptre (dpt) based on corneal adaptation to the double reverse surface of the OCL. This allows a temporary independence on glasses or contact lenses. It is known that the central corneal thickness decreases while the corneal thickness in the periphery probably increases. The aim of this study was to investigate the corneal changes of volunteers wearing OCL with in vivo confocal microscopy. **MATERIALS AND METHODS:** Five young adults (mean 22.8 years, three female, two male) with low to moderate myopia (range -1.75 to -3.5 dpt; sphere equivalent -2.7+/-0.59 dpt) were fitted with OCL of reverse-geometry design in both eyes. Lenses were worn in both eyes overnight and were removed immediately in the morning. The volunteers were examined with in vivo confocal microscopy using a combination of Heidelberg retina tomograph II and the Rostock cornea module before wearing the OCL and after the 1(st), 3(rd), 5(th), 7(th), 13(th), 20(th) and 25(th) nights. The central and mid-peripheral total corneal thickness as well as the epithelial thickness were examined in the morning between 7.30 am and 9.30 am. **RESULTS:** The central and the mid-peripheral epithelial corneal thickness was reduced significantly ($p < 0.05$) from day 1 to the 13(th) day. This stabilized later until the the examination was concluded. No significant changes ($p > 0.05$) were found in the central or mid-peripheral total corneal thickness after 25 days of wearing the OCL. **CONCLUSION:** Wearing OCL leads to a reduction in the central corneal epithelial thickness. Our inability to find an increase in mid-peripheral total and epithelial corneal thickness may be because the expected increase of the mid-peripheral cornea is limited to a defined area, which makes repeated measurements at a particular point difficult.

Lee, J.E., T.W. Hahn, B.S. Oum, et al.

Acanthamoeba keratitis related to orthokeratology

Int Ophthalmol, 2007. 27(1): p. 45-9.

PURPOSE: To report four cases of Acanthamoeba keratitis related to the overnight wearing of orthokeratology lenses. **METHODS:** Four patients had histories of overnight wearing of orthokeratology lenses when they presented with corneal ulcers. They had used a contact lens care system irregularly with tap water. **RESULTS:** The organism isolated by corneal scraping was Acanthamoeba. The patients were treated with polyhexamethylene biguanide (PHMB) and chlorhexidine, resulting in a resolution of ocular inflammation. **CONCLUSION:** The risk of Acanthamoeba keratitis as a potential complication of overnight orthokeratology should be considered, especially in patients with over one-year duration of contact lens wearing. Careful contact lens management is needed and tap-water rinsing should be eliminated from the lens care regimen.

Lum, E. and H. Swarbrick

Fibrillary lines in overnight orthokeratology

Clin Exp Optom, 2007. 90(4): p. 299-302.

This case report describes the appearance of fibrillary lines in the anterior stroma of a 39-year-old Asian woman wearing overnight orthokeratology (OK) lenses. The fibrillary lines were fine, slightly curved and sub-epithelial, arranged in a band-like annulus in the corneal mid-periphery. The lines were not associated with epithelial staining, although a marked Fischer-Schweitzer corneal mosaic was noted after blinking. Fibrillary lines are a relatively common finding in normal and keratoconic corneas and have been reported previously accompanying OK lens wear. Their origin is unknown and epithelial neural remodelling, corneal biomechanical stress and abrupt corneal curvature changes have been suggested as contributing factors. The appearance of fibrillary lines in our OK patient had no adverse consequences on vision or ocular health, at least in the medium term.

Mika, R., B. Morgan, M. Cron, et al.

Safety and efficacy of overnight orthokeratology in myopic children

Optometry, 2007. 78(5): p. 225-31.

BACKGROUND: This prospective case series was conducted to describe the safety and efficacy of orthokeratology with the Emerald Contact Lens for Overnight Orthokeratology (Oprifocon A; Euclid Systems Corporation, Herndon, Virginia) among young myopes. **METHODS:** Twenty subjects (ages 10 to 16) were enrolled in the 6-month pilot study. Subjects were fit empirically with overnight orthokeratology lenses and evaluated at 1 day, 1 week, 1 month, 2 months, 3 months, and 6 months. **RESULTS:** Sixteen subjects completed the study. The mean baseline spherical equivalent refraction (SER) was -2.06 diopters (D) (+/-0.75). The mean SER at 6 months was -0.16 D (+/-0.38). The mean baseline uncorrected acuity was 0.78 (+/-0.28) logarithmic minimum angle of resolution (logMAR) equivalent (20/100 Snellen). The mean logMAR equivalent at 6 months was -0.03 +/- 0.12 (<20/20 Snellen). On average, 40% of eyes showed some type of corneal staining between the 1-week and 6-month visits. No serious adverse events occurred during the study. **CONCLUSIONS:** In contrast to previously published studies that reported maximum results at 2 weeks, subjects reached maximum reduction in myopia at the 1-week visit and, on average, obtained a 92.2% reduction in spherical equivalent refractive error at 6 months. This pilot study lends to a growing body of evidence that short-term correction of mild to moderate myopia with overnight orthokeratology is safe and efficacious in children and adolescents.

Robertson, D.M., J.P. McCulley, and H.D. Cavanagh

Severe acanthamoeba keratitis after overnight orthokeratology

Eye Contact Lens, 2007. 33(3): p. 121-3.

PURPOSE: To document a clinical case of Acanthamoeba keratitis associated with orthokeratology overnight lens wear that resulted in severe, permanent vision loss. **METHODS:** Case report. **RESULTS:** At the age of 11 years, a boy received a spectacle correction for the following refractive error: -3.25 -0.50 x090 in the right eye and -3.50 -0.25 x 040 in the left eye. Alternative wear of daily-wear, disposable, soft contact lenses and rigid gas-permeable lenses was used for athletic activities to the age of 16 years. Between the ages of 16 and 19 years, the patient wore Boston Equalens 2c27 (type Percision Corneal Molding - 51) lenses with a base curve of 9.25, power of +2.50 diopters (D), and diameter of 10.6 mm in the right eye and a base curve of 9.15, power of +3.00 D, and diameter of 10.6 mm in the left eye for overnight orthokeratology wear. A corneal ulcer in the left eye was noted on November 13, 2004 (age of 19 years) and confirmed as Acanthamoeba infection by confocal microscopy on February 15, 2005, when triple topical therapy (Brolene, polyhexamethylbiguanide, and chlorhexidene) was initiated. Vision deteriorated to light perception with accurate projection by cessation of therapy on March 28, 2006. Additional complications included secondary angle-closure glaucoma, treated with an Ahmed tube shunt on April 12, 2005, and a mature cataract. **CONCLUSIONS:** The important message conveyed by this case was the finding that for several years, unknown to his eye care physicians, the patient cleaned his lenses with the Boston Cleaning System, as instructed, but followed this step with a routine rinse with tap water and storage in tap water in his lens case, which was not replaced or cleaned. The tragic loss of vision in this case probably could have been prevented by focused attention to lens hygiene by the patient, parents, and practitioner. Such heightened scrutiny is critically important in orthokeratology rigid lens wear, especially in children, independent of the lens polymer or fitting algorithm used.

Stillitano, I., E. Maidana, M. Lui, et al.

Bubble and corneal dimple formation after the first overnight wear of an orthokeratology lens: a case series

Eye Contact Lens, 2007. 33(5): p. 253-8.

PURPOSE: To report the first documented case series of bubbles and corneal dimples associated with corneal reshaping after the first overnight wear of an orthokeratology lens. **METHODS:** Three cases of transient corneal dimples are described after the first overnight use of the Be Free orthokeratology lens (BE; Ultravision Pty. Ltd., Brisbane, Australia) related to bubble formation under the posterior lens surface. **RESULTS:** The corneal dimples were located most centrally and peripherally in correspondence to the reverse curve and did not produce a significant change in best-corrected visual acuity except in one patient, who had many bubbles in the central cornea. **CONCLUSIONS:** The current findings suggest that the precorneal tear film between the corneal surface and the posterior orthokeratology contact lens surface plays a role in the development of bubbles and corneal dimples.

Stillitano, I., P. Schor, C. Lipener, and A.L. Hofling-Lima

Stability of wavefront aberrations during the daytime after 6 months of overnight orthokeratology corneal reshaping

J Refract Surg, 2007. 23(9): p. 978-83.

PURPOSE: To evaluate the stability of wavefront aberrations during the daytime after 6 months of overnight orthokeratology corneal reshaping. **METHODS:** A prospective study of 26 eyes using the Ultravision BE lens design during 6 months of overnight wear. Uncorrected visual acuity (UCVA), cycloplegic refraction, and wavefront aberrometry were measured at 8 AM (within 1 hour after awakening and removing lenses), 1 PM (5 to 6 hours after lens removal), and 6 PM (10 to 12 hours after lens removal). **RESULTS:** There was no significant difference in UCVA between 8 AM, 1 PM, and 6 PM ($P=.383$). Spherical power from wavefront aberrometry showed significant regression from 8 AM to 1 PM ($P<.001$) and stabilized near zero diopters. Total root-mean-square (RMS) increased and higher order aberration RMS and defocus (Z4) decreased between 8 AM and 1 PM ($P<.001$) but did not change for the rest of the day ($P>.001$). There was no statistically significant change in astigmatism (Z3 and Z5) ($P=.449$) and coma (Z7 and Z8) ($P=.145$) between 8 AM, 1 PM, and 6 PM. Spherical aberration (Z12) showed regression throughout the day ($P<.001$). **CONCLUSIONS:** After 6 months of overnight orthokeratology wear, some optical aberrations showed regression during the day. Despite no significant change in UCVA during 10 to 12 hours, there was a significant increase in defocus (Z4) within the first 5 hours after removing the orthokeratology lens and a decrease in spherical aberration (Z12) throughout the day.

Stillitano, I.G., M.R. Chalita, P. Schor, et al.

Corneal changes and wavefront analysis after orthokeratology fitting test

Am J Ophthalmol, 2007. 144(3): p. 378-86.

PURPOSE: To evaluate corneal changes and ocular aberrations during an orthokeratology test. **DESIGN:** A prospective, nonrandomized cohort study. **METHODS:** Fourteen myopic patients (26 eyes) underwent an orthokeratology fitting test with the BE contact lens (Ultravision Pty, Ltd, Brisbane, Australia). Best spectacle-corrected visual acuity (BSCVA), uncorrected (Ultravision Pty, Ltd, Brisbane, Australia) visual acuity (UCVA), subjective cycloplegic refraction, biomicroscopy, corneal topography, optical pachymetry, and aberrometry were performed at baseline and one and eight nights orthokeratology. The short-term effect of orthokeratology using corneal topography, tomography, and ocular aberrations was evaluated. **RESULTS:** The mean spherical equivalent changed from -2.24 ± 0.98 diopters (D) at baseline to 0.15 ± 0.76 D after the eight nights of lens wear ($P = .001$). All patients had an UCVA of 20/30, 69.2% with 20/20. Changes in central corneal pachymetry were not observed. There was a statistically significant increase in the temporal corneal thickness from night one, without any difference between nights one and eight ($P > .001$). A significant increase of higher-order root mean square values was observed from baseline (0.42 ± 0.16 μm), night one (0.81 ± 0.24 μm), and night eight (1.04 ± 0.24 μm). Increases in coma (Z7+Z8) and spherical aberration (Z12) were observed. Positive horizontal (Z8) coma increased in right eyes, and negative horizontal (Z8) coma increased in left eyes ($P < .001$). **CONCLUSIONS:** Myopia reduction resulting

from rapid central corneal flattening and improvement of UCVA occurred after orthokeratology. Higher-order aberrations (HOAs), particularly spherical aberration and coma, increased significantly during the orthokeratology test. An increase of temporal pachymetry and differences in coma direction induced between the eyes may be related to the subclinical lens decentration temporally.

Subramaniam, S.V., E.S. Bennett, V. Lakshminarayanan, and B.W. Morgan

Gas permeable (GP) versus non-GP lens wearers: accuracy of orthokeratology in myopia reduction

Optom Vis Sci, 2007. 84(5): p. 417-21.

PURPOSE: The primary objective of this study is to determine whether there are significant differences in visual and refractive outcomes between gas permeable (GP) and non-GP wearers following a 1-month period of overnight orthokeratology (OK).
METHODS: The study included 14 subjects between the ages of 18 and 42 years. Group 1 consisted of six subjects wearing GP lenses for the correction of myopia for, at minimum, 1 year. Group 2 consisted of eight subjects wearing soft contact lenses or spectacles for the correction of myopia. All subjects were fit into the BE design in Boston XO material and lenses were worn for a period of 1 month. Unaided visual acuity using high (90%) and low (10%) contrast log MAR Bailey-Lovie vision charts, subjective refraction, corneal topography, and slit lamp evaluation were performed. Subjects were evaluated at day 1, 7, 14, 21, and 30. **RESULTS:** One eye of each subject was considered for analysis; the eye with the better response was chosen based on post-OK measures. The mean post-OK spherical equivalent was 0.29 +/- 0.55 D in the GP group and 0.37 +/- 0.46 D in the non-GP group; the difference was statistically significant ($p = 0.03$). Baseline astigmatism decreased in the non-GP group after OK while there was no significant change in the GP group. The mean high contrast acuities were 0.06 +/- 0.12 in the GP group and 0.17 +/- 0.07 in the non-GP group ($p = 0.05$), whereas the low contrast acuities were 0.18 +/- 0.17 in the GP and 0.02 +/- 0.09 in the non-GP group ($p = 0.01$). **CONCLUSIONS:** Although the non-GP group has higher post-OK visual acuity and spherical equivalent statistically, the GP group has attained an average unaided acuity of >20/20 and residual myopia <0.5 D. Clinically, this shows that OK can be a promising technique in GP wearers.

Watt, K.G., G.C. Boneham, and H.A. Swarbrick

Microbial keratitis in orthokeratology: the Australian experience

Clin Exp Optom, 2007. 90(3): p. 182-7; quiz 188-9.

BACKGROUND: This study was conducted to investigate the demographics of orthokeratology (OK) practice in Australia, to uncover any previously undocumented cases of serious adverse responses in OK, including microbial keratitis (MK), and to review the demographics of MK in OK in Australia. **METHODS:** A questionnaire was sent to the 62 members of the Orthokeratology Society of Australia (OSA). Questions related to aspects of their OK practice, demographics of their OK patient base and any adverse responses to

OK lens wear that they had encountered. RESULTS: Thirty-three questionnaires (53 per cent) were returned. OSA members have been fitting OK lenses for a median of 7.5 years. OK patients were predominantly female, Caucasian, aged between 15 and 39 years and wearing lenses in an overnight modality. In addition to two cases reported previously, the survey uncovered seven further cases of MK in OK patients over an eight-year period. The infecting organism was *Pseudomonas aeruginosa* in four cases, *Acanthamoeba* spp. in two cases and unknown in three cases. There was no loss of visual acuity in seven cases. One case resulted in vision of counting fingers at one metre and another case resolved with 6/12 visual acuity. Non-compliance with instructions on lens care and after-care was reported in seven of nine cases of MK. CONCLUSION: Overall, OSA members who responded to the survey have many years of experience in OK. The typical Australian OK patient is in young adulthood, female and Caucasian. A total of nine cases of presumed MK associated with OK have been reported in Australia over an eight-year period and seven of these were new cases uncovered by this survey. Our analysis suggests that the demographics of MK cases in OK reflect the demographics of the OK lens-wearing population.

Watt, K.G. and H.A. Swarbrick

Trends in microbial keratitis associated with orthokeratology

Eye Contact Lens, 2007. 33(6 Pt 2): p. 373-7; discussion 382.

PURPOSE: Orthokeratology is a clinical technique that uses reverse-geometry rigid gas-permeable contact lenses to alter corneal shape to provide temporary reduction of refractive error. Microbial keratitis is the most severe, potentially vision-threatening adverse response associated with orthokeratology contact lens wear. This article aims to review all reported cases of confirmed and presumed microbial keratitis associated with orthokeratology and to examine trends in microbial keratitis in orthokeratology over time. METHODS: Cases of microbial keratitis associated with orthokeratology were identified from case reports published in the optometric, ophthalmologic, and vision science literature and published in abstract form for papers or posters presented at optometric or ophthalmologic conferences. RESULTS: A total of 123 cases of microbial keratitis associated with orthokeratology have been reported since 2001, dating back to 1997. Most patients were female, East Asian, and aged between 8 and 15 years. The infectious organism was implicated as *Pseudomonas aeruginosa* for 46 (38%) of these cases and as *Acanthamoeba* species for 41 (33%) cases. The peak year for occurrence of microbial keratitis was 2001 and accounted for more than half (64 [52%] of 123) of all reported cases. All cases in this year were reported from East Asia, including China (47 cases), Taiwan (11 cases), and Hong Kong (6 cases). CONCLUSIONS: Although there has been an increasing number of reports of microbial keratitis associated with orthokeratology since 2001, most (85 [69%] of 123) of these cases occurred in East Asia, particularly in China and Taiwan, during a relatively short period, when regulation of this modality was limited. The high prevalence of cases of *Acanthamoeba* keratitis reported with this modality emphasizes the importance of eliminating the use of tap water in care regimens for overnight orthokeratology.

Wong, V.W., S.C. Chi, and D.S. Lam

Good visual outcome after prompt treatment of acanthamoeba keratitis associated with overnight orthokeratology lens wear

Eye Contact Lens, 2007. 33(6 Pt 1): p. 329-31.

PURPOSE: To describe a patient with a good visual outcome after prompt treatment of Acanthamoeba keratitis as a complication of overnight orthokeratology lens wear. **METHODS:** Interventional case report. **RESULTS:** A 9-year-old boy experienced pain, photophobia, and redness in his right eye 3 days after visiting a swimming pool. He had been wearing overnight orthokeratology lenses for 5 months for the correction of moderate myopia in both eyes. On examination, best-corrected visual acuity in the right eye was 20/40. A diagnosis of Acanthamoeba keratitis with the presence of the classic feature of perineural infiltrates was made. The patient responded well to treatment with polyhexamethylene biguanide and propamidine isethionate (Brolene). Culture of corneal scrapings and contact lens solution showed heavy growth of Acanthamoeba. Treatment was tapered gradually during the next 4 months, and the final best-corrected visual acuity was 20/25. **CONCLUSIONS:** Acanthamoeba keratitis may be a vision-threatening complication associated with overnight orthokeratology lens wear. It is essential for eye care professionals to fully explain and warn parents of the potential downsides that may be associated with orthokeratology. Ophthalmologists should have a high level of suspicion of this complication because prompt diagnosis and treatment can result in good visual outcome.

Woods, C.A., D.A. Jones, L.W. Jones, and P.B. Morgan

A seven year survey of the contact lens prescribing habits of Canadian optometrists

Optom Vis Sci, 2007. 84(6): p. 505-10.

PURPOSE: Little is known about the contact lens prescribing habits of optometrists in North America. The purpose of this survey was to obtain data on the types of lenses and solutions prescribed by Canadian optometrists. **METHODS:** One thousand Canadian optometrists were surveyed annually over seven consecutive years (2000 to 2006; n = 7000) on their contact lens prescribing preferences. Each survey requested a range of information about the contact lenses prescribed to the first 10 patients after its receipt. **RESULTS:** Over this time period, 1008 (14.4%) of the surveys were returned, providing data on 9383 fits. During the seven-year period, the ratio of male:female fits was 1:2 (3123:6217, 43 not reported), with a mean age of 31.3 +/- 13.6 years (range 2 to 82 years). The ratio of new fits to refits was 2:3 (3780:5518, 85 not reported), with 91.3% of all fits being soft contact lenses (SCL). Of the SCL fits, 59.5% were spherical, 28.5% toric, 9.7% multifocal, and 2.3% cosmetic tints. Gas permeable (GP) fits were 46.6% spherical, 18.6% toric, 19.5% multifocal, and 6.6% were for orthokeratology (OK). Over the seven-year period, SCL prescribed for continuous wear (CW) increased from 3.2% to 14.3% between 2000 and 2004 and reduced to 8.1% in 2006, for all fits. The use of mid-water content (MWC) materials decreased from 34.6% to 2.7% and the use of silicone hydrogel (SH) lenses increased from 61.4% to 96.2%, for all CW fits. GP lens continuous wear increased from 0.7% to 30.6% of all GP lens fits by 2006. Daily wear (DW) of SH lenses

decreased from 49.6% (2000) to 33.7% (2004) and then increased to 86.1% in 2006, for SH fits. MWC SCL fit on a monthly planned replacement (PR) basis reduced in popularity over the seven-year period (75.0% to 39.9%) and in 2006 more patients were fit overall with SH lenses (42.9%). The use of non-PR SCL declined from 20.5% to 4.5% of all fits. Fitting of low-water content lenses also declined (15.1% to 7.0%). High-water content (5.4% to 10.2%) and SH lenses (5.4% to 42.9%) both increased. By 2006, the majority of GP lenses fit were with high Dk (HDK) materials (50.3%). CONCLUSIONS: The preferred contact lens modality for Canadian optometrists appears to be DW SCL, which are replaced monthly. The proportion of lenses used for CW peaked in 2004, with SH SCL being the preferred material. The market share for GP lenses remains relatively unchanged, with an increasing proportion used for OK and CW. The launch of DW SH lenses in 2004 resulted in a marked increase in their reported fits, with a similar effect following the launch of a HDK GP lens material for CW.

Xie, P.Y.

[Promote sound development of domestic modern orthokeratology]

Zhonghua Yan Ke Za Zhi, 2007. 43(8): p. 676-9.

Introduced the history of orthokeratology briefly. Give a definition of modern orthokeratology. Evaluated the effects and safety of orthokeratology for the myopia reduction and myopia control based on the studies from authoritative units domestic and abroad. Compared to international advanced level, approached any misunderstanding from different angles in domestic utility, such as unrealistic spread in the early, commercial operate, overstate the danger, and problems of applicable groups, wearing method and period also be discussed. Furthermore indicated that the further development of new material, new individual design and wavefront aberration guided technology should improve visual quality of orthokeratology, should make more longer effect, more safety and more comfortable results. It could promote sound development of domestic modern orthokeratology then.

Barbero, S.

Refractive power of a multilayer rotationally symmetric model of the human cornea and tear film

J Opt Soc Am A Opt Image Sci Vis, 2006. 23(7): p. 1578-85.

Optical models of the human cornea and tear film typically employ a single homogeneous cornea with an average refractive index. I propose to use a more realistic multilayer model based on morphological data from the literature. The mathematical methodology to derive the refractive power equation of this model is presented. Special attention is given to the axial gradient index of the refraction structure of the stroma layer because of its optical implications. The importance of considering this multilayer model is quantified in a specific example (orthokeratology) with the help of the derived power equation.

Boost, M., P. Cho, and S. Lai

Efficacy of multipurpose solutions for rigid gas permeable lenses

Ophthalmic Physiol Opt, 2006. 26(5): p. 468-75.

The use of multipurpose solutions for cleaning and disinfecting rigid gas permeable lenses has replaced single purpose solutions, but there are no reports of the efficacy of these multipurpose solutions, or of the effects of storage conditions on their disinfecting capacities. This study investigated activity against four bacterial and two fungal species, and the effects of storage in a refrigerator, at room temperature, at elevated temperature in both dry and humid conditions and with exposure to sunlight. The disinfecting solutions were challenged with the micro-organisms initially upon opening and then at 2-weekly intervals up to 12 weeks after being stored under the different conditions. Solutions were opened daily to simulate use. One solution failed to meet Food and Drug Administration (FDA) criteria to reduce numbers of bacteria by three log dilutions and of fungi by one log dilution. Storage reduced activity of all solutions over the 12-week period, but not below the requirements of the FDA. Storage in the refrigerator tended to reduce disinfecting capacity more quickly. Multipurpose solutions for rigid gas permeable (RGP) lenses lose activity over the 3 months recommended time of use but remain satisfactory for use over this time in the conditions tested. Practitioners need to remind patients to replace their solutions regularly and should advise against storage in the refrigerator. Multipurpose solutions for RGP lenses have simplified cleaning and disinfecting processes and the current formulations have improved disinfecting capacity compared to former disinfecting solutions, which is particularly important for wearers of orthokeratology lenses.

Chan, B., P. Cho, and S.W. Cheung

Repeatability and agreement of two A-scan ultrasonic biometers and IOLMaster in non-orthokeratology subjects and post-orthokeratology children

Clin Exp Optom, 2006. 89(3): p. 160-8.

PURPOSE: Our aim was to determine the repeatability of measurements of axial length (AL) and anterior chamber depth (ACD) made with two ultrasonic biometers and the IOLMaster in a group of non-orthokeratology (ortho-k) adult subjects and to investigate the agreement among instruments in children undergoing ortho-k therapy and in children wearing spectacles. **METHODS:** To determine repeatability, AL and ACD were measured twice in 22 non-ortho-k young adults using two A-scan ultrasonic biometers (A-5500 and A-2500) and the IOLMaster. To determine agreement, AL and ACD were measured with the same instruments in 30 children undergoing ortho-k therapy and 30 spectacle-wearing children. **RESULTS:** In the adult subjects, there were no significant differences in ACD and AL measurements obtained from the three instruments (repeated measures ANOVAs, $p > 0.05$). There was also no significant between-measurement difference for each instrument. The between-measurement agreement was better for the IOLMaster (95% limits of agreement (LA): -0.04 and +0.05 mm for both AL and ACD) than for the two A-scan ultrasonic biometers (95% LA: -0.12 and +0.11 mm for AL; -0.22 and +0.27 mm for ACD).

Among the children, AL measurements with all three instruments were not significantly different from each other for both the children undergoing ortho-k therapy and those wearing spectacles (repeated measures ANOVAs, $p > 0.05$). The 95% LA of differences obtained from any two instruments were also comparable for both groups of subjects (within -0.20 mm and $+0.20$ mm). ACD measurements of the children were significantly different among the three instruments (repeated measures ANOVAs, $p < 0.05$). No significant differences in ACD measurements were found between A-5500 and A-2500 for both groups of children (paired t tests, $p > 0.017$). CONCLUSIONS: The repeatability of AL and ACD measurements with the IOLMaster was very good, and was better than with the A-scan ultrasonic biometers. The agreements in AL measurements between A-scan ultrasonic biometers and IOLMaster were comparable in both the ortho-k and the spectacle-wearing subjects, and were comparable to the repeatability of the A-scan ultrasonic biometers. ACD measurements between A-scan ultrasonic biometry and the IOLMaster were not comparable. AL measurements with the IOLMaster can replace the measurements from the two A-scan ultrasonic biometers used, however, the reverse is not true. AL and ACD measurements with all three instruments were unaffected by the flattened cornea following ortho-k lens wear.

Charman, W.N., et al.

Peripheral refraction in orthokeratology patients

Optom Vis Sci, 2006. 83(9): p. 641-8.

PURPOSE: The purpose of this study is to measure refraction across the horizontal central visual field in orthokeratology patients before and during treatment. **METHODS:** Refractions were measured out to 34 degrees eccentricity in both temporal and nasal visual fields using a free-space autorefractor (Shin-Nippon SRW5000) for the right eyes of four consecutively presenting myopic adult patients. Measurements were made before orthokeratology treatment and during the course of treatment (usually 1 week and 2 weeks into treatment). Refractions were converted into mean sphere (M), 90 degrees to 180 degrees astigmatism (J180), and 45 degrees to 135 degrees astigmatism (J45) components. **RESULTS:** Before treatment, subjects had either a relatively constant mean sphere refraction across the field or a relative hypermetropia in the periphery as compared with the central refraction. As a result of treatment, myopia decreased but at reduced rate out into the periphery. Most patients had little change in mean sphere at 30 degrees to 34 degrees. In all patients, the refraction pattern altered little after the first week. **CONCLUSION:** Orthokeratology can correct myopia over the central ± 10 degrees of the visual field but produces only minor changes at field angles larger than 30 degrees. If converting relative peripheral hypermetropia to relative peripheral myopia is a good way of limiting the axial elongation that leads to myopia, orthokeratology is an excellent option for achieving this.

Cheung, S.W., et al.

Case report: the occurrence of fibrillary lines in overnight orthokeratology

Ophthalmic Physiol Opt, 2006. 26(5): p. 525-31.

BACKGROUND: To report the occurrence of concentric fibrillary lines in the central corneas of a 13-year-old girl during overnight orthokeratology. **METHODS:** Observational case report. **RESULTS:** The initial refractive errors and keratometric readings (flattest/steepest meridians) of the patient were -6.00/-0.50 x 180 and 45.25/46.20 D, respectively, in the right eye and -5.50 DS and 44.90/45.80 D, respectively in the left eye. She underwent orthokeratology for myopic control, with a target reduction of 4.00 D myopia. A pair of DreimLens lenses was prescribed to be worn on a nightly basis and spectacles were worn by day. The same orthokeratology lenses were used throughout the monitoring period. Corneal topography showed well-centred treatment zones but persistent peripheral corneal staining due to trichiasis. A faint, peripheral pigmented brownish corneal arc and bundles of fine concentric fibrillary lines were observed in the central cornea about 12 months after commencing lens wear. In view of the persistent corneal staining due to trichiasis, she was advised to stop the orthokeratology treatment after 16 months of lens wear and was prescribed 1-Day Acuvue daily disposable contact lenses. The pigmented line disappeared after 2 months of hydrogel lens wear, while the fibrillary lines took 10 months to resolve. **CONCLUSIONS:** Fibrillary lines are a feature of the normal cornea thought to represent the arrangement of the subbasal, epithelial nerve plexus. We hypothesize that orthokeratology lens wear stimulates an altered epithelial migration pattern and a structural reorganisation of the subbasal nerve plexus in relation to this. This is assumed to account for the concentric pattern of fibrillary lines seen in our patient. The lines had no effect on vision and resolved over a period of 10 months following cessation of orthokeratology lens wear.

Hammersmith, K.M.

Diagnosis and management of Acanthamoeba keratitis

Curr Opin Ophthalmol, 2006. 17(4): p. 327-31.

PURPOSE OF REVIEW: This paper reviews the literature generated on Acanthamoeba keratitis since 1998. **RECENT FINDINGS:** Acanthamoeba infections may be on the rise. Contact lenses are the biggest risk factor for their development. Silicone hydrogel lenses are increasingly prescribed and may be 'more sticky' to Acanthamoeba organisms. Orthokeratology for the treatment of myopia has been associated with many new cases of Acanthamoeba keratitis. Daily disposable contact lenses are the safest form of soft contact lens. Patients continue to be misdiagnosed as having herpetic keratitis. Impression cytology and confocal microscopy are newer diagnostic modalities. Topical polyhexamethylene biguanide, chlorhexidine and propamidine are the mainstay of medical therapy. Amniotic membrane may be used for cases of persistent epithelial defect and to control inflammation. Penetrating keratoplasty in a medically treated eye affords a good chance of positive outcome. **SUMMARY:** Acanthamoeba keratitis continues to be a difficult infection to diagnose and manage. The frequency of these infections may be on the rise, most commonly associated with frequent replacement soft contact lenses. The best chance for a good outcome is based on early diagnosis, so it is important for ophthalmologists consider it in patients, especially in the contact lens wearer with suspected herpes simplex keratitis.

Hiraoka, T., et al.

Optical quality of the cornea after overnight orthokeratology

Cornea, 2006. 25 Suppl 1: p. S59-63.

PURPOSE:: To review changes in the optical quality of the cornea induced by overnight orthokeratology for myopia. **METHODS::** Sixty-four eyes of 39 patients who underwent overnight orthokeratology for myopia were prospectively examined. Inclusion criteria were uncorrected visual acuity of 20/20 or better after treatment and a minimum follow-up of 3 months. To quantitatively assess changes in corneal regular and irregular astigmatism, videokeratography data were decomposed into spherical component, regular astigmatism, asymmetry, and higher-order irregularity using Fourier analysis. In addition, corneal wavefront aberrations were calculated by expanding anterior corneal height data from videokeratography into a set of orthogonal Zernike polynomials. **RESULTS::** Although orthokeratology significantly reduced manifest refraction and improved uncorrected visual acuity, the asymmetry component, which is one of the features of irregular astigmatism, increased significantly from 0.35 +/- 0.22 to 0.64 +/- 0.40 D after treatment ($P < 0.0001$, paired t test). The increases in the asymmetry component significantly correlated with the amount of myopic correction (Pearson correlation coefficient, $R = 0.40$, $P = 0.0009$). Furthermore, the root-mean-square of third-order (coma-like) and fourth-order (spherical-like) aberrations significantly increased after orthokeratology ($P < 0.0001$, paired t test), and these increases showed significant positive correlations with the amount of myopic correction (Pearson correlation coefficient, $R = 0.452$, $P = 0.0001$ and $R = 0.381$, $P = 0.0017$, respectively). **CONCLUSION::** Corneal irregular astigmatism and higher-order aberrations significantly increased even in clinically successful orthokeratology, and the increases correlated with the magnitude of myopic correction. A large myopic correction by orthokeratology should be avoided to not decrease corneal optical quality.

Ng, L.H.

Central corneal epitheliopathy in a long-term, overnight orthokeratology lens wearer: a case report

Optom Vis Sci, 2006. 83(10): p. 709-14.

PURPOSE: The purpose of this study is to report an unusual case of central corneal epitheliopathy (CCE) in a long-term orthokeratology lens wearer. **CASE REPORT:** A single observational case report of a 12-year-old Chinese female myope with 3(1/2) years' experience in wearing orthokeratology lenses overnight was diagnosed with a CCE lesion during her regular orthokeratology aftercare consultation. The patient was asymptomatic. Trace or almost negative fluorescein staining was observed over the particular lesion area and, according to the clinical features of the corneal lesion, was thought to be a partially formed "dellen." The lesion healed after the use of the orthokeratology lenses was suspended for 4 months and reappeared when the patient resumed wearing the lenses. Close monitoring of the corneal condition was needed on this patient, and permanent discontinuation of the orthokeratology procedures will be considered if the signs and

symptoms of the lesion worsen. DISCUSSION: The etiology, clinical management and the possible differential diagnosis of the central cornea "dellen" are discussed. CONCLUSION: A central corneal "dellen" may be associated with long-term, overnight use of orthokeratology lenses.

Soni, P.S. and T.T. Nguyen

Overnight orthokeratology experience with XO material

Eye Contact Lens, 2006. 32(1): p. 39-45.

PURPOSE: To evaluate long-term safety and effectiveness of overnight orthokeratology in a large sample of myopes by using three different lens designs and the highly gas-permeable Boston XO material (Bausch & Lomb, Rochester, NY). **METHODS:** A total of three hundred forty-two subjects, 99 of whom were juveniles, were enrolled in the investigation at 26 clinical centers in the United States and Canada. Three different lens designs in Boston XO material were used. Subjects were limited to a measured visual need for correction of myopia less than or equal to 4.00 diopters and astigmatism less than or equal to 1.50 diopters with best-corrected Snellen visual acuity of 20/40 or better. Refractive error and unaided visual acuity were used to determine the effectiveness of the procedure at short-term (1 month) and long-term (12 months). The safety of the procedure was determined by the symptoms reported, and slitlamp findings suggested physiologic rejection of the procedure. **RESULTS:** One hundred thirty-three adults and 68 juveniles completed the 12-month study. More than 60% of the subjects reached 20/20 vision or better at the end of 1 month of overnight lens wear, and this number remained stable during the next 11 months. A reduction in myopia of 70% and of more than 90% was measured at the 1- and 12-month visits, respectively. Safety data indicate a decrease in symptoms and in general a decrease in positive slitlamp findings with time. **CONCLUSIONS:** The procedure with all three lenses in Boston XO material is effective. However, the safe use of orthokeratology lenses is predicated on the emphasis of clear patient direction on how to wear and take care of the lenses followed by regular examinations by an eye care practitioner.

Sun, X., et al.

Infectious keratitis related to orthokeratology

Ophthalmic Physiol Opt, 2006. 26(2): p. 133-6.

PURPOSE: To report 28 cases of infectious keratitis related to orthokeratology lens overnight wear in China. **METHODS:** From March 2000 to August 2001, 28 cases of infectious keratitis related to overnight orthokeratology lens wear were diagnosed in Beijing Institute of Ophthalmology. These were retrospectively reviewed with regard to the pathogens isolated, duration of wear, the time since onset of symptoms, and age. Cultures of corneal scrapes for bacteria, fungus and Acanthamoeba were performed in all of the 28 cases. **RESULTS:** All cases were students, including 10 males and 18 females, average age was 16 years (range 10-21 years). The duration of orthokeratology overnight wearing

was from 2 weeks to 2 years. Uncorrected visual acuity (UCVA) on initial examination in our institute was from 20/200 to light perception. Of 28 isolates, 24 were culture positive (including 11 bacteria, 11 Acanthamoeba and two fungi), and four were culture negative. In two of the four culture negative cases, Acanthamoeba cysts were detected in the corneal stroma with the confocal microscope. Acanthamoeba and Pseudomonas aeruginosa accounted for 75% (21 of 28) of the cases of infectious keratitis. CONCLUSION: Infectious keratitis is a severe complication associated with overnight orthokeratology lens wear. Ophthalmologists should pay more attention to this complication in practice.

Swarbrick, H.A.

Orthokeratology review and update

Clin Exp Optom, 2006. 89(3): p. 124-43.

Orthokeratology (OK) is a clinical technique that uses specially designed rigid contact lenses to reshape the cornea to temporarily reduce or eliminate refractive error. This article reviews the history of traditional daily-wear OK (1960s to 1980s) and discusses the reasons for the recent resurgence in interest in the new modality of overnight OK, using reverse-geometry lens designs (1990s to the present). The clinical efficacy of the current procedure is examined and outcomes from clinical studies in terms of refractive error change and unaided visual acuity are summarised. Onset of the effects of overnight OK lens wear is rapid, with most change after the first night of lens wear and stability of refractive change after seven to 10 days. Mean reductions in myopic refractive error of between 1.75 and 3.33 D and individual reductions of up to 5.00 D have been reported. There appear to be slight reductions or minimal changes in astigmatism with the use of reverse-geometry lenses and most patients are reported to achieve 6/6 unaided vision or better. The induction of higher order aberrations, in particular, spherical aberration, has been reported and this may affect subjective vision under conditions of low contrast and pupil dilation. Patient satisfaction with overnight OK has been reported as similar to or better than with other popular modalities of contact lens wear. Available evidence suggests that the corneal changes induced by overnight OK are fully reversible. The refractive effect in OK is achieved by central epithelial thinning and this has raised concerns about compromise of the epithelial barrier to microbial infection. Recent reports of microbial keratitis in the modality are reviewed and the overall safety of the procedure is examined critically. Recent research on stromal contributions to the OK effect, particularly relating to overnight oedema, is summarised. Emerging issues in OK, including myopic control, correction of other refractive errors and permanency of the OK effect, are discussed.

Ying-Cheng, L., et al.

Daytime orthokeratology associated with infectious keratitis by multiple gram-negative bacilli: Burkholderia cepacia, Pseudomonas putida, and Pseudomonas aeruginosa

Eye Contact Lens, 2006. 32(1): p. 19-20.

PURPOSE: To report a case of a corneal ulcer in a patient who wore orthokeratology contact lenses during the day. **METHODS:** Case report. **RESULTS:** A 16-year-old girl who underwent orthokeratology treatment developed a corneal ulcer in her right eye. The refractive status of the affected eye was -5.75 -1.75 x 180, and the best-corrected visual acuity was 20/40. Corneal topography showed the temporal upper dislocation of a central flattened zone in the right eye. The patient had worn orthokeratology contact lenses during the day for more than 4 years. Her ulcer became worse after treatment with tobramycin and gentamicin for 1 day. After treatment with ciprofloxacin, the ulcer healed, and visual acuity returned to 20/20 with spectacle correction. Cultures of the cornea, contact lens, and lens solution all grew *Burkholderia cepacia*, *Pseudomonas putida*, and *Pseudomonas aeruginosa*. **CONCLUSIONS:** Improper fitting of lenses and contamination of lenses or solutions in orthokeratology therapy are risk factors for a corneal ulcer, even when patients wear orthokeratology lenses only during the day.

Alharbi, A., D. La Hood, and H.A. Swarbrick

Overnight orthokeratology lens wear can inhibit the central stromal edema response

Invest Ophthalmol Vis Sci, 2005. 46(7): p. 2334-40.

PURPOSE: To investigate the overnight corneal edema response during overnight orthokeratology (OK). **METHODS:** Eighteen young adult myopic subjects wore reverse-geometry lenses in Boston XO material (nominal Dk/t 46 x 10(-9) cm.mL O₂/s.mL.mmHg) on an overnight wearing schedule for 1 month. Another 10 subjects wore conventional rigid gas-permeable (GP) lenses of similar Dk/t in one eye only, on an identical schedule. Corneal stromal thicknesses in the center, midperiphery, and periphery were measured by optical pachometry in the morning after lens removal, after 1, 4, 10, and 30 nights of wear. Changes from baseline for OK, GP and no-lens eyes were compared by repeated-measures ANOVA and protected post hoc t-tests. **RESULTS:** The central stroma swelled significantly less in OK than in GP eyes ($P < 0.001$, ANOVA), and less than with no lens wear ($P < 0.001$, ANOVA) throughout the study. Overnight edema levels consistent with Dk/t were found on day 1 in the midperiphery (3.5 mm from apex) and periphery (5.0 mm) with both OK and GP lenses. The overnight edema response decreased significantly through the study with both lens types. Recovery to baseline stromal thickness during the day was demonstrated for GP eyes and for OK eyes in the central and peripheral cornea. **CONCLUSIONS:** Overnight wear of reverse-geometry OK lenses inhibited the central stromal edema response. Overnight edema levels consistent with Dk/t were found in the corneal midperiphery and periphery. Adaptation of the edema response occurred with continuing overnight lens wear. The results suggest that central pressure exerted by the flat-fitting base curve of the OK lens acts locally as a "clamp" to inhibit overnight central corneal swelling.

Araki-Sasaki, K., I. Nishi, N. Yonemura, et al.

Characteristics of *Pseudomonas* corneal infection related to orthokeratology

Cornea, 2005. 24(7): p. 861-3.

PURPOSE: To describe a *Pseudomonas aeruginosa* corneal infection resulting from orthokeratology. **METHODS:** Case report. **RESULTS:** A 17-year-old boy wearing orthokeratology (OK) lenses was referred to our clinic because of redness in his right eye in spite of his usage of ofloxacin (OFLX) eye drops. An excavated paracentral corneal ulcer with an immune ring and hypopyon was observed. It was positioned under the paracentral steeper portion of the optic of the OK lens. Culture of the lens solution revealed *P. aeruginosa*. The patient was treated with topical OFLX and cefmenoxime (CMX) plus intravenous and subconjunctival injections of ceftazidime (CZOP), successfully. The antibiotic susceptibility of *P. aeruginosa* by the disk diffusion susceptibility test was reduced under moderately hypoxic conditions. Glycocalyx slime was formed on the OK lens in vitro by *P. aeruginosa* isolated from the case. **CONCLUSIONS:** Changes in *P. aeruginosa* susceptibility to antibiotics under moderately hypoxic conditions and glycocalyx slime formation might affect the features of OK lens-associated infections.

Berntsen, D.A., J.T. Barr, and G.L. Mitchell

The effect of overnight contact lens corneal reshaping on higher-order aberrations and best-corrected visual acuity

Optom Vis Sci, 2005. 82(6): p. 490-7.

PURPOSE: The purpose of this study is to determine the effect of higher-order aberrations after Corneal Refractive Therapy (CRT) on best-corrected visual acuity (BCVA) and the impact of pupil size on BCVA. **METHODS:** High-contrast (HC) and low-contrast (LC) Bailey-Lovie BCVA was measured in the morning before and after pupil dilation on 20 myopes (mean spherical equivalent $-3.11 \text{ D} \pm 0.96 \text{ D}$) under age 40. BCVA was measured again in the afternoon after dilation. Dilated am and pm aberrations were measured using the Complete Ophthalmic Analysis System (WaveFront Sciences). Patients were fit with CRT lenses in each eye. One month after finalizing the lens fit, BCVA and aberration testing were repeated. Average higher-order RMS error (third to sixth order), spherical aberration, third-, fourth-, fifth-, and sixth-order RMS error were calculated at each visit for a 3-mm and 5-mm pupil. BCVA and aberration data were analyzed using a repeated measures analysis of variance. Linear regression was used to describe the relationship between aberrations and BCVA reductions after CRT. **RESULTS:** Mean refractive error changed by $+3.33 \text{ D} \pm 0.96 \text{ D}$. No clinically significant changes were found in HC BCVA post-CRT, whereas LC BCVA reductions of 0.07 logarithm of the minimum angle of resolution (logMAR) (nondilated, $p = 0.002$) and 0.12 logMAR (dilated, $p < 0.001$) were found. No additional decrease in HC BCVA was found after pupil dilation, whereas a mean additional decrease of 0.08 logMAR in LC BCVA was found with dilation post-CRT ($p = 0.013$). Higher-order RMS error increased for both 3-mm and 5-mm pupils ($p < 0.0001$) and remained stable between measurements. Spherical aberration increased for 5-mm pupils after CRT ($p < 0.0001$). For a 5-mm pupil, a 0.1-mum increase in spherical aberration was associated with an additional decrease in LC BCVA after pupil dilation post-CRT of 0.056 logMAR ($R = 0.382$, $p = 0.004$). **CONCLUSIONS:** CRT results in reduced low-contrast BCVA as a result of increased higher-order aberrations. Higher-order

aberrations appear to be relatively stable after CRT. Spherical aberration appears to drive additional low-contrast BCVA losses as pupil size increases.

Boost, M.V. and P. Cho

Microbial flora of tears of orthokeratology patients, and microbial contamination of contact lenses and contact lens accessories

Optom Vis Sci, 2005. 82(6): p. 451-8.

PURPOSE: The purpose of this study is to determine if there are changes in the ocular flora of overnight orthokeratology (ortho-k) patients, and the levels of contamination of their lenses and lens accessories, and to correlate compliance with levels of contamination. **METHOD:** Normal ocular flora of 41 subjects was determined twice before commencing ortho-k lens wear by culture of the lower conjunctiva. Further specimens were collected on six follow-up visits after beginning lens wear, as were samples from their lenses, cases, and suction holders. A questionnaire on lens care was administered after the fifth visit. **RESULTS:** Three subjects provided conjunctival samples yielding *Staphylococcus aureus* on one occasion before lens wear, one being positive for this organism after beginning lens wear. Of 38 subjects yielding no growth or only normal eye flora before use, 28 remained free of ocular pathogens after beginning lens wear. Only four subjects had positive cultures on more than one occasion after lens wear. There was no significant difference in isolation levels of pathogens with lens wear ($p = 0.423$). Lens culture of 54% of subjects yielded no growth or normal flora only; lenses of 16 subjects yielded potential pathogens, including three subjects contaminated on more than one occasion. Lens isolates did not match the organisms transiently colonizing the eye. Lens case, the most frequently contaminated item, was associated with lens contamination ($p < 0.001$), the same organism being isolated from both items in 11 subjects. Lens suction holder was less frequently contaminated. Neither lens case nor suction holder contamination was associated with isolates from the eye. Reported good compliance correlated with lack of contamination in all but one subject. The most frequent breaches in the lens care protocol were failure to clean, disinfect, and replace the lens case. **CONCLUSION:** Ocular flora was not altered by ortho-k lens wear over an extended period, and patients remained free of infection. Contaminants identified were generally of a transient nature. Most patients had significant contamination of at least one item, most frequently the lens case. Lens case isolates were significantly associated with those from the lens. The majority of patients reporting good compliance had low or no contamination of their lenses and accessories.

Cabrera Fernandez, D., A.M. Niazy, R.M. Kurtz, et al.

Finite element analysis applied to cornea reshaping

J Biomed Opt, 2005. 10(6): p. 064018.

A 2-D finite element model of the cornea is developed to simulate corneal reshaping and the resulting deformation induced by refractive surgery. In the numerical simulations, linear and nonlinear elastic models are applied when stiffness inhomogeneities varying with

depth are considered. Multiple simulations are created that employ different geometric configurations for the removal of the corneal tissue. Side-by-side comparisons of the different constitutive laws are also performed. To facilitate the comparison, the material property constants are identified from the same experimental data, which are obtained from mechanical tests on corneal strips and membrane inflation experiments. We then validate the resulting models by comparing computed refractive power changes with clinical results. Tissue deformations created by simulated corneal tissue removal using finite elements are consistent with clinically observed postsurgical results. The model developed provides a much more predictable refractive outcome when the stiffness inhomogeneities of the cornea and nonlinearities of the deformations are included in the simulations. Finite element analysis is a useful tool for modeling surgical effects on the cornea and developing a better understanding of the biomechanics of the cornea. The creation of patient-specific simulations would allow surgical outcomes to be predicted based on individualized finite element models.

Charman, W.N.

Wavefront technology: past, present and future

Cont Lens Anterior Eye, 2005. 28(2): p. 75-92.

After outlining what is meant by wavefront aberration, the history of the field of wavefront technology is sketched and methods for measuring ocular wavefront aberration are briefly described. The variations in aberration of the normal eye with the individual and their pupil size, accommodation and age are summarised. Potential contact lens applications are outlined, including the design and on-eye performance of single-vision lenses, lenses for presbyopes and keratoconics, orthokeratology, tear film studies, and the design and performance of customised contact lenses intended to minimise residual lens-eye wavefront error.

Cheung, S.W., P. Cho, and A. Cheung

White lesion in the corneal pigmented ring associated with orthokeratology

Ophthalmic Physiol Opt, 2005. 25(3): p. 264-8.

The development of the pigmented corneal arc and a white lesion near the inner margin of the arc in a girl wearing overnight orthokeratology (ortho-k) lenses for myopic control is reported. The girl was examined before and followed up every 6 months after the treatment over a 3-year period. The initial spherical equivalent refractive error and keratometric readings (flattest/steepest meridians) were -2.37 D and 45.00 D/46.75 D respectively in the right eye and -3.12 D and 45.25 D/46.00 D respectively in the left eye. She was wearing ortho-k lenses of a four-zone design made of Boston XO material on a nightly basis. The same lens design was used throughout the monitoring period. Corneal topography showed a rather well-centred treatment zone but vision varied between visits because of fluctuations in residual refractive error. The corneal condition of each eye was unremarkable except for the presence of the pigmented corneal arc first observed 6

months after the commencement of the treatment. The intensity of the arc did not change over the years in the right eye but increased in the left eye. A faint white lesion within the inner border of the left pigmented arc was first observed at the end of the second year and it became more obvious at the end of the third year. This lesion appears to be similar to those reported in intense Fleischer's rings associated with keratoconus. Although the presence of the arc may have no clinical ramification, the change in the intensity and the development of the white lesion may reflect an increased stress exerted on the cornea with continued ortho-k lens wear.

Cho, P., S.W. Cheung, and M. Edwards

The longitudinal orthokeratology research in children (LORIC) in Hong Kong: a pilot study on refractive changes and myopic control

Curr Eye Res, 2005. 30(1): p. 71-80.

PURPOSE: Myopia is a common ocular disorder, and progression of myopia in children is of increasing concern. Modern overnight orthokeratology (ortho-k) is effective for myopic reduction and has been claimed to be effective in slowing the progression of myopia (myopic control) in children, although scientific evidence for this has been lacking. This 2 year pilot study was conducted to determine whether ortho-k can effectively reduce and control myopia in children. **METHODS:** We monitored the growth of axial length (AL) and vitreous chamber depth (VCD) in 35 children (7-12 years of age), undergoing ortho-k treatment and compared the rates of change with 35 children wearing single-vision spectacles from an earlier study (control). For the ortho-k subjects, we also determined the changes in corneal curvature and the relationships with changes of refractive errors, AL and VCD. **RESULTS:** The baseline spherical equivalent refractive errors (SER), the AL, and VCD of the ortho-k and control subjects were not statistically different. All the ortho-k subjects found post-ortho-k unaided vision acceptable in the daytime. The residual SER at the end of the study was -0.18 ± 0.69 D (dioptre) and the reduction (less myopic) in SER was 2.09 ± 1.34 D (all values are mean \pm SD). At the end of 24 months, the increases in AL were 0.29 ± 0.27 mm and 0.54 ± 0.27 mm for the ortho-k and control groups, respectively (unpaired t test; $p = 0.012$); the increases in VCD were 0.23 ± 0.25 mm and 0.48 ± 0.26 mm for the ortho-k and control groups, respectively ($p = 0.005$). There was significant initial corneal flattening in the ortho-k group but no significant relationships were found between changes in corneal power and changes in AL and VCD. **CONCLUSION:** Ortho-k can have both a corrective and preventive/control effect in childhood myopia. However, there are substantial variations in changes in eye length among children and there is no way to predict the effect for individual subjects.

Cho, P., S.W. Cheung, J. Mountford, and W.S. Chui

Incidence of corneal pigmented arc and factors associated with its appearance in orthokeratology

Ophthalmic Physiol Opt, 2005. 25(6): p. 478-84.

PURPOSE: To determine the incidence of the corneal pigmented arc in orthokeratology (ortho-k) lens wearers over 12 months of lens wear and the factors associated with its appearance. **METHOD:** Thirty-five ortho-k subjects were recruited; refractive and corneal changes after lens wear (single-lens protocol) were monitored over 12 months. The incidence of the pigmented arc after 3, 6 and 12 months of lens wear was determined. **RESULTS:** The incidence of corneal pigmented arc was 17% (27%), 49% (49%) and 90% (93%) after 3, 6 and 12 months lens wear respectively in the left and right eyes. For subjects with arcs observed in the left eye within the first 6 months of lens wear, the mean +/- S.D. period of lens wear before initial detection of the arc was 14 +/- 7.4 weeks, and no correlation was found between this factor and the baseline spherical and cylindrical refractive errors (i.e. refractive sphere and cylinder, respectively), spherical equivalent refractive error (SERE), the target myopia reduction, the amount of refractive sphere (or SERE) reduction and changes in central and peripheral corneal curvatures after 6 months of lens wear. Baseline refractive sphere, baseline SERE, target, amount of myopia reduction, and change in central corneal curvature were significantly larger ($p < 0.05$) in those subjects with pigmented arcs after about 6 months of lens wear. The intensity of the observed pigmented arcs after about 6 months of lens wear was significantly related to the time when it was first observed ($p = 0.003$). Significant correlation was also found between the intensity of the arcs and the following parameters: baseline refractive sphere and SERE, target, change in central corneal curvature, and amount of myopia reduction ($p < 0.006$). After about 12 months of lens wear, the intensity of observed arcs was significantly related to the baseline refractive sphere, SERE and the target ($p < 0.006$). **CONCLUSION:** The incidence of ortho-k-associated pigmented arc increases from 17% after 3 months of lens wear to over 90% after 12 months of lens wear. The intensity of the arc is related to the time when the arc first appeared. Both the incidence and the intensity of the arc are related to the period of lens wear, baseline refractive sphere, SERE and the target.

Chui, W.S. and P. Cho

A comparative study of the performance of different corneal topographers on children with respect to orthokeratology practice

Optom Vis Sci, 2005. 82(5): p. 420-7.

PURPOSE: The purpose of this study was to evaluate and compare the performance of three topographers, Medmont E300, Keratron Scout, and Humphrey Atlas 991, for the measurement of corneal parameters of interest in orthokeratology practice on young children. **METHODS:** Apical radius (R0), flattest corneal curvature (flat k), eccentricity (e) value, and elevation at 9-mm chord were measured twice on 22 healthy subjects of mean +/- standard deviation (SD) age 11.2 +/- 2.2 years using the topographers under investigation. **RESULTS:** The repeatability of the Medmont and Humphrey were good for the measurements of R0 and flat k. The repeatability of the Humphrey was also good for the measurement of e-value. However, for both topographers, the measurement of elevation was not precise enough for orthokeratology empirical lens design. The Keratron showed poor repeatability for all the parameters evaluated. The agreement of the parameters of interest between these instruments was poor. **CONCLUSIONS:** The Medmont and the Humphrey showed good repeatability on children, but the precision of elevation measurements was not good enough to be used for designing empiric orthokeratology lenses on children. The Keratron is not recommended to be used on

children in orthokeratology fitting and management. Interinstrumental agreements were significantly different and therefore measurements from different topographers should not be used interchangeably.

Hiraoka, T., Y. Matsumoto, F. Okamoto, et al.

Corneal higher-order aberrations induced by overnight orthokeratology

Am J Ophthalmol, 2005. 139(3): p. 429-36.

PURPOSE: To evaluate corneal higher-order aberrations induced by overnight orthokeratology for myopia. **DESIGN:** Prospective, noncomparative, consecutive, interventional case series. **METHODS:** A prospective study was conducted in 64 eyes of 39 patients with overnight orthokeratology for myopia, who were followed up for at least 3 months and attained uncorrected visual acuity of 20/20 or better. Corneal height data were obtained with computerized videokeratography (TMS-2N, Tomey), and wavefront aberration was derived using Zernike polynomials. Higher-order aberrations of the cornea were calculated for 3- and 6-mm pupils. **RESULTS:** Orthokeratology significantly reduced manifest refraction from -2.60 ± 1.13 (mean \pm SD) diopters to -0.17 ± 0.31 diopters ($P < .0001$, paired t test). Root-mean-square (RMS) of third-order (coma-like) aberrations significantly increased by orthokeratology for both 3-mm ($P < .0001$, paired t test) and 6-mm ($P < .0001$) pupils. Fourth-order RMS (spherical-like) aberrations increased significantly by the treatment for both 3-mm ($P < .0001$) and 6-mm ($P < .0001$) pupils. Vertical coma significantly changed from positive to negative for both 3-mm ($P = .0323$) and 6-mm ($P < .0001$) pupils. Horizontal coma significantly increased to the positive direction for both 3-mm ($P < .0001$) and 6-mm ($P < .0001$) pupils. Increases in the third- and fourth-order RMS showed significant positive correlations with the amount of myopic correction for 3-mm (Pearson correlation coefficient, $r = .452$, $P = .0001$ for third-order RMS, $r = .381$, $P = .0017$ for fourth-order RMS) and 6-mm ($r = .499$, $P < .0001$, $r = .455$, $P = .0001$) pupils. **CONCLUSIONS:** Corneal higher-order aberrations significantly increased, even in clinically successful orthokeratology cases. The increases in the higher-order aberrations correlated with the magnitude of myopic correction.

Hsiao, C.H., H.C. Lin, Y.F. Chen, et al.

Infectious keratitis related to overnight orthokeratology

Cornea, 2005. 24(7): p. 783-8.

PURPOSE: To report the microbial culture results, clinical course, and visual outcomes for infectious keratitis related to overnight orthokeratology. **METHODS:** The records of patients with infectious keratitis related to overnight orthokeratology who presented to a tertiary referral center from April 2000 to March 2003 were retrospectively reviewed. **RESULTS:** Twenty patients (21 eyes) were included; 1 patient had bilateral infections. The average age of the patients was 14 years. The average period between the time the patient started the overnight orthokeratology program and the onset of infectious keratitis was 23 months. Thirteen of the 21 eyes were culture positive. Organisms cultured were

Pseudomonas aeruginosa (n = 9), coagulase-negative *Staphylococcus* species (n = 2), *Serratia marcescens* (n = 1), and *Acanthamoeba* species (n = 1). All patients responded well to medical antimicrobial treatment. Final best spectacle-corrected visual acuity ranged from 20/20 to 20/100. CONCLUSIONS: Infectious keratitis is a potential complication of overnight orthokeratology that may cause significant visual impairment. Parents of children who consider overnight orthokeratology should evaluate the benefit of temporary myopia reduction and the risk of infection.

Jayakumar, J. and H.A. Swarbrick

The effect of age on short-term orthokeratology

Optom Vis Sci, 2005. 82(6): p. 505-11.

PURPOSE: The purpose of this study is to investigate the effect of age on the response to short-term (one hour) open eye orthokeratology (OK) lens wear. **METHODS:** Sixty volunteer subjects were divided into three groups (n = 20 per group) comprising children (group I, mean age: 9.5 +/- 1.7 years), young adults (group II, mean age: 24.6 +/- 3.7 years), and older adults (group III, mean age: 43.9 +/- 6.1 years). Subjects wore reverse-geometry lenses (BE; UltraVision Pty. Ltd., Brisbane, Australia) under open-eye conditions for 1 hour in one eye only. Unaided logarithm of the minimum angle of resolution (logMAR) visual acuity, corneal astigmatism calculated from simulated keratometric (SimK) readings, corneal asphericity and apical radius of curvature (Medmont corneal topographer), and total corneal, stromal, and epithelial thickness (Holden-Payor optical pachometer) were measured before and after lens wear. Two-tailed paired Student t-test were used to examine changes after OK, and analysis of variance and Bonferroni post hoc t tests were used to compare between groups with a critical p value of 0.05. **RESULTS:** All groups showed statistically significant (p < 0.05) improvement in unaided visual acuity, a trend for more positive (less prolate) corneal asphericity, increase in apical corneal radius, and decrease in central total corneal thickness after OK lens wear. Compared with groups I and II, group III showed significantly less change (p < 0.05) in visual acuity, apical corneal radius, corneal asphericity, central total corneal thickness, and epithelial thickness. **CONCLUSIONS:** Corneal and visual changes found in this study confirm previous reports of the rapid effects of short-term OK lens wear. Older lens wearers showed a reduced or delayed response to reverse-geometry lens wear in the short term, suggesting a reduced corneal epithelial response to interventions with increasing age.

Kwok, L.S., B.K. Pierscionek, M. Bullimore, et al.

Orthokeratology for myopic children: wolf in sheep's clothing?

Clin Experiment Ophthalmol, 2005. 33(4): p. 343-7.

Orthokeratology attempts to reduce myopia by remoulding the corneal shape with contact lenses. A recent resurgence is predicated on new contact lens designs with a prefigured back contact surface and higher oxygen transmissibility. This Clinical Controversy presents an analysis of the risk factors associated with orthokeratology and its suitability

for children, followed by commentaries from specialists who have an interest in the method. Some state that there is a lack of data on relative risks of corneal infection and that there is a need for large-scale randomized controlled studies; however, opinion is expressed by others that orthokeratology is a clinically safe procedure using modern lenses. It is noted that the physiological and biophysical bases of orthokeratology are virtually unknown, and further research on the human cornea is indicated to scientifically establish the safety of orthokeratology. Prospective patients, and their parents in the case of children, should be fully informed of the risks.

Lipson, M.J., A. Sugar, and D.C. Musch

Overnight corneal reshaping versus soft disposable contact lenses: vision-related quality-of-life differences from a randomized clinical trial

Optom Vis Sci, 2005. 82(10): p. 886-91.

PURPOSE: The purpose of this article is to evaluate patients' visual acuity, symptoms, and perceptions of vision-related quality of life in a randomized crossover clinical trial of overnight corneal reshaping (OCR) and daily wear soft lenses (SCL). **METHODS:** Qualified subjects were randomly assigned to wear one mode of contact lens for 8 weeks and then, after a washout period, they wore the alternate mode for 8 weeks. On concluding each contact lens wear mode, subjects completed the NEI-RQL42 questionnaire. During the SCL mode, subjects wore lenses during their waking hours. During the OCR mode, subjects wore lenses only while sleeping. Soft lenses were Biomedics 55 2-week disposable lenses. OCR lenses were CRT lenses by Paragon. (Three subjects were fit with custom-designed OCR lenses in Boston XO material, manufactured by Art Optical.) LogMAR acuity was measured and slit lamp evaluation was performed at specified intervals during follow up. After completing both phases of the study, patients chose which mode they preferred. **RESULTS:** Of 81 enrolled patients, 65 completed both phases and 16 dropped out during the study. Significant differences ($p < 0.01$) favoring SCL wear included better visual acuity and less trouble with glare. Significant differences ($p < 0.01$) favoring OCR wear included less activity limitations, less trouble with symptoms, and less dependence on refractive correction. Of 65 completing both phases, 44 preferred the OCR lenses and 21 preferred the soft lenses. Subjects who preferred the OCR lenses were less myopic and had steeper K readings at baseline, and showed less difference between visual acuity during OCR wear and visual acuity with SCL. **CONCLUSION:** In subjects with mild myopia who experienced both SCL and OCR, better visual acuity and less glare resulted from SCL wear, whereas activity limitations, symptoms, and dependence on refractive correction were less troublesome with OCR wear. When the study was completed, 67.7% chose OCR lenses worn only while sleeping, whereas 32.3% preferred 2-week disposable soft lenses worn during the day as their preferred correction.

Maldonado-Codina, C., S. Efron, P. Morgan, et al.

Empirical versus trial set fitting systems for accelerated orthokeratology

Eye Contact Lens, 2005. 31(4): p. 137-47.

PURPOSE: To compare the short-term clinical performance of two reverse-geometry rigid contact lens systems for accelerated orthokeratology with different fitting approaches and designs: an experimental lens that was fitted empirically (No. 7 Contact Lens Laboratory, Ltd.) and a more established lens using a trial set system, the BE lens (NKL). **METHODS:** Twenty-four subjects were enrolled in a clinical study in which the two reverse-geometry lenses were worn contralaterally for seven nights. The No. 7 lens was manufactured based on subject keratometric readings, refraction, and horizontal visible iris diameter. The BE lens was fitted in accordance with fitting guidelines provided by the manufacturer and included the use of proprietary computer software in addition to an overnight trial before lens ordering. Data were collected at baseline, day 1, and day 7 (morning and afternoon). Unaided visual acuity, best-corrected visual acuity, subjective refraction, corneal topography, biomicroscopy (corneal staining), and subjective reaction were recorded at each visit. **RESULTS:** Nine subjects (18 eyes) completed the study. All eyes fitted with the No. 7 lens and 67% of the eyes fitted with the BE lens were within ± 1.00 diopter of the attempted correction after seven nights of lens wear. There was more myopic reduction ($F = 16.2$, $P=0.0002$), better unaided high-contrast visual acuity ($F = 8.7$, $P=0.005$) and low-contrast visual acuity ($F = 9.5$, $P=0.003$), and more change in corneal numerical eccentricity ($F = 8.6$, $P=0.005$) with the BE lens than with the No. 7 lens. There were no significant differences between the lenses for best-corrected visual acuity, change in apical radius, corneal staining, and subjective reaction. **DISCUSSION:** Both lens types investigated in this study were effective in temporarily reducing myopia and in providing good unaided visual acuity during the day (without lenses) in subjects with low levels of myopia. Subjective reaction showed that the lenses were perceived as being equally effective, but clinical data showed that the BE lens effected more myopic reduction and better unaided visual acuity than did the No. 7 lens during the 7-day period investigated.

Mountford, J., P. Cho, and W.S. Chui

Is fluorescein pattern analysis a valid method of assessing the accuracy of reverse geometry lenses for orthokeratology?

Clin Exp Optom, 2005. 88(1): p. 33-8.

BACKGROUND: The aims of this study were to investigate the relative frequencies of correct identifications of variations in the fit of conventional rigid gas permeable (RGP) lenses and reverse geometry lenses (RGL) from fluorescein pattern analysis by orthokeratology (ortho-k) practitioners and non-ortho-k practitioners and to determine whether fluorescein pattern analysis is sensitive for assessing ortho-k lens fittings. **METHODS:** Slides of fluorescein patterns of different lens fittings were shown to the practitioners, who were asked to identify the ideal, flatter, flattest, steeper and steepest lens fittings. **RESULTS:** Observed frequencies of correct identifications of most of the conventional RGP lens fittings were not significantly different from the expected frequencies for both groups of practitioners. The observed frequencies of correct identifications of all of the RGL fittings were either not significantly different or were lower than the expected frequencies. **CONCLUSION:** The relative frequencies of correct identifications of fluorescein patterns of both conventional RGP lens and RGL fittings by experienced ortho-k practitioners were not different from those by non-experienced ortho-k

practitioners. Practitioners from the two groups were not always able to diagnose conventional RGP lens and RGL fittings adequately from fluorescein pattern analysis alone. Fluorescein pattern analysis alone may not be sufficiently sensitive for assessing ortho-k lens fitting.

Riley, C. and R.L. Chalmers

Survey of contact lens-wearing habits and attitudes toward methods of refractive correction: 2002 versus 2004

Optom Vis Sci, 2005. 82(6): p. 555-61.

PURPOSE: The purpose of this study is to measure patient attitudes toward methods of refractive correction among cross-sectional populations of contact lens wearers in 2002 and 2004 at the School of Optometry contact lens clinic at Indiana University. We also assessed the role of age and gender on these attitudes. **METHODS:** Attitudes toward methods of refractive correction were surveyed among 349 consecutive contact lens wearers in the spring of 2002 and compared with surveyed attitudes among 99 contact lens wearers in the winter of 2004. The 23 questions in the survey queried attitudes on the health and safety, cost, and interest in methods of refractive correction in addition to questions about the wearing schedule for the subjects' current contact lenses (CL). Refractive methods that were compared included glasses, daily wear CL (DW), 7-day extended wear (EW) CL, 30-day continuous wear (CW) CL, LASIK, and orthokeratology (OK). The proportion of answers citing "agree" or "strongly agree" were combined and analyzed by chi-squared tests comparing the results for stratified groups in the previous and the current survey. The groups were stratified by gender and age over or under 30 years. Significance level was set at $p < \text{or} = 0.05$. **RESULTS:** In the 2004 survey, the age of the subjects was significantly younger. Subjects' interest in EW increased significantly in 2004 (59% vs. 45% with high level of interest 2004 vs. 2002, respectively; $p = 0.015$) and the proportion of subjects reporting overnight wear increased significantly (DW = 58% vs. 69% 2004 vs. 2002, $p = 0.0017$, controlling for age and gender). In 2004, glasses and EW CL were rated as more healthy compared with 2002 (glasses 95% vs. 88%, $p = 0.05$; EW CL 48% vs. 34%, $p = 0.005$). Males are now less likely in 2004 to rate EW as healthy compared with females (38% vs. 53%, $p = 0.01$). In the 2004 survey, subjects over age 30 were significantly less interested in LASIK compared with those under age 30 (59% vs. 33%, $p = 0.02$) and less interested than they were in 2002. **CONCLUSIONS:** In the 2004 survey, significantly more subjects reported overnight lens wear, an increased interest in, and opinion of overnight wear as a healthy method of refractive correction compared with the 2002 survey. There was some dampening of enthusiasm for LASIK among subjects over 30 years of age in the 2004 survey. Age and gender can influence attitudes toward refractive correction, with females in this sample showing the most change over time, most probably as a result of different health information sources used by various demographic groups.

Shin, Y.J., M.K. Kim, W.R. Wee, et al.

Change of proliferation rate of corneal epithelium in the rabbit with orthokeratology lens

Ophthalmic Res, 2005. 37(2): p. 94-103.

OBJECTIVE: To investigate the cell proliferation rate of normal corneal epithelium with extended orthokeratology lens (OKL) wear in comparison with extended rigid gas-permeable (RGP) lens wear. **METHODS:** Twenty-four rabbits were fitted unilaterally with either an OKL or an RGP lens, and the other eye was used as a control. They were injected with 5-bromo-2-deoxyuridine (BrdU) 24 h prior to being sacrificed. The rabbits were sacrificed at 1, 3, 7 and 14 days after lens fitting. The cornea from the superior limbus to the center was taken at 1.0-mm intervals. The BrdU-labeled cells were counted in medium power fields (x200) in each sample using light microscopy. **RESULTS:** The number of BrdU-labeled cells in the RGP lens group initially increased, but the number decreased in the corneal center and superior limbus by 32 and 8%, respectively, after 14 days. There was no statistically significant change. However, the number of BrdU-labeled cells in the OKL group decreased after 3 days, and the number of BrdU-labeled cells was reduced in the center and superior limbus by 63 and 8%, respectively, after 14 days. The change in proliferation in the corneal center in the OKL-wearing rabbits was statistically significant compared to the control ($p < 0.05$). **CONCLUSIONS:** Wearing an OKL had a greater effect on the change of the proliferation pattern in the epithelium than wearing an RGP lens, which suggests that the OKL might be less physiologic than the RGP lens is.

Tseng, C.H., C.F. Fong, W.L. Chen, et al.

Overnight orthokeratology-associated microbial keratitis

Cornea, 2005. 24(7): p. 778-82.

PURPOSE: This study was designed to report the clinical aspects, microbiologic findings, and treatment outcomes of overnight orthokeratology-associated microbial keratitis. **METHODS:** Medical records of patients with overnight orthokeratology-associated microbial keratitis at National Taiwan University Hospital from August 2000 to October 2001 were reviewed. The clinical and microbiologic characteristics and treatment outcomes were investigated. **RESULTS:** Nine patients (in total 10 eyes) from aged 8 to 17 (mean, 12.3 +/- 2.9) years were included in this study. Eight patients had a unilateral infection and one had a bilateral infection. The initial best corrected visual acuities ranged from hand motion to 20/20. The lesions were located at the central cornea in nine eyes (90%). Smears and cultures from corneal scrapings were obtained from all patients. Four eyes were culture-positive, which included nonfermentative Gram-negative bacillus, *Pseudomonas aeruginosa* and *Acanthamoeba*. Positive smears from another two eyes revealed Gram-negative bacilli and double-walled cyst. All patients were cured using antimicrobial medications with complete re-epithelization and disappearance of corneal infiltrates. Four eyes had a final best corrected visual acuity of 20/30 or worse after a mean follow-up of 9.4 months, including one eye that had visual acuity of hand motion only. Complications included corneal opacity in all eyes, glaucoma in one eye, and cataract in one eye. **CONCLUSIONS:** Overnight orthokeratology is an important risk factor of microbial keratitis, especially in school children. *Acanthamoeba* and Gram-negative bacilli, especially *Pseudomonas aeruginosa*, are the most common pathogens in our series. The risk of microbial keratitis after overnight orthokeratology should not be overlooked.

Walline, J.J., B.A. Holden, M.A. Bullimore, et al.

The current state of corneal reshaping

Eye Contact Lens, 2005. 31(5): p. 209-14.

PURPOSE: The application of contact lenses to alter the shape of the cornea and temporarily reduce or eliminate myopia is known as orthokeratology, corneal refractive therapy, or corneal reshaping. It was first introduced in the 1960s, but high oxygen permeable materials and more sophisticated designs allow patients to wear contact lenses only during sleep, while dramatically improving the predictability and rate of myopia reduction. Many studies have shown that most corneal reshaping patients achieve uncorrected visual acuity of 20/25 or better that lasts all day long in one to two weeks of nighttime wear. Treatment is primarily effective through central epithelial thinning and midperipheral epithelial and stromal thickening. Much remains to be learned about corneal reshaping contact lenses and their effects on the cornea. **METHODS:** The authors reviewed existing knowledge and determined what needs to be learned in order to provide patients with appropriate informed consent prior to corneal reshaping contact lens wear. **RESULTS:** While corneal reshaping contact lenses are effective at temporarily reducing or eliminating myopia, claims about the progress of myopia being controlled with corneal reshaping contact lenses should not be made until further studies are published in peer-reviewed literature. The incidence and prevalence of microbial keratitis related to corneal reshaping contact lens wear is not known. Any overnight wear of contact lenses increases the risk of infection, but it is not known whether the risks of microbial keratitis are greater for corneal reshaping overnight contact lens wearers than other form of overnight contact lens wear. It is also not known whether the risk of microbial keratitis is greater for children than adults, but we must determine if children are at greater risk than adults because many children are wearing corneal reshaping contact lenses. **CONCLUSIONS:** Finally, it is recommended that ongoing education be provided to practitioners and staff regarding safety, informed consent, and prevention of potential problems, with special emphasis on the critical need to properly and thoroughly disinfect lenses that will be worn overnight.

Watt, K. and H.A. Swarbrick

Microbial keratitis in overnight orthokeratology: review of the first 50 cases

Eye Contact Lens, 2005. 31(5): p. 201-8.

PURPOSE: Despite growing evidence for clinical efficacy of orthokeratology (OK) for the temporary reduction of myopic refractive error, there has been an increasing number of reports of microbial keratitis (MK) in association with overnight wear of OK lenses. This article analyzes the first 50 cases of MK reported in overnight OK, in order to define the spectrum of the disease and to identify possible risk factors. **METHODS:** All reported cases of presumed MK in overnight OK from 2001 onwards were included in the analysis. Demographic data of patients affected and lenses worn, and details of the disease process and possible risk factors were extracted from these reports. **RESULTS:** Most cases of MK in OK were reported from East Asia (80%) and most affected patients were Asian (88%).

The peak age range was from 9 to 15 years (61%). Although *Pseudomonas aeruginosa* was the predominant organism implicated in this series of cases (52%), an alarmingly high frequency of *Acanthamoeba* infection (30%) was found. Inappropriate lens care procedures, patient noncompliance with practitioner instructions, and persisting in lens wear despite discomfort emerged as potential risk factors. CONCLUSIONS: The high frequency of MK in overnight OK in young Asian patients is likely to reflect the demographics of the OK lens-wearing population. The high frequency of *Acanthamoeba* infection strongly suggests that tap water rinsing should be eliminated from the lens care regimen for overnight OK. This study does not reveal the absolute incidence or relative risk of MK in overnight OK, and it is therefore premature to ascribe increased risk to this lens-wearing modality compared with other contact lens modalities.

Wilhelmus, K.R.

Acanthamoeba keratitis during orthokeratology

Cornea, 2005. 24(7): p. 864-6.

PURPOSE: To report an infectious complication of overnight rigid gas-permeable contact lenses. METHODS: Case report and medical literature review. RESULTS: A 16-year-old girl developed laboratory-confirmed *Acanthamoeba* keratitis during orthokeratology for myopic reduction. Recent case reports suggest that *Acanthamoeba* is a cause of microbial keratitis associated with gas-permeable contact lenses among teenagers and young adults undergoing orthokeratology. CONCLUSIONS: *Acanthamoeba* keratitis is an emerging complication of orthokeratology in young myopes.

Yepes, N., S.B. Lee, V. Hill, et al.

Infectious keratitis after overnight orthokeratology in Canada

Cornea, 2005. 24(7): p. 857-60.

PURPOSE: To report 3 cases of infectious keratitis related to overnight orthokeratology use. METHODS: Retrospective case observation. RESULTS: All 3 patients were using overnight orthokeratology lenses when they presented with unilateral corneal ulcers. The organisms isolated were *Acanthamoeba*, *Pseudomonas aeruginosa*, and *Serratia marcescens*. The clinical presentation and treatment of each case is presented.

CONCLUSIONS: Overnight orthokeratology use may be associated with infectious keratitis despite the use of more oxygen-permeable materials and improved lens design. Patient education with informed consent, appropriate lens care, and meticulous follow-up is important. Because this complication is potentially sight threatening, orthokeratology requires further analysis and evaluation to establish its safety. The cases here are the first few reported cases in North America.

Yung, A.M., P. Cho, and M. Yap

A market survey of contact lens practice in Hong Kong

Clin Exp Optom, 2005. 88(3): p. 165-75.

PURPOSE: The aim of this survey was to evaluate the use of contact lenses, current prescribing habits of practitioners and the development of the contact lens market in Hong Kong. **METHODS:** Questionnaires were sent to all registered contact lens practitioners in Hong Kong. This questionnaire sought information about their choices on prescribing contact lenses and lens care products and their opinions on continuing education and future trends of contact lens development. **RESULTS:** A total of 286 responses (22 per cent) were returned. On average, the respondents reported that 36 per cent of their patients were contact lens wearers and most were myopes. The ratio of new fittings to refittings was 1:3. Of the contact lens wearers, 66 per cent were fitted with planned replacement lenses, mostly daily disposable lenses. Multipurpose solution was the most popular lens care regimen prescribed. Only 48 per cent of astigmatic patients were fitted with toric lenses and the use of overnight orthokeratology and silicone hydrogel lenses was limited. Single vision contact lenses with over-spectacles and monovision contact lenses were the most popular management for presbyopes. Dryness was the major problem reported by contact lens wearers. Practitioners look forward to further development of custom-made toric, multifocal and silicone hydrogel lenses. The major source of new contact lens information was communication with contact lens suppliers. **CONCLUSION:** Compared to previous reports, there was no significant change in the prescribing habits of practitioners. The major complaint of contact lens wearers is still ocular dryness. The contact lens market is driven by younger contact lens wearers, and planned replacement soft contact lenses together with multipurpose solutions dominate. The use of bifocal/multifocal lenses remained low and practitioners want low cost bifocal/multifocal contact lenses with better visual performance and toric lenses with a wider range in parameters. The use of overnight wear lenses such as silicone hydrogel and ortho-k lenses is limited and 30 days continuous wear silicone hydrogel lenses are prescribed mainly for daily wear.

Cheung, S.W. and P. Cho

Subjective and objective assessments of the effect of orthokeratology--a cross-sectional study

Curr Eye Res, 2004. 28(2): p. 121-7.

PURPOSE: To determine which clinical tests are useful in orthokeratology aftercare examination, and to examine the objective and subjective characteristics of a group of orthokeratology lens wearers. **METHODS:** Thirty orthokeratology subjects (8-19 years) who had been wearing orthokeratology lenses for over 12 months were recruited. Autorefractometry, corneal topography, retinoscopy, subjective refraction and biomicroscopy were performed. Only left eye results were analysed. Subjective ratings of symptoms and problems experienced by subjects were obtained using a questionnaire. **RESULTS:** Autorefractometry yielded higher residual sphere and residual cylinder by -0.54 D and -0.39 D respectively while retinoscopy yielded higher residual sphere and residual cylinder by -

0.20 D and -0.03 D respectively. Corneal toricity measured by autokeratometry and corneal topography overpredicted the residual cylinder by -2.02 D and -2.08 D respectively. The mean +/- SD residual spherical equivalent refractive error was -0.11 +/- 0.57 D and the mean +/- SD unaided postorthokeratology visual acuity was 0.08 +/- 0.14 logMAR. The unaided visual acuity was significantly related to the residual cylinder. Pigmented arc was present in 16 corneas (53%). The most common problems/symptoms experienced by the subjects were lens binding (73%), ocular discharge in the morning (69%) and blur distance vision (47%). Over 80% of the subjects found lens handling troublesome in varying degree. All, except two subjects (who disliked the lens handling), wanted to continue the treatment. CONCLUSIONS: History taking, subjective refraction, biomicroscopy and corneal topography are important in a routine orthokeratology aftercare examination. Corneal pigmented arc, ocular discharge in the morning and lens binding were the most common sign, symptom and problem respectively observed/ reported. Most orthokeratology lens wearers with low to moderate myopia and low astigmatism enjoyed reasonably good unaided post-orthokeratology vision in the daytime.

Cheung, S.W., P. Cho, and D. Fan

Asymmetrical increase in axial length in the two eyes of a monocular orthokeratology patient

Optom Vis Sci, 2004. 81(9): p. 653-6.

To report the myopia progression (change in axial length) of a boy in whom the progression was slower in the eye treated with overnight orthokeratology (ortho-k) than in the fellow eye with no visual correction. An 11-year-old boy was fitted with an ortho-k lens in his left eye in 1999 in a private practice. The refractive errors were OD -0.25 - 0.75 x 168 and OS -2.50 - 0.50 x 170 before commencing ortho-k lens wear. He participated in one of our research studies and made yearly visits to our clinic in 2001, 2002, and 2003. Logarithm of the minimum angle of resolution (logMAR) visual acuity, refraction, ocular health, and axial length were assessed at each visit. At the visit in 2003, the unaided visual acuity was OD 0.40 logMAR and OS -0.04 logMAR. Between 2001 and 2003, there was a small increase in axial length in the left eye (0.13 mm) but a significant increase in the axial length (0.34 mm) with a corresponding increase in spherical equivalent refractive error (0.75 D) in the right eye. This case suggests that myopia progression may have been slowed down by ortho-k lens wear in the eye undergoing treatment of a boy undergoing unilateral ortho-k treatment.

Choy, C.K., et al.

Effect of one overnight wear of orthokeratology lenses on tear composition

Optom Vis Sci, 2004. 81(6): p. 414-20.

PURPOSE: To evaluate the effect of one night of orthokeratology lens wear on ocular surface health based on the changes in tear components, including ascorbate, urate, lactate dehydrogenase (LD), lactoferrin, lipocalin, lysozyme, secretory immunoglobulin A

(slgA), and serum albumin. METHODS: Changes in tear components in eight healthy young men before and after 7-h overnight ortho-k lens wear were studied. Subjects attended on two separate occasions during a 1-week period, on one occasion wearing lens overnight and on the other wearing no lens. Tears (yawn-induced) were collected by capillary tube before lens fitting and on awakening. Tear ascorbate and urate were measured by high-performance liquid chromatography; LD was measured by a commercial kit method; tear proteins were measured by sodium dodecyl sulfate-polyacrylamide gel electrophoresis. RESULTS: Ascorbate, slgA, albumin, and LD increased significantly overnight with and without overnight lens wear ($p < 0.05$); however, no significant increases were found in tear urate, lactoferrin, lipocalin, or lysozyme ($p > 0.05$). Without lens wear, tear ascorbate, slgA, albumin, and LD increased by 21%, 34%, 9-fold, and 13-fold, respectively ($p < 0.05$). With ortho-k lens wear, significant flattening of the apical curvature was observed as expected, and the increases in tear ascorbate, slgA, albumin, and LD (increases were 56%, 76%, 13-fold, and 14-fold, respectively) were significantly ($p < 0.05$) greater than with no lens. There was significant correlation seen between changes in albumin and LD with ($r = 0.762$; $p = 0.037$) and without ($r = 0.738$; $p = 0.046$) ortho-k lens wear. CONCLUSIONS: The result of tear ascorbate suggests that corneal cell disturbance is small after one night of ortho-k lens wear. The marked increases in albumin and LD suggest that the ocular surface is under additional hypoxic stress during overnight ortho-k lens wear.

Doughman, D.

Is corneal refractive therapy a new modality whose time has come or repackaged orthokeratology whose time has passed?: a view from an experienced corneal clinician

Eye Contact Lens, 2004. 30(4): p. 219-22.

I was asked to evaluate corneal refractive therapy (CRT) as an experienced ophthalmologist, who is a corneal specialist. I reviewed the literature and listened to and talked with ophthalmologists, optometrists, and researchers using and studying CRT. I feel that CRT is safe and effective. It offers a nonsurgical option for patients who are not eligible for surgery, particularly because of age, or for those who want to correct myopia for daytime vision but do not want to have surgery or wear a contact lens. CRT can be a valuable option to provide patients in a refractive surgery practice.

Garner, L.F. and H. Owens

The relationship between the sagitta of the anterior corneal surface and refractive error of the eye

Optom Vis Sci, 2004. 81(8): p. 636-9.

Changes in the sagitta of the anterior corneal surface associated with a change in the corneal radius of curvature have been used to calculate the change in refractive error of the eye in two areas: the ablation depth for laser surgery, and the change in corneal thickness associated with orthokeratology lens wear. An approximate formula known as

Munnerlyn's formula is commonly used to calculate the refractive error change from sagittal data. This article compares the change in refraction calculated using the approximate formulae with the change calculated from a formula based on an elliptical corneal section. The approximate formula underestimates the ablation depth for a given refractive change and overestimates the refractive change for a given change in corneal thickness, assuming a constant asphericity. When the corneal asphericity increases together with an increase in radius of curvature, a suggested mechanism in orthokeratology, the approximate formula underestimates the change in ocular refraction.

Haque, S., et al.

Corneal and epithelial thickness changes after 4 weeks of overnight corneal refractive therapy lens wear, measured with optical coherence tomography

Eye Contact Lens, 2004. 30(4): p. 189-93.

PURPOSE.: To investigate thickness changes of the total cornea and epithelium across the horizontal corneal meridian after 4 weeks of overnight corneal refractive therapy (CRT) rigid contact lens (Paragon Vision Sciences, Mesa, AZ) wear. **METHODS.:** Thirty subjects were fitted with CRT contact lenses (Dk/t = 67), which were worn overnight for 4 weeks. Corneal thickness was measured at nine locations along the horizontal meridian by using optical coherence tomography (OCT) before lens insertion in the evening. Corneal thickness was measured the next morning immediately after lens removal and 1, 3, 7, and 14 hours later. This was repeated on days 4, 10, and 28 of the study and then 3 days after discontinuing lens wear. **RESULTS.:** Twenty-three subjects completed the study. At lens removal on day 1, the central and paracentral cornea swelled by 4.9% and 6.2%, respectively (both P= 0.000). The central epithelium thinned by 7.3%, and the mid peripheral epithelium thickened by 13% (both P= 0.000). Corneal swelling recovered throughout the day, with most of the deswelling taking place within the first 3 hours after lens removal. Maximal central epithelial thinning reached 13.5% by day 4. Three days after the study completion, corneal and epithelial thickness had recovered to baseline values. **CONCLUSIONS.:** This study shows that CRT lenses induce differential overnight swelling across the cornea, with rapid deswelling during the day. Central epithelial thinning and paracentral thickening occurs, with recovery 3 days after discontinuation of lens wear.

Hiraoka, T., et al.

Corneal Iron Ring Formation Associated With Overnight Orthokeratology

Cornea, 2004. 23(8): p. S78-S81.

PURPOSE: To describe a case of iron deposition in both eyes after overnight orthokeratology. **METHODS:** This is a case report of a 31-year-old man who underwent overnight orthokeratology. The subject was fitted with rigid gas-permeable contact lenses of reverse-geometry design to correct myopia. **RESULTS:** The prefitting manifest refraction was -4.75 -0.25 x 175 in the right eye and -4.50 -0.25 x 175 in the left eye. There was no corneal abnormality until 9 months after treatment, but development of corneal

arcuate lines in both eyes was observed at the 1-year follow-up visit. Visual acuity was not affected. The deposition pattern corresponded to the outside border of central flatter zone, as shown on the corneal topography map. CONCLUSION: The current findings suggest that tear pooling between the corneal surface and the back surface of the contact lens plays a role in the development of corneal iron ring after orthokeratology with reverse-geometry contact lenses.

Hiraoka, T., et al.

Influence of Overnight Orthokeratology on Corneal Endothelium

Cornea, 2004. 23(8): p. S82-S86.

PURPOSE: To evaluate the influence of overnight orthokeratology on the corneal endothelium. **METHODS:** Fifty-two eyes of 31 patients undergoing overnight orthokeratology for myopia were examined. They wore the lens every night and were followed up for at least 1 year. The corneal endothelium was examined with specular microscopy to calculate mean endothelial cell density, coefficient of variation of cell area, and percentage of hexagonal cells. Data obtained at 1-year follow-up examinations were compared with those at the baseline examinations using a paired t test. **RESULTS:** Orthokeratology significantly reduced manifest refraction from -2.32 ± 1.18 D (mean \pm standard deviation) to -0.16 ± 0.33 D ($P < 0.0001$) and improved uncorrected visual acuity from 0.77 ± 0.29 to -0.07 ± 0.10 logMAR ($P < 0.0001$). The endothelial cell density did not change significantly (2879 ± 231 cells/mm before and 2864 ± 260 cells/mm after treatment, $P = 0.252$). The coefficient of variation of cell area was 22.3 ± 2.7 at baseline and 22.1 ± 2.4 at 1-year posttreatment, which did not change significantly ($P = 0.537$). The percentage of hexagonal cells was $72.8 \pm 10.2\%$ pretreatment and $72.5 \pm 10.9\%$ posttreatment ($P = 0.800$). **CONCLUSIONS:** Overnight orthokeratology for 1 year did not influence the density or morphology of corneal endothelial cells.

Hiraoka, T., et al.

Quantitative evaluation of regular and irregular corneal astigmatism in patients having overnight orthokeratology

J Cataract Refract Surg, 2004. 30(7): p. 1425-9.

PURPOSE: To quantitatively assess changes in regular and irregular corneal astigmatism in patients having overnight orthokeratology. **SETTING:** Matsumoto Eye Clinic, Ibaraki, Japan. **METHODS:** A prospective study was conducted of 64 eyes of 39 patients having overnight orthokeratology for myopia. Inclusion criteria were an uncorrected visual acuity (UCVA) of 20/20 or better after treatment and a minimum follow-up of 3 months. Using Fourier series harmonic analysis, videokeratography data were decomposed into spherical component, regular astigmatism, asymmetry (tilt or decentration), and higher-order irregularity. **RESULTS:** Orthokeratology significantly reduced the manifest refraction from -2.60 diopters (D) ± 1.13 (SD) to -0.17 ± 0.31 D ($P < .0001$, paired t test) and improved the UCVA from 0.82 ± 0.30 to -0.11 ± 0.06 logMAR ($P < .0001$). Regular astigmatism

increased significantly from 0.53 +/- 0.23 D preoperatively to 0.63 +/- 0.40 D postoperatively (P = .0206). The asymmetry component increased significantly from 0.35 +/- 0.22 D to 0.64 +/- 0.40 D (P < .0001). Higher-order irregularity did not change significantly: 0.14 +/- 0.11 D before treatment and 0.17 +/- 0.20 D after treatment (P = .2166). The amount of myopic correction correlated significantly with the increase in the asymmetry component (Pearson correlation coefficient, R = 0.40, P = .0009) but not with the increase in regular astigmatism (R = 0.24, P = .055). CONCLUSIONS: Irregular corneal astigmatism significantly increased, even in clinically successful orthokeratology cases. The effect of the changes on visual function should be studied further.

Hsiao, C.H., et al.

Pseudomonas aeruginosa corneal ulcer related to overnight orthokeratology

Chang Gung Med J, 2004. 27(3): p. 182-7.

BACKGROUND: Overnight orthokeratology was thought to be a safe and non-invasive alternative for low-grade myopia and astigmatism correction. We assessed histories, clinical courses, and visual outcomes of the patients with pseudomonal keratitis related to overnight orthokeratology. **METHODS:** The records of six patients with pseudomonal keratitis related to overnight orthokeratology were reviewed from January 2001 through December 2002. **RESULTS:** The average age of the patients was 13 years. The average period between the time that the patient started the overnight orthokeratology program and the onset of infectious keratitis was 17 months. All patients presented with painful red eyes. The area of the corneal ulcer was central in three, and paracentral in three eyes. The corneal infiltrate was small in one eye, and medium in five eyes. The corneal scrapings from these six patients revealed *Pseudomonas aeruginosa*. All patients responded well to topical antibiotic treatment. Two of six eyes had a final visual acuity within two lines of the pre-infection vision at the last follow-up. Four of the eyes examined lost their best-corrected visual acuity due to central corneal scar or irregular astigmatism. **CONCLUSIONS:** Overnight orthokeratology contact lens wear has the potential complication of pseudomonal keratitis and may cause significant visual impairment.

Ladage, P.M., et al.

Pseudomonas aeruginosa corneal binding after 24-hour orthokeratology lens wear

Eye Contact Lens, 2004. 30(3): p. 173-8.

PURPOSE: To examine the effect of short-term 24-hr orthokeratology lens (OKL) wear on *Pseudomonas aeruginosa* binding, epithelial surface cell morphology, epithelial sheet thickness, and stromal thickness in a rabbit model. **METHODS:** Seventeen New Zealand white rabbits were treated according to the Association for Research in Vision and Ophthalmology Statement for the Use of Animals in Ophthalmic and Vision Research. Partial membranectomy was performed on all rabbits 1 week before the experiments. Baseline values for epithelial and stromal thickness and epithelial surface cell size were determined by in vivo confocal microscopy in one randomly chosen eye (n = 6). One week

later, rabbits were fitted in the same eye with a hyper oxygen-transmissible OKL. Twenty-four hours later, confocal microscopy was repeated. The second group of rabbits (n = 6) was fitted with an OKL in one randomly chosen eye for 24 hr. *P. aeruginosa* binding to the corneal epithelium was assessed for the control corneas and those exposed to the test lens. Scanning electron microscopy was performed on a third group of rabbits to assess epithelial surface damage (n = 5). RESULTS: There was a statistically significant difference ($P < 0.001$) in *P. aeruginosa* binding between the control ($1.11 \pm 0.74 \times 10^5$) colony-forming units per cornea) and the OKL-wearing eyes ($2.74 \pm 0.69 \times 10^5$) colony-forming units per cornea). The central epithelium thinned by 6.5% after lens wear (48.2 ± 1.9 microm to 45 ± 1.7 microm, $P = 0.005$); however, central stromal thickness increased by 7.3% (322 ± 22 microm to 345 ± 29 microm, $P = 0.006$). Compared with the baseline value, central epithelial cell size increased significantly from $1,253 \pm 140$ mm² to $1,627 \pm 393$ mm² (29.4%, $P = 0.02$). Scanning electron microscopy showed increased surface epithelial damage associated with OKL wear. CONCLUSIONS: This prospective, masked, pilot study showed that 24-hr hyper oxygen-transmissible OKL wear induced a statistically significant increase in *P. aeruginosa* binding to the epithelium of the rabbit cornea, accompanied by central epithelial thinning, stromal thickening, and surface cell damage assessed by scanning electron microscopy. Collectively, the data suggest that despite adequate lens oxygen transmissibility, the mechanical pressure inherent in the OKL design exerted on the corneal surface appears to be associated with increased adherence of *P. aeruginosa* to surface corneal epithelial cells, which may pose an increased risk for lens-related microbial keratitis, especially in overnight (i.e., closed-eye) wearing conditions. Future studies are needed to determine whether these results are similar in human wear and how *P. aeruginosa* binding during OKL wear compares with other lens-wearing modalities, such as daily or continuous soft lens wear.

Lang, J. and M.J. Rah

Adverse corneal events associated with corneal reshaping: a case series

Eye Contact Lens, 2004. 30(4): p. 231-3.

PURPOSE.: This case series presents the first documented cases of infectious ulcers associated with overnight orthokeratology in North America and other less serious complications associated with overnight corneal reshaping. CASE REPORTS.: Five cases of adverse corneal events associated with corneal refractive therapy are described: two cases of microbial keratitis, one case of infiltrates, one case of toxic keratitis, and one corneal abrasion. CONCLUSIONS.: Corneal compromise and poor compliance can cause adverse events with corneal reshaping. The need for ongoing patient education is important not only for pediatric contact lens patients, but also for adults.

Lowe, R.

Corneal Refractive Therapy, Uncorrected Visual Acuity, and "E" Values: Personal Experiences

Eye Contact Lens, 2004. 30(4): p. 238-241.

PURPOSE.: The author describes selected aspects of his clinical experience in fitting and prescribing orthokeratology lenses to temporarily reduce or eliminate myopia. The precision of videokeratography (VK) data in determining corneal sagittal depth is examined. Treatment outcomes are analyzed after overnight wear of two proprietary corneal remodeling systems. Two case reports describing off-label treatments are presented. **METHODS.:** A retrospective analysis was performed of the baseline VK data of 25 consecutive candidates (50 eyes) for corneal remodeling, captured with a Keratron topographer. Sixteen consecutive patients fitted with Paragon corneal refractive therapy (CRT) lenses were compared against an age- and sex-matched group of patients fitted with the Mountford BE lens for 1-day, 1-week, and 1-month uncorrected visual acuity. **RESULTS.:** The mean \pm SD of the apical radius ("Ro") and corneal eccentricity ("E") values was 0.03 \pm 0.01 mm and 0.03 \pm 0.01 degrees, respectively, indicating a spread of 24 μ m in the sagittal elevation data. Mean target myopia and 1-day uncorrected visual acuity were -1.71 \pm 0.71 diopters and 20/20 \pm 20/0.86, respectively, for the Paragon CRT lenses and -2.30 \pm 0.89 diopters and 20/31 \pm 20/20.6, respectively, for the Mountford BE lenses. **CONCLUSIONS.:** The Paragon CRT and the Mountford BE lenses delivered impressive reductions in uncorrected visual acuity after the first night of overnight wear. The Paragon CRT lens had the advantage of not requiring a previous overnight lens trial before commencing the treatment program.

Mao, X.J., F. Lu, and J. Qu

[Effects after orthokeratology on corneal topography and monochromatic wavefront aberration]

Zhonghua Yan Ke Za Zhi, 2004. 40(7): p. 471-3.

OBJECTIVE: To assess the corneal topography and monochromatic wavefront aberration among subjects using orthokeratology. Changes of ocular optical quality and related visual functions induced by corneal topography were studied. **METHODS:** Twenty-five young myopic subjects (50 eyes) were recruited with myopia from -1.75 approximately -4.75 D. Orthokeratology lens were fitted at the initial visit with overnight wear program. Subjective refraction, corrective visual acuity, corneal topography and slit lamp examination were performed before and 1 day, 1 week, 2 weeks, 4 weeks, 8 weeks and 12 weeks after the fitting of orthokeratology lens. The monochromatic wavefront aberration was measured in initial visit and after 12 weeks. **RESULT:** The best corrected visual acuity was reduced significantly from (-0.0628 \pm 0.0286) LogMAR (before orthokeratology) to -0.0120 \pm 0.0318 (12 weeks after orthokeratology) ($F = 17.821$, $P < 0.001$). Root-mean-square (RMS) of wavefront aberration increased significantly from (0.5766 \pm 0.4771) micro m (before orthokeratology) to (1.3731 \pm 0.8039) micro m (12 weeks after orthokeratology) ($F = 36.513$, $P < 0.001$). RMS of Zernike function of each order was increased as well. The rate of eccentric in posterior surface of corneal increased significantly after the using of orthokeratology lens. **CONCLUSIONS:** Orthokeratology is one of the effective methods for reducing myopia temporarily. However, the best corrected visual acuity is decreased after using of orthokeratology. The increase of aberration induced by orthokeratology can be the cause of reduction of ocular optical quality.

Matsubara, M., et al.

Histologic and Histochemical Changes in Rabbit Cornea Produced by an Orthokeratology Lens

Eye Contact Lens, 2004. 30(4): p. 198-204.

PURPOSE:: To report the histologic and histochemical properties of rabbit cornea after insertion of an orthokeratology lens. **METHODS::** An orthokeratology lens was placed on the left corneas of rabbits for 8 hours daily, and their eyes were enucleated after 7, 14, 21, and 28 days and examined histologically and histochemically. The right eyes were used as controls. **RESULTS::** After 7-14 days, hematoxylin and eosin staining of the cornea revealed that the epithelial layer was slightly thinner in the central area and thicker in the intermediate area, but its thickness gradually became normal toward the limbus. Periodic acid-Schiff staining showed no abnormal distribution of glycogen granules or glycogen producing cells. 5-bromo-2-deoxyuridine staining revealed more mitoses in the central area than in the intermediate area. Histochemical staining showed lactic dehydrogenase activity in the central area of the lens, whereas alkaline phosphatase activity and beta-glucuronidase activity were slightly increased in the intermediate area. There were no other clearly abnormal findings. **CONCLUSIONS::** The thickness of the corneal epithelium showed topographical variation consistent with the effect of orthokeratology. The result of histochemical studies suggested that there were no marked alterations in epithelial function.

McMonnies, C.W.

Keratoconus fittings: apical clearance or apical support?

Eye Contact Lens, 2004. 30(3): p. 147-55.

PURPOSE: To examine the relative merits of apical support and apical clearance fitting of rigid gas-permeable contact lenses for keratoconus. **METHODS:** After an historic review of fitting approaches for keratoconus, a case report is described in which an adventitious apical clearance fitting for early keratoconus might have been associated with accelerated progress of the ectasia. **DISCUSSION:** The hypothesis that apical clearance fittings increase the risk of accelerating ectasia progression in early keratoconus is examined in counterpoint to the hypothesis that apical support fittings increase the risk of apical scarring. Reference is made to the responses of normal corneas to apical clearance fitting and to apical contact fittings used in orthokeratology fittings. The tendency for corneas to mold to contact lens curvature is reviewed. The possibility that reduced corneal thickness or tissue softening and associated changes to the biomechanical properties of the cornea in keratoconus may facilitate molding with apical clearance fitting is examined. **CONCLUSIONS:** Known and putative risk factors for fitting complications that are associated with apical clearance and apical touch contact lens fitting are given as a basis for the reader to draw conclusions about the management of contact lens fitting for keratoconus. The possibility of symptomless adverse responses is a strong indication for frequent routine aftercare reviews.

Owens, H., et al.

Posterior corneal changes with orthokeratology

Optom Vis Sci, 2004. 81(6): p. 421-6.

PURPOSE: To investigate changes in corneal thickness and the radius of curvature of the posterior corneal surface after orthokeratology (OK) rigid lens wear. **METHODS:** Nineteen young myopic subjects wore reverse-geometry OK lenses (BE/ABE, Ultravision Contact Lenses, Brisbane, Australia) every night for 1 month. Central and midperipheral corneal thickness (Allergan Humphrey ultrasound, Carl Zeiss Meditec, Dublin, CA), topography (EyeSys v.3.1, Houston, TX), subjective refraction, and posterior corneal radii (video photography of Purkinje images) were evaluated within 2 h of waking, prelens wear, and on four occasions postlens wear during a 1-month period. A mixed-models approach was used to analyze the data. We modeled the changes in posterior corneal radius of curvature and corneal thickness in terms of the sagittal height of the anterior and posterior cornea using an ellipsoidal model for the corneal surfaces. **RESULTS:** Refractive error reduced from -2.28 to -0.01 DS within 1 month. A significant thinning of the cornea was evident between 1 ($p = 0.03$) and 2 weeks ($p = 0.0048$) postlens wear. A significant increase in the anterior corneal radius of curvature was present at all time periods beyond 1 night ($p < 0.001$), and a significant posterior corneal flattening occurred centrally and midperipherally after 1 week ($p = 0.04$ and $p = 0.013$, respectively). **CONCLUSIONS:** These findings suggest that in addition to the significant topographic flattening of the anterior corneal surfaces, there is also a significant flattening of the posterior surface during the early adaptive stages of OK lens wear.

Riley, C. and N. Pence

Forms of vision correction: demographic factors in patient attitudes and perceptions

Eye Contact Lens, 2004. 30(3): p. 138-43.

PURPOSE: To evaluate attitudes toward current treatments for vision correction in a clinical population of adults wearing spectacles and contact lenses (CLs). **METHODS:** Patients seen in the Indiana University Contact Lens and Primary Care Clinics in the spring of 2002 completed multiple-choice questionnaires evaluating their current device for vision, comfort, convenience, health and safety, cost, and overall satisfaction. They also rated their interest in and the convenience and health and safety of 30-day continuous wear (CW), 7-day extended wear (EW), modern orthokeratology, and LASIK and were given a forced choice on their preferred method of vision correction. **RESULTS:** Three hundred forty-nine CL and 177 primary care patients completed questionnaires. Subjects reported high satisfaction with their current treatment. Seventy percent of glasses wearers were neutral or not interested in CLs or LASIK. CL patients were interested or very interested in orthokeratology (70%) followed by LASIK (65%), 7-day EW (51%), and 30-day CW (44%). Age and sex were the most significant factors that influenced wearing practices and attitudes, with males (especially young) indicating significantly higher use of EW than females ($P = 0.0005$, $\chi^2(2)$). Males were also more interested in 7-day EW ($P =$

0.011) and 30-day CW ($P = 0.001$) and rated their health and safety higher ($P = 0.045$ and $P = 0.003$, respectively). CONCLUSIONS: In the spring of 2002, many of these patients remained cautious about the health and safety of 7-day EW and 30-day CW CLs.

Soni, P.S., T.T. Nguyen, and J.A. Bonanno

Overnight orthokeratology: refractive and corneal recovery after discontinuation of reverse-geometry lenses

Eye Contact Lens, 2004. 30(4): p. 254-62.

PURPOSE.: To determine the refractive and corneal topographic recovery after the use of reverse-geometry contact lenses for overnight orthokeratology. **METHODS.:** Both eyes of 15 subjects were fitted with reverse-geometry contact lenses that were worn by the subjects for 1 month. Uncorrected visual acuity, refractive correction (sphere and spherical equivalent), corneal curvature, and corneal thickness were measured during this time and for 2 weeks after discontinuation of lens wear. **RESULTS.:** Ten subjects completed the investigation. Uncorrected visual acuity, refractive correction, and corneal curvature had changed significantly ($P = 0.01$) after 1 month of lens wear. By the end of 1 month, central corneal thickness was significantly thinner than the baseline value ($P = 0.01$), but it recovered fully after one night of no lens wear. Recovery of corneal curvature was complete 1 week after lens wear was discontinued. Refractive correction and binocular uncorrected visual acuity recovered fully after 2 weeks. Monocular uncorrected visual acuity remained significantly ($P = 0.01$) different from baseline acuity 2 weeks after lens discontinuation. **CONCLUSIONS.:** Full effect of overnight orthokeratology in low myopes is achieved within 1 week of initiating use of reverse-geometry lenses. Recovery after short-term use of reverse-geometry lenses is rapid for corneal thickness and corneal curvature. Refractive correction and binocular uncorrected visual acuity recovered fully after 2 weeks. Monocular uncorrected visual acuity was the slowest to recover and had not achieved full recovery after 2 weeks.

Swarbrick, H.A.

Orthokeratology (corneal refractive therapy): what is it and how does it work?

Eye Contact Lens, 2004. 30(4): p. 181-5.

This article reviews current knowledge regarding orthokeratology, also known as corneal refractive therapy. Modern orthokeratology using reverse-geometry gas-permeable lenses is an effective procedure for the temporary reduction of low to moderate myopia. The use of an overnight lens-wearing protocol provides an alternative to refractive surgery for many patients. Onset of the refractive effect is rapid, with observable changes within minutes and stability of effect after 7 to 10 days of treatment. The procedure appears to be fully reversible on cessation of lens wear. The orthokeratology effect is achieved through central corneal epithelial thinning and mid peripheral stromal thickening, although the cellular basis for these changes requires further research. Because of recent reports of severe corneal infections with overnight orthokeratology, the safety of the procedure is

under active investigation, and it is clear that minimal clinical standards must be promulgated internationally to ensure a future for this approach to refractive correction.

Walline, J.J., M.J. Rah, and L.A. Jones

The Children's Overnight Orthokeratology Investigation (COOKI) pilot study

Optom Vis Sci, 2004. 81(6): p. 407-13.

PURPOSE: Innovations in contact lens materials and designs allow patients to wear contact lenses during sleep to flatten the cornea and temporarily to reduce myopic refractive error and improve unaided visual acuity. We conducted the Children's Overnight Orthokeratology Investigation (COOKI) pilot study, a case series, to describe the refractive error and visual changes, as well as the slitlamp observations associated with overnight orthokeratology in children, over a period of 6 months. **METHODS:** Twenty-nine 8- to 11-year-old children with myopia between -0.75 and -5.00 D and <-1.50 D corneal toricity were fitted with corneal refractive therapy contact lenses (Paragon Vision Sciences, Mesa, AZ). They were examined within 1 hour of awakening and about 6 hours later at 1 day, 1 week, 2 weeks, 1 month, 3 months, and 6 months after the first night of contact lens wear. At each visit, the logarithm of the minimum angle of resolution (logMAR) visual acuity, manifest refraction, slitlamp examination, and corneal topography were performed. **RESULTS:** Twenty-three subjects completed the 6-month study. Three subjects decided not to wear contact lenses, two did not achieve acceptable fits, and one moved from the area. At the 6-month afternoon visit, the mean \pm SD uncorrected high-contrast visual acuity was $+0.08 \pm 0.15$ logMAR (Snellen equivalent, 20/24), and the mean \pm SD spherical equivalent refraction was -0.16 ± 0.66 D. The corneas of three-fifths of the subjects showed mild staining at the morning visit, and one-third of the patients showed mild corneal staining at the afternoon visit. The most common type of stain was central punctate staining. No subjects experienced lasting adverse visual effects from cornea-reshaping contact lens wear during the study period. **CONCLUSIONS:** Overnight cornea-reshaping contact lenses are efficacious for young myopic patients, and no children experienced a serious adverse event during the study.

Young, A.L., et al.

Orthokeratology lens-related corneal ulcers in children: a case series

Ophthalmology, 2004. 111(3): p. 590-5.

OBJECTIVE: Orthokeratology is a process by which the corneal curvature is flattened by sequentially fitting rigid gas permeable contact lenses of decreasing central curvature. There has been a resurgence of interest with the recent introduction of reverse geometry lenses. Although promising results have been described in reducing the myopic refractive error, the use of these lenses can be associated with corneal problems, as reported in this case series. **DESIGN:** Observational case series. **PARTICIPANTS:** Six children with orthokeratology-related corneal ulcers. **METHODS:** Consecutive cases of orthokeratology lens (OKL)-related corneal ulcers in children presented to a tertiary referral center (March

1999-June 2001) were reviewed. MAIN OUTCOME MEASURES: Preinfection and postinfection visual acuity, refraction, any organisms identified. RESULTS: Six children between the ages of 9 and 14 years (mean = 12.1) were treated. The male:female ratio was 1:5. All cases were unilateral, with equal numbers of left and right eyes. All children wore the OKL at night for a duration of 8 to 12 hours, with the onset of infection between 3 and 36 months (mean = 16.6) of OKL wear. All of the patients suffered a resultant best-corrected visual acuity loss. Five of the 6 cases were culture positive for *Pseudomonas aeruginosa*. CONCLUSIONS: In view of the temporary benefits of orthokeratology, together with a known increased risk of infection associated with overnight lens wear, parents of children considering orthokeratology must be informed and warned of the potential for permanent loss of vision. The ophthalmic community should have a heightened awareness of the associated complications.

Alharbi, A. and H.A. Swarbrick

The effects of overnight orthokeratology lens wear on corneal thickness

Invest Ophthalmol Vis Sci, 2003. 44(6): p. 2518-23.

PURPOSE: To investigate corneal thickness changes during overnight orthokeratology with reverse-geometry rigid gas-permeable (RGP) contact lenses worn over a 3-month period. METHODS: Eighteen young adult subjects with low myopia (≤ 4.00 D) were fitted with reverse-geometry lenses (BE; UltraVision Pty. Ltd., Brisbane, Queensland, Australia), which were worn for 3 months on an overnight basis and were removed during the day. Another 10 subjects were fitted with conventional RGP lenses (J-Contour; UltraVision) that were worn for 1 month in the right eye on a similar wearing schedule; the left eye acted as a non-lens-wearing control. Refractive error was recorded in the morning and evening, and total, epithelial, and stromal corneal thicknesses were measured across the horizontal meridian with an optical pachometer. RESULTS: The orthokeratology group showed significant reductions in myopia ($+1.66 \pm 0.50$ D; $P < 0.001$) from day 1, which stabilized by day 10. Central corneal thinning (-9.3 ± 5.3 microm, $P < 0.001$), which was epithelial in origin, was found from day 1; central stromal change was negligible. Midperipheral corneal thickening, which was stromal in origin, was confirmed by day 4 ($+10.9 \pm 5.9$ microm, $P < 0.001$). No change was found in peripheral corneal thickness. Analysis of day-90 data by Munnerlyn's formula indicated that corneal sagittal height change resulting from the thickness changes could account for the refractive effect. In the conventional RGP group, there were no significant changes in refractive error or corneal thickness. CONCLUSIONS: Overnight orthokeratology causes rapid central corneal epithelial thinning and midperipheral stromal thickening. The consequent change in corneal sagittal height is the primary factor underlying the refractive effect of orthokeratology.

Barr, J.T., et al.

Orthokeratology and corneal refractive therapy: a review and recent findings

Eye Contact Lens, 2003. 29(1 Suppl): p. S49-53; discussion S57-9, S192-4.

PURPOSE: To review the past and current literature and present recent findings on orthokeratology and corneal refractive therapy. **METHODS:** Various articles on contact lens corneal reshaping were analyzed. Common clinical procedures and interference measurement of tear-film thickness were also used. **RESULTS:** Although the numbers of patients tested to date do not allow conclusions of great certainty, based on a review of the current literature, our recent study of 60 patients, and the Food and Drug Administration approval of overnight contact lens corneal refractive therapy, there is a low incidence of complications, and unaided visual acuity of 20/20 in the morning is possible in most (74%) successful cases. Refractive error change of 2.25diopter (D) +/- 1.00D is common. A presumed iron ring may appear in some patients in the midperipheral corneal epithelium. **CONCLUSION:** Overnight orthokeratology and corneal refractive therapy with modern design reverse-return zone lenses in high-Dk rigid gas-permeable contact lens materials is an option for transient vision correction for some myopic patients.

Cho, P., S.W. Cheung, and M.H. Edwards

Practice of orthokeratology by a group of contact lens practitioners in Hong Kong. Part 2: orthokeratology lenses

Clin Exp Optom, 2003. 86(1): p. 42-6.

PURPOSE: The aim of the study was to provide information about the characteristics of three main types of orthokeratology (ortho-k) lenses used in Hong Kong and to report on their performance based on the clinical impressions of a group of ortho-k practitioners. **METHOD:** Twelve ortho-k practitioners were interviewed between 1 March and 30 June 2001. **RESULTS:** Most ortho-k lenses were ordered from three manufacturers: DreimLens, Fargo and Contex. The median maximum myopia reduction reported for DreimLens, Contex and Fargo lenses were 6.25 D, 6.00 D and 4.50 D respectively. The time to reduce myopia by up to 4.00 D could be up to three weeks for Contex and DreimLens and up to four weeks for Fargo. For reduction of myopia by up to 4.00 D, the treatment usually required only one or two lenses per eye for all three types of lenses. The incidence of lens binding and lens tightening after achieving the optimal reduction was reported to be higher with the DreimLens design. Good centration, less lens binding, relatively lower incidence of complications and lens tightening after achieving the optimal reduction were reported with the Fargo lenses. **CONCLUSIONS:** DreimLens tended to be more effective for myopia reduction. However, some practitioners were concerned with the aggressiveness of myopia reduction using this lens design and the higher potential for ocular complications. Selection of the lens design is dependent on various factors, in particular, practitioners need to be comfortable with the design they choose and to consider the needs of their patients and the final goal of the treatment.

Cho, P., et al.

An assessment of consecutively presenting orthokeratology patients in a Hong Kong based private practice

Clin Exp Optom, 2003. 86(5): p. 331-8.

PURPOSE: The aim of this study was to collect objective, subjective and demographic data on consecutively presenting orthokeratology (ortho-k) patients who attended for routine follow-up examination in a Hong Kong based private practice in May 2001.

METHOD: Sixty-nine patients who returned to the surveyed practice for follow-up visits during the study period (May 2001) were interviewed and relevant data extracted from their files. Data collected included identification and estimation of the extent of complications encountered by ortho-k patients and their satisfaction with the treatment.

RESULTS: Among the 61 patients who had been wearing ortho-k lenses for at least one month, 50 patients were younger than 16 years old. Twelve children (24 per cent) had been reluctant to wear ortho-k lenses before undergoing the treatment but, after commencement of lens wear, only one child was not very willing to wear the ortho-k lenses. The mean pre-ortho-k spherical refractive error of these patients was -3.93 ± 2.30 D (OS only). Of the 59 patients who wore ortho-k lenses for at least one month and who were on night therapy, 10 patients had to wear spectacles or contact lenses in the daytime due to significant residual myopia. There was no statistically significant correlation between post-ortho-k unaided visual acuity and pre-ortho-k refractive error (spherical, cylindrical or the equivalent sphere) in the 49 patients who did not need to wear any vision correction in the daytime. Of the 61 patients, four reported eye inflammation/infection during the treatment. All recovered their ocular health without any effect on their vision or corneal health. The incidence of corneal staining that required lens wear to be stopped appeared to increase with the duration of ortho-k lens treatment. The incidence of staining was not related to refractive error, unaided visual acuity or the age of the subjects. The most common problem reported by the patients was lens binding and there were also reports of increased redness, itching, light sensitivity and secretion of mucus in the morning after opening their eyes. More than 50 per cent of the patients experienced some distance vision blur, which was worse towards the end of the day. For most patients, these problems occurred only occasionally. Higher pre-ortho-k spherical refractive error was related to poor near and distance vision and worse distance vision towards the end of the day.

CONCLUSION: The majority of the patients interviewed were children who reported being 'happy with the results of the treatment'. Night wear is the main wearing modality and in view of the increased risk of complications in overnight wear and the fact that a large number of the patients are children, the need for strict compliance with the practitioner's instructions for lens use and care cannot be overemphasised. With careful monitoring and good compliance, complications with overnight ortho-k wear can be minimised. In view of the high incidence of lens binding, it is essential that patients and parents of young patients know the correct method to free a bound lens.

Cho, P., W.S. Chui, and S.W. Cheung

Reversibility of corneal pigmented arc associated with orthokeratology

Optom Vis Sci, 2003. 80(12): p. 791-5.

Corneal pigmented (brown) arcs were observed in two orthokeratology patients, both aged 23 years. The preorthokeratology refractive data were OD $-5.25 -0.50 \times 175$ and OS $-6.00 -0.75 \times 5$ for patient A and OD $-3.75 -1.00 \times 10$ and OS $-3.00 -1.25 \times 175$ for patient B. The time course for the development of the arcs was different not only between the two

patients but also between the two eyes of patient A. For patient A, the pigmented arc was observed in the left eye 1 week after commencement of lens wear and was not observed in his right eye until a visit about 6 weeks later. For patient B, the arcs were only observed at an aftercare visit about 28 weeks after commencing lens wear. Both patients had been participating in an orthokeratology research study for about 12 months and decided to stop the treatment after completion of the study. The pigmented arcs were no longer present when they returned about 2 months later for assessment of the regression of the refractive and corneal changes induced by the procedure.

Chui, W.S. and P. Cho

Recurrent lens binding and central island formations in a fast-responding orthokeratology lens wearer

Optom Vis Sci, 2003. 80(7): p. 490-4.

A 12-year-old girl with a history of fast myopia progression underwent advanced orthokeratology (ortho-k) treatment and suffered from recurrent lens binding and central corneal staining. The problem could not be fixed by lens fenestration and refitting with a less aggressive lens (three-zone ortho-k) design. After refitting with a lower target advanced ortho-k lens, these complications were no longer occurring, and the amount of power reduction was greater than expected considering the target designed for the refitted lenses. During the following 15 months of ortho-k lens wear, there was no clinically significant change to her refractive error. The patient and her parents were happy with the outcome, although the refractive error was not totally eliminated and she still needed to wear spectacles for clear vision. Possible etiologies of the complications are discussed.

Lau, L.I., et al.

Pseudomonas corneal ulcer related to overnight orthokeratology

Cornea, 2003. 22(3): p. 262-4.

PURPOSE: To report two cases of *Pseudomonas aeruginosa* corneal ulcers as a complication of overnight orthokeratology lens wear. **METHODS:** Case report. **RESULTS:** Two 11-year-old girls with acute central corneal ulcers were referred to our hospital. In both cases, the ulcers were about 2 mm in diameter, located centrally, contained dense cellular infiltration, and discharged purulent material. Intensive topical ceftazidime was applied to treat the ulcers. Cultures of the scraped corneal tissues and the contact lens storage solutions in both cases grew *P. aeruginosa*, which was sensitive to the antibiotic. The presenting best-corrected visual acuity was hand motion at 20 cm in one patient and 6/20 in the other. Both patients had received several months of overnight orthokeratology treatment with rigid gas permeable contact lenses to correct myopia (-4.25 D and -4.75 D in the two affected eyes). The final best-corrected visual acuity was 6/60 in one patient and 6/7.5 in the other. **CONCLUSIONS:** Overnight orthokeratology contact lens wear carries a potential risk of corneal ulcer and may cause significant visual impairment in children.

Liang, J.B., et al.

Corneal iron ring associated with orthokeratology

J Cataract Refract Surg, 2003. 29(3): p. 624-6.

Two teenaged girls had orthokeratology to correct myopia. The postoperative development of corneal iron rings in both eyes was disclosed by a biomicroscopic examination at 3 months in 1 patient and 5 months in the other. The location of the corneal iron rings coincided with the fitting curve of the reverse-geometry rigid contact lens, suggesting that the rings might have developed from tear pooling.

Soni, P.S., T.T. Nguyen, and J.A. Bonanno

Overnight orthokeratology: visual and corneal changes

Eye Contact Lens, 2003. 29(3): p. 137-45.

PURPOSE: To achieve an optimal fit with reverse geometry Contex OK lenses and to determine a time course for and the stability of visual and corneal changes in achieving maximal refractive, corneal curvature, and corneal thickness changes after overnight wear of OK B and D series lenses. **METHODS:** This investigation was conducted under an Food and Drug Administration IDE G000059. Both eyes of 10 subjects were fitted with the lenses, and uncorrected visual acuity, refractive correction, contrast sensitivity, corneal curvature, and corneal thickness were measured at baseline and at 1 day, 1 week, 1 month, and 3 months after lenses were worn. Except for baseline, data were collected at four different times during the day, immediately following lens removal and 4, 8, and 12 hours after lens removal. **RESULTS:** The results from eight subjects showed that uncorrected visual acuity, refractive correction, contrast sensitivity, and corneal curvature all changed significantly ($P=0.01$) overnight. By the end of 1 week, all corneal and visual changes had reached a maximal level and remained fairly stable during the day. These changes were sustained at 3 months. The epithelial thickness data from four subjects showed that the corneal epithelial thickness was reduced by approximately 19 microm after 3 months of lens wear. **CONCLUSIONS:** Successful fitting of OK B and D series lenses requires a thorough understanding of the lens-cornea relationship. Full effect of overnight orthokeratology is achieved by the end of 1 week. The visual and corneal changes remain stable for all waking hours of the day and allow patients to enjoy excellent device-free vision (20/20).

Sridharan, R. and H. Swarbrick

Corneal response to short-term orthokeratology lens wear

Optom Vis Sci, 2003. 80(3): p. 200-6.

PURPOSE: This study investigated short-term corneal changes induced by reverse-geometry lenses worn for orthokeratology. **METHODS:** Nine young adult subjects wore reverse-geometry rigid gas-permeable lenses (BE; UltraVision Contact Lenses, Brisbane, Australia) in one eye only for 10, 30, and 60 min in the open eye and 8 h in the closed eye. The fellow eye acted as a non-lens-wearing control. Corneal topographic changes were monitored using the Medmont E-300 corneal topographer and keratometry. Changes in uncorrected logarithm of the minimum angle of resolution (log MAR) visual acuity were also recorded. Data were analyzed by analysis of variance and t-tests. **RESULTS:** Significant central corneal flattening (-0.61 ± 0.35 D; $p = 0.014$) and the formation of a defined "treatment zone" (diameter, 3.86 ± 0.88 mm) were found after 10 min of open-eye lens wear, which progressed with increasing periods of lens wear. Significant improvement in unaided logMAR (-0.16 ± 0.18 ; $p = 0.005$) was also apparent after 10 min and showed further improvement with longer periods of lens wear. Corneal asphericity showed a trend toward corneal sphericalization, which reached statistical significance after 8 h of lens wear. There was no significant change in corneal toricity. **CONCLUSIONS:** The cornea responds rapidly to the application of reverse-geometry lenses for orthokeratology, with significant central corneal flattening and improvement in visual acuity after just 10 min of lens wear. This suggests that the corneal epithelium is able to be molded or redistributed very rapidly in response to the tear film forces generated behind reverse-geometry lenses.

Tahhan, N., et al.

Comparison of reverse-geometry lens designs for overnight orthokeratology

Optom Vis Sci, 2003. 80(12): p. 796-804.

PURPOSE: The efficacy of overnight wear of four types of reverse-geometry lenses was compared. The length of time needed to achieve correction and any adverse events that occurred during the course of the study were recorded. **METHODS:** In this prospective, randomized study, 60 subjects (18 to 35 years old) with refractive error between -1.00 to -4.00 D (cyl ≤ -1.50) wore reverse-geometry lenses overnight only. All subjects were assigned a Rinehart Reeves lens in one eye, and subsets of 20 subjects were randomly assigned a Mountford BE, DreimLens, or Contex D Series 4 lens for the contralateral eye. Visits included baseline, dispensing, 1 day, 1 week, and 1 month. Biomicroscopy, unaided visual acuity, subjective refraction, best-corrected visual acuity at high and low contrast and high and low illumination, corneal topography, and subjective rating data were collected. **RESULTS:** Forty-six subjects completed the study. At 1 month, there were no significant differences between lens types in their effect on unaided visual acuity, subjective sphere, subjective cylinder, best-corrected visual acuity at high and low contrast at high illumination and low contrast at low illumination, apical corneal radius, corneal eccentricity, and subjective ratings. Between 1 week and 1 month, there was a significant improvement in subjective ratings of quality of day and night vision ($p < 0.05$) but no significant change in the objective measures. No significant ocular adverse events were observed during the trial. **CONCLUSIONS:** The lens types tested were all similarly effective in the reduction of myopic refractive error. Subjective ratings continued to improve after objective measures stabilized at 1 week. Overnight lens wear proceeded for 1 month without significant adverse reactions.

Wang, J., et al.

Topographical thickness of the epithelium and total cornea after overnight wear of reverse-geometry rigid contact lenses for myopia reduction

Invest Ophthalmol Vis Sci, 2003. 44(11): p. 4742-6.

PURPOSE: To investigate topographical thickness changes of the epithelium and total cornea measured with optical coherence tomography (OCT) after overnight wear of rigid gas-permeable lenses. **METHODS:** Reverse geometry design CRT (Dk=100) rigid (test) lenses (Paragon Vision Sciences, Mesa, AZ) were randomly fitted on one eye of each of 20 neophyte subjects (mean age, 24.6 +/- 2.7 years) and the other eye was fitted with an alignment tricurve rigid lens of the same material (control). Epithelial and total corneal thickness was measured at intervals of 10 degrees across a 10-mm zone of the horizontal meridian of the cornea, before and after overnight wear. Refractive error was measured with an autorefractor. These measurements were repeated 20 and 60 minutes and 3, 6, and 12 hours after lens removal. **RESULTS:** After one night of lens wear, myopia decreased in the test eye by 1.18 +/- 0.81 D, which was significantly different from baseline ($P < 0.001$). No significant change was found in the control eye. Twelve hours after removal, two thirds of the myopic reduction was still present. Different topographical swelling patterns were induced by the two lens designs, with greatest swelling occurring in the center with the control lens and in the midperiphery with the test lenses (polynomial regression: $P < 0.005$). Significantly greater central corneal swelling was found with the control lens than the test lens (6.9% +/- 3.1% vs. 4.9% +/- 2.0%, respectively, $P = 0.006$). The effect on epithelial thickness differed between lenses and depended on both position and time ($F(48,912) = 2.3$; $P = 0.000$). Immediately after removal of the test lens, the central epithelium was 5.1% +/- 4.5% thinner than baseline, and all other locations ($P < 0.005$ post hoc tests) and the epithelium in the midperiphery showed significant thickening (1.9% on the temporal side and 2.4% on the nasal side, both $P < 0.006$ compared with the baseline). There were no significant changes in epithelial thickness with the control lens during the study period (post hoc tests: $P > 0.05$). **CONCLUSIONS:** The optical coherence tomograph is a sensitive instrument that can detect small changes in epithelial and corneal thickness across the entire cornea. Topographical thickness changes of the epithelium and total cornea induced by one night of reverse-geometry lens wear appear to be associated with the decrease of myopia.

Wang, J.C. and L. Lim

Unusual morphology in orthokeratology contact lens-related cornea ulcer

Eye Contact Lens, 2003. 29(3): p. 190-2.

PURPOSE: To report a case of unusual ulcer morphology in orthokeratology-related corneal ulcer. **METHODS:** A single observational case report of a 14-year-old Chinese female myope with a 1.5-month experience wearing overnight B.E. orthokeratology (Capricornia) lenses and presenting with a right stellate-shaped central cornea abscess.

Cornea scrapings for Gram stains, culture, and antibiotic sensitivity were performed. The patient was prescribed hourly fortified cefazolin and gentamicin drops. RESULTS: Pseudomonas aeruginosa grew on blood and chocolate agar cultures. The ulcer was successfully treated with antibiotics and reepithelialized over 5 days. There was a residual central corneal scar. The refraction changed from -4.25 sphere OD and -1.75 -1.75 x160 OS to -3.50 -1.50 x160 OD and -1.50 -1.75 x165, giving a visual acuity of 20/ 25 OD and 20/20 OS. CONCLUSIONS: A flatter fit of orthokeratology lenses may be associated with unusual cornea ulcer morphology.

White, P. and P. Cho

Legal issues in contact lens practice with special reference to the practice of orthokeratology

Ophthalmic Physiol Opt, 2003. 23(2): p. 151-61.

This report aims to encourage optometrists to reflect on the legal implications of clinical contact lens practice, with particular reference to the practice of orthokeratology (ortho-k), which has seen a recent revival of interest. A patient may claim compensation if an optometrist is negligent by breaching his duty to exercise reasonable care and skill in diagnosis, advice or treatment. However, the optometrist will only be liable for reasonably foreseeable harm to the patient, so practitioners need to be fully aware of the foreseeable risks. Failure to adequately inform the patient may lead to a claim for negligence, if disclosure of the risks would have influenced the patient's decision to undergo or forego the procedure. It is important that the professional bodies establish guidelines on acceptable practice, with particular emphasis on the provision of information to patients. Reasonable disclosure, use of appropriate information/consent forms, and proper documentation of cases, should all focus on the needs of, and benefits to, patients.

Xuguang, S., et al.

Acanthamoeba keratitis as a complication of orthokeratology

Am J Ophthalmol, 2003. 136(6): p. 1159-61.

PURPOSE: To present four cases of Acanthamoeba keratitis as a complication of orthokeratology. DESIGN: Observational case report. METHODS: Four patients with Acanthamoeba keratitis had histories of overnight orthokeratology lens wear of 6 months to 2 years. RESULTS: Three cases were diagnosed with Acanthamoeba keratitis by corneal scraping and one by confocal microscopy examination. The patients were treated with chlorhexidine, metronidazole, and neomycin sulfate, resulting in a rapid resolution of ocular inflammation. CONCLUSION: Overnight wear of orthokeratology lenses may induce Acanthamoeba keratitis.

Yang, X., et al.

[Topographical evaluation on decentration of orthokeratology lenses]

Zhonghua Yan Ke Za Zhi, 2003. 39(6): p. 335-8.

OBJECTIVE: To evaluate the degree and correlative factors of decentration of orthokeratology lenses and its effect on the visual function. **METHODS:** Two different kinds of orthokeratology lenses were fitted to 270 eyes of 135 patients [initial mean refractive error: (-3.98 +/- 1.51) D]. Humphrey Instruments ATLAS 8.0 was used for the computer-assisted analysis of corneal differential topographical maps. The examination of corneal topography was proceeded on the patients before the fitting of orthokeratology lenses and 6-month later. The distance from center of optic zone to apex of the cornea was measured as the value of decentration of orthokeratology lenses. The factors influenced the value of decentration were analyzed, including the initial refraction error, astigmatism, keratometry values, corneal eccentricity, and the diameter of the lens. The complaints of patients were recorded. Questionnaires, involving the symptoms of monocular diplopia and glare, were used to evaluate the effects of decentration of orthokeratology lenses on the visual function. **RESULTS:** The mean distance of decentration was (0.49 +/- 0.34) mm after one night fitting, the mean distance of decentration after follow-up for 1 month, 3 months and 6 months was (0.57 +/- 0.41) mm, (0.55 +/- 0.48) mm and (0.59 +/- 0.39) mm, respectively. After one month, the distance of decentration was less than 0.5 mm in 51.1% eyes, 0.5 - 1.0 mm in 35.6% eyes and more than 1.0 mm in 13.3% eyes. The direction of decentration in eyes with more than 0.50 mm decentration was mainly in the temporal side (48.5%). Patients with greater initial astigmatism and smaller diameter of lens showed greater distance of decentration ($P < 0.05$). There was no statistically significant difference in the distance of decentration between two groups with different corneal eccentricities and keratometry values ($P > 0.05$). The distance of decentration was greater in patients with monocular diplopia and glare. **CONCLUSIONS:** The degree of decentration of orthokeratology depends on the degree of initial refractive error, astigmatism and the design of orthokeratology lenses. The degree of decentration can influence the visual function.

Young, A.L., et al.

Orthokeratology lens-related *Pseudomonas aeruginosa* infectious keratitis

Cornea, 2003. 22(3): p. 265-6.

PURPOSE: To report a case of orthokeratology lens-related *Pseudomonas* corneal ulcer in an adult. **METHODS:** Case report. **RESULTS:** A 37-year-old man presented with a 1-day history of painful red eye. He was a soft contact lens wearer before he started on nocturnal orthokeratology lens wear of 8 to 10 hours per night 9 months ago. Corneal scraping sent for culture revealed a heavy growth of *Pseudomonas aeruginosa*. The patient was treated with intensive topical fortified tobramycin and ceftazidime drops. The ulcer healed with a residual paraxial corneal scar. Although his best-corrected visual acuity (BCVA) recovered from finger counting (8/200) at presentation to 20/30, he suffered visual loss from a premonitory BSCVA of 20/15. His contrast sensitivity (Vector Vision CSV 1000 test) performance was also worse than his fellow eye. **CONCLUSION:** Nocturnal orthokeratology lens wear may be associated with an increased risk of infection.

Cheung, S.W., P. Cho, and M.H. Edwards

Contact lens practice in Hong Kong in the new millennium

Clin Exp Optom, 2002. 85(6): p. 358-64.

PURPOSE: We evaluated the contact lens services provided by practitioners in Hong Kong, the fitting habits of the contact lens practitioners and their attitudes regarding the use of orthokeratology (ortho-k) and silicone hydrogel (SH) lenses for overnight wear. **METHODS:** Questionnaires were sent to all Hong Kong optometrists licensed to prescribe contact lenses. **RESULTS:** Two hundred and seventy-five questionnaires (21 per cent) were returned. Most of the respondents (96 per cent) were employed in optical shops and worked in practices that provided contact lens services. The number of new/refit cases per practice per month was about 55, with the percentages of new and refit cases being 48 per cent and 52 per cent respectively. Eighty-eight per cent of the patients were fitted with soft lenses and 10 per cent were fitted with rigid gas permeable (RGP) lenses. Fifty-nine per cent of soft lens patients were fitted with planned replacement (frequent replacement and disposable) soft lenses. Fifty per cent of soft lenses were low water content lenses and 85 per cent of RGP lenses were in low DK (< or = 40) material. Multipurpose solutions and soaking solutions with separate cleaner were the most commonly prescribed care regimens for soft and rigid lenses, respectively. Thirteen per cent of the practitioners provided ortho-k services and the mean number of ortho-k cases per month per ortho-k practitioner was six, the majority of patients being children. DreimLens was the lens design most commonly used and Boston XO the most used material. However, 96 per cent of the responding practitioners had reservations about the practice of ortho-k and the use of SH lenses for overnight wear. **CONCLUSIONS:** The contact lens market in HK is still dominated by soft lenses, particularly planned replacement lenses, whereas the percentage of RGP fits has changed little in the past decade. Few respondents used overnight ortho-k and SH lenses in view of concerns about their efficacy and long-term safety.

Cho, P., S.W. Cheung, and M.H. Edwards

Practice of orthokeratology by a group of contact lens practitioners in Hong Kong--Part 1. General overview

Clin Exp Optom, 2002. 85(6): p. 365-71.

PURPOSE: To describe orthokeratology (ortho-k) as practised by a number of practitioners in Hong Kong. **METHODS:** Twelve optometrists who had been practising ortho-k for between 2.5 and four years were interviewed in the period 1 March to 30 June 2001. **RESULTS:** The number of ortho-k cases seen by each practitioner ranged from 50 to 800, and the main reason for fitting was myopia control in children. All practitioners were using advanced ortho-k lens designs and most recommended night therapy. In general, patients were accepted if they had less than five dioptres of myopia; one or two lenses were required for a myopia reduction of four dioptres or less, whereas two to four lenses

were required to achieve reduction of more than four dioptres. Success, defined as the percentage of the target reduction agreed with patients that was actually achieved, was reported as better than 80 per cent for most practitioners. The time for trial lens wear was from 15 minutes to four hours and was 30 minutes in most cases. Suction holders were generally used for lens removal. Foggy vision was the most frequently reported adverse symptom and mild corneal staining the most frequent sign. CONCLUSIONS: It is clear that there is considerable variation in the practice of ortho-k in Hong Kong even among the relatively experienced practitioners interviewed here. The skills of contact lens practitioners in Hong Kong vary considerably because of the nature of the registration arrangements. We suggest that a statement of best clinical practice for ortho-k should be developed to assist practitioners to carry out this procedure effectively and safely.

Cho, P., et al.

Corneal iron ring associated with orthokeratology lens wear

Optom Vis Sci, 2002. 79(9): p. 565-8.

A healthy 27-year-old female with a history of daily wear soft contact lenses requested orthokeratology (ortho-k) treatment and was fitted with a pair of reverse geometry lenses. Two weeks later, a faint brown pigmented arc, with fuzzy margins, extending from four to eight o'clock at the inferior midperipheral part of the corneal surface was observed in both corneas. The patient was asymptomatic and happy with the results of the ortho-k treatment, and topographical maps showed a sharp and slightly decentered bull's eye pattern that indicated a clinically acceptable ortho-k effect for both eyes. The rings extended to a near-complete ring in both eyes and became denser and more significant as lens wear continued. The rings were similar in appearance to Fleischer's rings seen in keratoconic eyes and coincided with the margin of the bull's eye observed in the topographical maps. The patient continued to be asymptomatic with unaided visual acuity of 20/20(+1) (OD) and 20/25(-1) (OS). Apart from the presence of the iron rings bilaterally, the corneal integrity and topography were stable and clinically unremarkable; the patient was allowed to continue wearing the lenses with regular aftercare scheduled on a 3-month basis. Possible etiologies of the formation of iron rings are discussed.

Cho, P., et al.

The performance of four different corneal topographers on normal human corneas and its impact on orthokeratology lens fitting

Optom Vis Sci, 2002. 79(3): p. 175-83.

PURPOSE: To evaluate the performances of Humphrey Atlas 991, Orbscan II, Dicon CT200, Medmont E300 on young Chinese adults. METHODS: Three sets of corneal topography measurements were obtained from each topographer from 22 subjects-two sets by the same examiner and one set by another examiner on the same day. RESULTS: There were no significant within-examiner and between-examiner differences for any of the parameters tested for each topographer. However, only the repeatability and

reproducibility (of apical radius[Ro], eccentricity, and elevation) of the Humphrey and Medmont were good. There was no statistically significant between-topographer difference in R(o), but significant differences in eccentricity and elevation values were found. The number of repeated readings that should be taken for a precision of 2 microm (elevation) were 12 for the Humphrey and 2 for the Medmont. CONCLUSIONS: The performance of both the Humphrey and the Medmont was very good. R(o) and eccentricity values of different topographers cannot be used interchangeably, but the agreement in elevation values was good for these topographers. The number of repeated readings required for maximum precision varies with the topographer used, and they are not interchangeable.

Hutchinson, K. and A. Apel

Infectious keratitis in orthokeratology

Clin Experiment Ophthalmol, 2002. 30(1): p. 49-51.

Orthokeratology is a method of changing refraction in myopic patients by using rigid contact lenses to reduce the curvature of the cornea. This treatment was in use in the two cases of corneal ulcer described in this paper and appears to have contributed to the development of their disease. As with extended wear contact lenses, patients undergoing orthokeratology treatment are frequently advised to wear the orthokeratology lenses overnight increasing the risk of corneal ulceration and infection. Patients should be adequately warned of the associated risks and advised that any envisaged benefits of the procedure are temporary.

Mountford, J. and K. Pesudovs

An analysis of the astigmatic changes induced by accelerated orthokeratology

Clin Exp Optom, 2002. 85(5): p. 284-93.

PURPOSE: The change in corneal astigmatism induced by reverse geometry lenses for orthokeratology has not been described previously. This study examines the efficacy of accelerated orthokeratology for reducing astigmatism and whether this varies with the degree of pre-existing astigmatism. METHOD: Twenty-three randomly chosen eyes exhibiting 0.50 D to 1.75 D pre-fitting with-the-rule astigmatism were retrospectively analysed. Astigmatism was measured by simulated keratometry and corneal topography before and at the completion of a course of orthokeratology. The change in astigmatism measured by keratometry was calculated by two vector analysis techniques: the Bailey-Carney method, which was designed for contact lens-induced corneal shape changes, and the Alpines method, which was designed for surgically-induced corneal shape changes. The change in astigmatism measured by corneal topography was calculated by the EyeSys Version 3.2 software. RESULTS: Most patients (20/23) had some reduction of astigmatism but orthokeratology is incapable of a total elimination of pre-fit astigmatism. Alpines vector analysis showed that an increased efficacy of 60 to 80 per cent would be required to eliminate astigmatism. All three methods found a 50 per cent mean reduction in astigmatism from the pre-fit level. Topographical analysis indicates that the reduction in

astigmatism occurs mainly over the central 2.00 mm chord. There is a very poor correlation between the pre-and post-wear corneal astigmatism at the 2.00 mm chord ($R(2) = 0.11$, $p = 0.04$) and the predictability of the final astigmatic axis is also poor (angle of error = 1.22 ± 27.35). CONCLUSIONS: Accelerated orthokeratology seems more successful than conventional orthokeratology at reducing with-the-rule astigmatism. However, it reduces pre-existing astigmatism by an average of only 50 per cent and it does not do so reliably either for magnitude or direction. These results provide two useful patient selection criteria for orthokeratology. They are: assuming 0.50 D to 0.75 D of astigmatism is a satisfactory outcome, orthokeratology can be expected to be successful for pre-fitting astigmatism of up to 1.00 D to 1.50 D; and the greater the pre-existing astigmatism, the less likely orthokeratology is to be successful.

Nakagawara, V.B., K.J. Wood, and R.W. Montgomery

The use of contact lenses by U.S. civilian pilots

Optometry, 2002. 73(11): p. 674-84.

BACKGROUND: Since 1976, the use of contact lenses by civilian pilots has been permitted to correct distant vision for obtaining a Federal Aviation Administration (FAA) aeromedical certificate. This study examined the civil airman population's experience with contact lens use for a 30-year period (1967 to 1997). METHODS: Population totals for airmen who carried pathology codes 161 (contact lens) and 158 (orthokeratology) from January 1, 1967 through December 31, 1997 were used to calculate prevalence rates by class of medical certificate and age. The National Transportation Safety Board and FAA databases were queried to determine if contact lens use had contributed to aviation mishaps. RESULTS: The prevalence of contact lens use grew faster for first-class medical certificate holders and airmen $> \text{ or } = 40$ years of age during the period. The frequency of airmen with orthokeratology increased by 23 times in a 10-year period. Reports from five aviation accidents and one incident suggested that contact lens use was a contributing factor in these mishaps. CONCLUSIONS: Professional pilots and older airmen were found to be more inclined to use contact lenses. The increasing use of contact lenses and the rapid changes in contact lens technology warrant continued monitoring to ensure aviation safety.

Rah, M.J., J.T. Barr, and M.D. Bailey

Corneal pigmentation in overnight orthokeratology: a case series

Optometry, 2002. 73(7): p. 425-34.

BACKGROUND: Iron deposition within the basal corneal epithelium, or a Hudson-Stahli line, is a common physiological finding. Variations of this deposition can be seen after surgical refractive procedures and as a result of corneal disease. This case series provides evidence of corneal deposition of a similar nature in patients who wear reverse geometry rigid gas-permeable contact lenses for overnight orthokeratology. To date, similar findings associated with orthokeratology have not been published. CASE REPORTS: Deposition-

presumably of iron-was found in the corneal epithelium in a small sample of patients who have been undergoing treatment with overnight orthokeratology for a duration of 6 months to 2 years. Paragon CRT lenses were worn by four patients, the DreimLens was worn by one patient, and one patient initially began treatment in the FARGO 6 lens design and ultimately was refitted into Paragon CRT lenses. The finding was more prominent in patients with dark irides and in patients with higher baseline refractive errors.

CONCLUSIONS: Although this is an interesting finding, it does not appear to affect visual acuity nor does it appear to be adverse in nature. No treatment has been necessary in any of the cases presented. All six patients are still undergoing treatment with overnight orthokeratology.

Rah, M.J., et al.

Overnight orthokeratology: preliminary results of the Lenses and Overnight Orthokeratology (LOOK) study

Optom Vis Sci, 2002. 79(9): p. 598-605.

BACKGROUND: The Lenses and Overnight Orthokeratology (LOOK) study is a pilot study designed to learn the procedures of orthokeratology lens fitting in preparation for a planned larger clinical trial and to obtain data with which to calculate a sample size for that larger study. Data are presented for the first 3 months of the LOOK study. METHODS: Sixty subjects were enrolled in this multicenter pilot study to evaluate the success and safety of treatment with overnight orthokeratology contact lenses. Refractive error, corneal topography, and biomicroscopic data were collected to determine the amount of refractive error change achieved, corneal changes, and a safety profile of overnight wear of reverse geometry rigid gas permeable lenses for orthokeratology. RESULTS: Of the 60 subjects enrolled, 46 completed the 1-month visit, and 31 completed the 3-month visit. The mean change in spherical equivalent manifest refraction from baseline to the morning 3-month visit was 2.08 +/- 1.11 D in the right eye and 2.16 +/- 1.05 D in the left eye. At the 3-month morning visit, 74% of right eyes and 61 % of left eyes had 20/20 unaided visual acuity. No corneal infiltrates or ulcers were noted in any subjects. Observations of fluorescein staining of the cornea, imprinting, and microcysts were noted in some patients at the 3-month visit. CONCLUSIONS: The preliminary results of the LOOK study indicate that improvement in unaided visual acuity can be attained for at least 6 h after lens removal. The short-term safety and efficacy of the procedure appear to be favorable; however, future studies are needed to determine the long-term outcomes of treatment.

Van Nakagawara, B., K.J. Wood, and R.W. Montgomery

The use of contact lenses by U.S. civilian pilots

Optometry, 2002. 73(11): p. 674-84.

BACKGROUND: Since 1976, the use of contact lenses by civilian pilots has been permitted to correct distant vision for obtaining a Federal Aviation Administration (FAA) aeromedical certificate. This study examined the civil airman population's experience with

contact lens use for a 30-year period (1967 to 1997). METHODS: Population totals for airmen who carried pathology codes 161 (contact lens) and 158 (orthokeratology) from January 1, 1967 through December 31, 1997 were used to calculate prevalence rates by class of medical certificate and age. The National Transportation Safety Board and FAA databases were queried to determine if contact lens use had contributed to aviation mishaps. RESULTS: The prevalence of contact lens use grew faster for first-class medical certificate holders and airmen $>$ or $=$ 40 years of age during the period. The frequency of airmen with orthokeratology increased by 23 times in a 10-year period. Reports from five aviation accidents and one incident suggested that contact lens use was a contributing factor in these mishaps. CONCLUSIONS: Professional pilots and older airmen were found to be more inclined to use contact lenses. The increasing use of contact lenses and the rapid changes in contact lens technology warrant continued monitoring to ensure aviation safety.

Chen, K.H., T.M. Kuang, and W.M. Hsu

Serratia Marcescens corneal ulcer as a complication of orthokeratology

Am J Ophthalmol, 2001. 132(2): p. 257-8.

PURPOSE: To report a case of Serratia Marcescens corneal ulcer as a complication of orthokeratology treatment. METHODS: Case report. RESULTS: A 9-year-old male who underwent orthokeratology treatment for 6 months suffered from a corneal ulcer. The refractive state of lesion eye was $-5.5D/-1.25D \times 180$ degrees, and visual acuity was hand motion at 30 cm. He wore a retainer lens, rigid gas permeable lens, overnight for 2 months before the corneal ulcer occurred. Ulcer became worse after tobramycin and gentamycin treatment for 2 days. After ciprofloxacin treatment, the ulcer healed and visual acuity recovered to 20/20 with spectacle correction. Cultures of the cornea tissue and contact lens storage solution both grew Serratia Marcescens, which was sensitive to ciprofloxacin. CONCLUSION: Overnight wearing of a rigid contact lens is a risk factor for a corneal ulcer.

Lu, L., L. Zou, and R. Wang

[Orthokeratology induced infective corneal ulcer]

Zhonghua Yan Ke Za Zhi, 2001. 37(6): p. 443-6.

OBJECTIVE: To investigate the clinical course, treatment and outcome of infective corneal ulcer induced by orthokeratology. METHODS: Sixteen cases of infective corneal ulcer caused by orthokeratology were reported, including 7 cases of pseudomonas corneal ulcers, 8 cases of acanthamoeba keratitis and 1 case of mycotic keratitis. Smears and cultures from corneal scrapings for bacteria, fungi and amoeba were performed for all of the patients. According to the results of pathogenic microorganisms, different therapeutic approaches were given. Lamellar keratoplasty or penetrating keratoplasty was performed for 9 patients whose corneal lesions were serious and unresponsive to medical therapy. RESULTS: After medical treatment or keratoplasty, corneal infections of all the patients were controlled. The visual acuity of most cases was improved. CONCLUSIONS: The

infective corneal ulcer is the most serious complication of orthokeratology. The treatment of infective corneal ulcer should be directed toward the elimination of the pathogenic microorganisms from the cornea. Keratoplasty continues to have a central role in the management of some advanced cases. Although the infections can be controlled, the vision of these patients is seriously damaged.

Nichols, J.J., et al.

Overnight orthokeratology

Optom Vis Sci, 2000. 77(5): p. 252-9.

PURPOSE: Orthokeratology is defined as the temporary reduction in myopia by the programmed application of rigid gas-permeable contact lenses. New reverse geometry contact lens designs and materials have led to a renewed interest in this field. The purpose of this study is to assess visual, refractive, topographic, and corneal thickness changes in subjects undergoing overnight orthokeratology. **METHODS:** Ten myopic subjects (mean age, 25.9 \pm 3.9 years) were recruited for a 60-day trial of overnight orthokeratology using reverse geometry rigid contact lenses. After commencing lens wear, subjects were examined on days 1, 7, 14, 30, and 60 at several times throughout the day. High- and low-contrast logarithm of the minimum angle of resolution (logMAR) visual acuity, monocular subjective refraction, autorefraction, autokeratometry, corneal topography, corneal thickness, and slit lamp examinations were performed at each session. **RESULTS:** Eight subjects completed the study. Both high- and low-contrast uncorrected visual acuity improved significantly by day 7. The mean change in uncorrected high contrast visual acuity at day 60 was -0.55 \pm 0.20 logMAR (mean at day 60, -0.03 \pm 0.16; Snellen equivalent, 20/19). The mean change in uncorrected low-contrast visual acuity at day 60 was -0.48 \pm 0.26 logMAR (mean at day 60, +0.22 \pm 0.23; Snellen equivalent, 20/33). The mean subjective refraction and autorefraction were significantly reduced from baseline at day 60 (mean change in subjective refraction, +1.83 \pm 1.23 D; mean change in autorefraction, +0.64 \pm 0.52 D). Corneal topography showed significant central flattening (mean change in apical radius, +0.20 \pm 0.9 mm; mean change in shape factor, -0.11 \pm 0.18 at day 60). The central cornea also showed significant thinning (mean change, -12 \pm 11 microm at day 60). All visual, refractive, and topographic outcomes were sustained over the course of an 8-h day. **CONCLUSIONS:** Overnight orthokeratology is an effective means of temporarily reducing myopia. The possible mechanism of corneal remodeling through central corneal thinning is discussed.

Sima, J., et al.

[Result of orthokeratology for treatment of young people with myopia]

Yan Ke Xue Bao, 2000. 16(2): p. 149-52.

PURPOSE: To evaluate the effectiveness of orthokeratology (Ortho-K) for treatment of myopia in youngsters. **METHODS:** 110 eyes of 56 young peoples with myopia received Ortho-K were studied. The patients were divided into 3 groups according to preoperative

diopters. No. I: -1.00(-)-3.00 D, No. II: -3.25(-)-6.00 D, NO. III: -6.25(-)-7.50 D. The uncorrected visual acuities, residual diopters and corneal refractive powers at various time of three months after the operation were statistically analyzed and compared with that of preoperation. Correlation analysis and linear regression analysis were performed between the corneal refractive reduction (X) and clinical refractive reduction (Y) after 3 months of the operation. RESULTS: In 110 eyes, the uncorrected visual acuities in the first day, first week, first month, second month and third month after operation were significantly improved than that of the preoperation ($P < 0.01$). The mean residual diopters were significantly reduced than that of preoperation ($P < 0.01$). The mean refractive powers of cornea were significantly decreased than that of the preoperative ($P < 0.01$). There was significant correlation between the corneal refractive reduction and clinical refractive reduction. ($r = 0.3181$, $P < 0.001$). CONCLUSION: Orthokeratology is a safe and effective therapeutic method for treatment of myopia in youngths. The long term effect of Orthokeratology need further observation.

Fan, L., et al.

Clinical study of orthokeratology in young myopic adolescents

1999. 26(5): p. 113-116.

This project was designed to study the efficacy of orthokeratology and its related problems in a population of young myopic adolescents. Fifty-four young myopia adolescents ages 11 to 15 years were enrolled in the study and followed over a 6-month period. The procedures included (1) baseline refraction, assessment of tear quality and quantity, and cornea examination including cornea topography, A-scan ultrasound of cornea thickness, and spectromicroscopy of the corneal endothelium; (2) diagnostic lens fitting and evaluation; (3) lens dispensing and educating the patients or their parents; (4) follow-up schedule and data analysis; and (5) maintenance lens dispensing and analysis of wearing schedules. Myopia was reduced between -1.25 and -5.00 D (-3.00 D average). Myopia reduction was almost complete in the first 6 months, with most of the reduction occurring during the first 2 weeks. Seventy-five percent of the possible reduction occurred during this 2-week time period. Tear quality and quantity influenced reduction speed and amount. Corneal thickness and endothelium remained unchanged over the study period. Subjective refraction is the most reliable method to measure the status of ocular refractive changes. Corneal staining occurred in 45% of subjects during the procedure, mainly in subjects with tear problems. Eighteen percent of the subjects showed induced astigmatism, which could be reversed by refitting the lens or changing the wearing schedule. Maintenance lenses had to be worn every night for young adolescents to maintain myopia reduction. Orthokeratology is a reliable option for reducing some myopia in young adolescents. The first 2 weeks are critical for the procedure. Complete examination and the data analysis procedures are important for monitoring prognosis and eye health.

Dave, T. and D. Ruston

Current trends in modern orthokeratology

Ophthalmic Physiol Opt, 1998. 18(2): p. 224-33.

The present article describes the basic concepts and principles of modern orthokeratology. Early investigators postulated a variety of theories. However, controlled clinical studies have shown these methods to be both unpredictable and also modest in their ability to correct myopia. These traditional techniques involved fitting lenses according to a 'rule-of-thumb' and clinicians had no means of accurately evaluating corneal topography. More recently, with the significant advances in corneal topography systems and the application of reverse geometry lenses (lenses where the secondary curve steepens) certain investigators have concluded that the technique can rapidly reduce greater levels of myopia with greater predictability. The procedure involves a more scientific sagitta based fitting philosophy and predictability is defined according to corneal asphericity.

Swarbrick, H.A., G. Wong, and D.J. O'Leary

Corneal response to orthokeratology

Optom Vis Sci, 1998. 75(11): p. 791-9.

PURPOSE: The technique of orthokeratology produces a corneal response to the mechanical pressures exerted by rigid contact lenses. This paper reports a study which investigated the topographic and pachometric corneal changes induced by orthokeratology. **METHODS:** Six young myopic subjects (11 eyes) wore "accelerated orthokeratology" lenses (OK-74; Contex Inc., Sherman Oaks, CA) in a high Dk material (AirPerm; Dk = 88) for 28 days. Corneal and epithelial thickness were measured topographically using the Holden-Payor optical micropachometer, and corneal topography was monitored using the EyeSys system. **RESULTS:** Refractive error change reached 1.71 +/- 0.59 D reduction in myopia after 28 days. After 1 day of lens wear, statistically significant central corneal flattening was noted, which progressed to reach 0.22 +/- 0.07 mm (1.19 +/- 0.38 D) at 28 days. A trend toward central epithelial thinning was apparent, reaching statistical significance on day 28 (7.1 +/- 7.1 microm; 9.6%). Midperipheral corneal thickening was also found approximately 2.5 mm from the corneal center, which was statistically significant by day 14 (13.0 +/- 11.1 microm; 2.4%). Calculations using Munnerlyn's formula indicate that changes in corneal sagittal height based on topographical thickness changes across the flattened central 5.25-mm zone can account for the refractive changes observed. **CONCLUSIONS:** These findings suggest that the initial corneal response to orthokeratology may be explained by redistribution of corneal tissue, rather than by overall bending of the cornea.

Joe, J.J., H.J. Marsden, and T.B. Edrington

The relationship between corneal eccentricity and improvement in visual acuity with orthokeratology

J Am Optom Assoc, 1996. 67(2): p. 87-97.

BACKGROUND: Due to the renewed attention given to reduction of myopia, interest in orthokeratology has dramatically increased. This study was performed to determine whether or not a predictor for orthokeratologic changes can be identified. **METHODS:** Fifteen subjects enrolled in the study. For each subject, corneal eccentricity (e) was measured, subjective refraction and autorefractometry were performed, and intraocular pressures were taken. Each subject was then fitted with a rigid contact lens for orthokeratology and followed for a minimum of 16 weeks. Eleven subjects completed the study. **RESULTS:** No correlation between corneal eccentricity and improvement in visual acuity was found. Correlations were found between e and changes in subjective refraction, and between e and changes in autorefractometry. There was also correlation between lower intraocular pressure and changes in subjective refraction, and between lower intraocular pressure and changes in autorefractometry. **CONCLUSIONS:** These findings suggest that corneal eccentricity and lower intraocular pressures may be predictors of orthokeratologic changes. A longitudinal study with a larger subject size will be needed to conclusively determine if these two measurements are predictors of orthokeratologic changes.

Carkeet, N.L., J.A. Mountford, and L.G. Carney

Predicting success with orthokeratology lens wear: a retrospective analysis of ocular characteristics

Optom Vis Sci, 1995. 72(12): p. 892-8.

PURPOSE: Orthokeratology procedures suffer from lack of predictability in the response of individuals. To identify factors contributing to this, we have retrospectively studied a range of ocular parameters in patients with varying outcomes from orthokeratology lens wear. **EXPERIMENTAL DESIGN:** Three groups were studied: an experimental group (9 subjects wearing Contax OK-3 design orthokeratology contact lenses), and 2 control groups [10 rigid gas permeable (RGP) contact lens wearers and 10 non-contact lens wearers]. Three categories were identified among the orthokeratology group: those responding well, moderately, or poorly to orthokeratology lens wear. Measurements included subjective refraction, intraocular distances, corneal thickness, ocular rigidity, and epithelial fragility. **RESULTS:** When comparing the three orthokeratology categories, there was no significant difference for central and peripheral epithelial fragility and ocular rigidity. There was also no significant difference for any of the biometric characteristics measured. The prefitting spherical equivalent power was found to be significantly different between categories of responders ($p = 0.0228$), with the poor responders having the highest initial level of myopia. None of the measured characteristics differed significantly among the orthokeratology group and the two control groups. **CONCLUSIONS:** In this pilot study, the success of orthokeratology lens wear was not related to ocular biomechanical or biometric attributes, but it was related to prefitting refractive error.

Heng, L.S. and C.Y. Khoo

Can contact lenses control the progression of myopia?

Singapore Med J, 1994. 35(4): p. 367-70.

Myopia is a potentially blinding condition with serious socio-economic ramifications. Many causes have been alluded to and one of the strongest associations is that of formal education and nearwork. Studies done both locally and abroad illustrate this. In addition, Singaporeans were found to have one of the highest incidences of myopia in the world. Many methods, including the use of contact lenses, have been advocated in the control of myopia. Hard contact lenses and more recently, rigid gas permeable lenses, have been studied both to arrest the progression of myopia in the young and reduce existing myopia (by orthokeratology) in the Caucasian population. However, the Asian eye differs from the Caucasian eye. This is evidenced by the increased frequency and severity of myopia, and the difference in the pattern of corneal diseases in our population. As such, there is a need for local studies to be conducted to assess the effectiveness of this method in our population.

Wilson, D.R. and A.H. Keeney

Corrective measures for myopia

Surv Ophthalmol, 1990. 34(4): p. 294-304.

Many myopic people, expressing dissatisfaction with traditional methods of optical correction, are interested in a permanent correction of their refractive error which would alleviate dependence on corrective lenses. Although much effort has been put forth in the last century, there is still no method of correcting myopia which is broadly acceptable as safe and effective. The nonsurgical procedures of orthokeratology and the topical use of cycloplegics have not been well proven. Surgical measures are the current vectors of hope. Surgical procedures on parts of the eye other than the cornea have proven to be difficult. Surgery which alters the refractive power of the cornea (refractive keratoplasty) has been used frequently in the past decade. These procedures include keratomileusis, epikeratophakia and radial keratotomy. The latter is currently the most often performed method for the correction of myopia. This paper critiques the major methods, explains their historical development and basic procedures, lists major published studies and discusses their problems and promise for their future.

Woo, G.C. and M.A. Wilson

Current methods of treating and preventing myopia

Optom Vis Sci, 1990. 67(9): p. 719-27.

In this review, we discuss and compare current methods of treating and preventing myopia including radial keratotomy, keratomileusis, keratophakia, epikeratoplasty, keratokyphosis, scleral reinforcement, phakoemulsification, and heat application. Among the visual training methods are such procedures as biofeedback and behavior modification. The use of drugs, orthokeratology, spectacles, bifocals, prisms, intraocular lenses, contact lenses, and ultrasound are described.

Coon, L.J.

Orthokeratology. Part II: Evaluating the Tabb method

J Am Optom Assoc, 1984. 55(6): p. 409-18.

This summary of the experimental design and methodology of a study evaluating ocular response to orthokeratology presents a method of orthokeratology that involves modifying the optic zone diameter, intermediate, and peripheral curve zones of a PMMA contact lens. An evaluation of the Tabb method of orthokeratology to determine the ocular tissue changes most responsible for observed refractive and acuity changes found that noncorneal parameters measured did not change, whereas two corneal parameters measured did change as orthokeratology occurred. The corneal parameters that appeared most involved in refractive and acuity changes were corneal thickness and shape factor. The Tabb method of orthokeratology did not cause an increase in corneal with-the-rule astigmatism.

Brand, R.J., K.A. Polse, and J.S. Schwalbe

The Berkeley Orthokeratology Study, Part I: General conduct of the study

Am J Optom Physiol Opt, 1983. 60(3): p. 175-86.

The Berkeley Orthokeratology Study was a single center, randomized, concurrently controlled masked clinical trial. Eighty subjects were studied--40 in an orthokeratology (OK) treatment group and 40 in a control group fitted with conventional hard contact lenses. Visual and ocular characteristics were monitored for 1.5 years in order to assess relative efficacy, duration, and safety of the OK treatment. This report describes the general conduct of the study including recruitment methods, eligibility requirements, randomization and masking procedures, contact lens materials, and the treatment and follow-up plan. Baseline comparison revealed that the 21 subjects lost to follow-up were similar to the 59 subjects who completed follow-up and also that the 31 treatment and 28 control subjects in this group were quite similar in their baseline characteristics. In the course of adaptation and subsequent follow-up, treatment subjects were fitted with six lenses per eye on the average compared with three per eye in the control group. Analysis of lens prescriptions shows that the treatment lenses were substantially larger, thicker, and fitted optically flatter than those worn by the control group.

Polse, K.A., et al.

The Berkeley Orthokeratology Study, part III: safety

Am J Optom Physiol Opt, 1983. 60(4): p. 321-8.

The safety of orthokeratological (OK) procedures was assessed by monitoring several ocular characteristics including corneal thickness, refractive astigmatism, corneal astigmatism, correctable spectacle-acuity, corneal edema, corneal staining, and endothelial cell density. Safety was also assessed by reviewing the number and causes of extra clinical visits that occurred because of ocular complications and by determining whether safety factors were related to patients lost to follow-up. Over the 1.2-year period from the baseline examination to the end of the lens-wearing phase of the study, the Treatment (T) and Control (C) groups had, respectively, only small changes in their mean levels of corneal thickness (0.2 vs. 3.2 microns), refractive astigmatism (0.07 vs 0.01 D), and corrected spectacle acuity (0.02 vs 0.018 logarithm of the minimum angle of resolution). Analysis of time trend data obtained from scheduled monthly examinations also showed that changes in mean corneal thickness and mean corneal astigmatism were small and not clinically important in either comparison group during the course of the treatment. As a result of complications from lens wear, the T group required 1.25 times as many extra visits as the C group ($p = 0.14$). However, none of these visits provided sufficient clinical indication for the discontinuance of lens wear. Loss to follow-up typically occurred because of either poor compliance with the study protocol or loss of motivation caused by minor contact lens-related symptoms such as blurred vision, slight discomfort, or frequently lost lenses. These reasons were similar in both comparison groups. It appears that OK treatment is safe for the types of patients who participated in this study, but it may require more patient monitoring than would be needed to achieve and maintain a physiologically acceptable fit with conventional hard contact lens prescriptions.

Polse, K.A., et al.

The Berkeley Orthokeratology Study, Part II: Efficacy and duration

Am J Optom Physiol Opt, 1983. 60(3): p. 187-98.

Relative efficacy of orthokeratology (OK) was evaluated by assessing changes in refractive error, visual acuity, and corneal curvature in 31 treated and 28 randomized control subjects who wore conventional rigid contact lenses. The duration of changes was studied by monitoring subjects after lens wear was discontinued. After an average of 444 days of contact lens wear the treatment group showed an overall mean reduction in spherical equivalent refractive error of 1.01 D compared with 0.54 D in the control group ($p = 0.02$). Both groups had considerable variation in refractive error change. Corresponding mean improvements in unaided visual acuity were -0.27 and -0.20 log of the minimum angle of resolution [\log (MAR)]. Corneal curvature decreased in both comparison groups, but the actual diopter value was about one-half that of the refractive change. The changes in these characteristics tended to occur during the first 132 days of wear, and additional aggressive lens therapy during the remaining 241 days of treatment produced little additional change. The refractive error fluctuated considerably during the period of follow-up and these fluctuations tended to be larger in those subjects who had shown greater changes in refractive error. When the lenses were removed, ocular characteristics returned steadily toward baseline levels. Ninety-five days after discontinuing lens wear, the refractive error had returned 75 and 69% of the way to baseline levels for the treatment and control groups, respectively. Visual acuity and corneal curvature showed similar rebound after 95 days. We conclude that it is possible to reduce myopia about 1D; however, the change is not permanent. Results indicate that the level of vision during

periods of nonlens wear would be unstable, making it difficult to predict what the quality of vision would be under a retainer lens wear program.

Polse, K.A., et al.

Corneal change accompanying orthokeratology. Plastic or elastic? Results of a randomized controlled clinical trial

Arch Ophthalmol, 1983. 101(12): p. 1873-8.

Effects of orthokeratology on refractive error, visual acuity, and corneal curvature were monitored on two randomized comparison groups for 364 days of lens wear and 95 days of follow-up after lens wear was discontinued. Approximately 36% of the treatment group compared with 13% of the control group had 1 diopter or more change in refractive error; however, after lens wear was discontinued, there was substantial remission and differences between the groups were small. Although there was a positive correlation between the amount of change during lens wear and the persistence of change after discontinuation, neither the magnitude of persistence nor differences between groups were clinically important. The lack of persistence indicates that the cornea is either highly elastic or has some other memory mechanism. We conclude that orthokeratology produces modest reductions in myopia; however, the effect will not persist without continued lens wear and therefore is of limited clinical value in permanently reducing myopia.

Coon, L.J.

Orthokeratology: part I historical perspective

J Am Optom Assoc, 1982. 53(3): p. 187-95.

This history of orthokeratology includes contributions made by Jessen, Ziff, Nolan, Paige, Gates, May, Grant, Fontana, Tabb, Freeman, Shed, Kerns, and Binder to the use of contact lenses for myopia reduction. It reviews the early use of extremely flat lenses to flatten corneas and the more recent use of lenses fit with apical clearance to reduce myopia. The controlled studies of Kerns and Binder are described and the need for further research is indicated.

Binder, P.S., C.H. May, and S.C. Grant

An evaluation of orthokeratology

Ophthalmology, 1980. 87(8): p. 729-44.

Twenty-three orthokeratology (OK) patients and 16 cosmetic hard contact lens (CL) patients were evaluated. Initially, each patient underwent a complete examination including central and peripheral keratometry, specular microscopy, axial length

determination, uncorrected visual acuity, and cycloplegic refraction. The patients were then re-evaluated every three months. When the retainer lens stage was reached, the contacts were removed, and the patients were again re-examined for six additional months. Nine of ten CL patients remained in the study, during which time there was no improvement in unaided visual acuity or spherical equivalent. Both the central horizontal and vertical meridians flattened during this time. Twenty of 21 OK patients were also studied. A different technique of fitting contact lenses was used for this group, which produced significant changes in uncorrected visual acuity ($P > 0.01$) and spherical equivalent ($0.1 > P > 0.05$), but not in the central or peripheral corneal curvature. Five of the OK patients failed to respond. Six had variable, unpredictable responses, and nine had good responses. Analysis of the information in this study demonstrates that an OK procedure utilizes techniques of fitting that differ from standard contact lens techniques. The responses to OK are unpredictable and uncontrollable. The quality of uncorrected vision is worse than with contacts or glasses, and the chances of attaining 6/12 (20/40) uncorrected vision are small. Once lenses are removed, the corneal parameters return toward prefit levels.

Tredici, T.J.

Symposium: Clinical management of physiologic myopia. Role of orthokeratology: a perspective

Ophthalmology, 1979. 86(5): p. 698-705.

Orthokeratology is the reduction, modification, or elimination of refractive anomalies by the programmed application of contact lenses. A brief background is given on corneal changes induced by contact lenses fitted by normal and orthokeratology techniques. A common orthokeratology fitting method is described, results of inducing refractive changes are discussed, and a recently published study of this method of contact lens fitting and the author's personal observation on patients fitted by this technique are reported. Recent trends in orthokeratology and their possible effects on contact lens fitting are discussed, and a summarization of the effects of this contact lens fitting technique on myopia is given.

Kerns, R.L.

Research in orthokeratology. Part VIII: results, conclusions and discussion of techniques

J Am Optom Assoc, 1978. 49(3): p. 308-14.

In this paper, the results, discussions and conclusions concerning selected variables relative to orthokeratological effects and procedures are presented. The data, clinical observations and subsequent analyses suggest that corneal modification with contact lenses is not clearly understood. Hypothesis are offered to explain certain results obtained, to account for observed discrepancies and to collectively assemble a rational understanding for the effects of contact lenses on purposeful corneal modification.

Erickson, P. and F. Thorn

Dose refractive error change twice as fast as corneal power in orthokeratology?

Am J Optom Physiol Opt, 1977. 54(9): p. 581-7.

We analyzed data from 4 orthokeratology studies of refractive error change (ΔRE) and keratometer-reading change (ΔK). Instead of the reported $\Delta RE/\Delta K$ ratio of 2:1, we calculated from linear-regression analysis a ratio (slope) of 2:3. The ordinate intercept of the straight line fitted to the data ($N = 181$ eyes) indicates that when $\Delta K = 0$, $\Delta RE = 0.72$. The correlation between ΔK and ΔRE is poor (+0.63). Causes and interpretations of these results are discussed.

Kerns, R.L.

Research in orthokeratology. Part VII: examination of techniques, procedures and control

J Am Optom Assoc, 1977. 48(12): p. 1541-53.

Since contact lenses are responsible for producing corneal change it is essential to rigorously examine for variables involved. The need to control corneal change further dictates that fitting procedures or techniques should also be critically evaluated. Given in this first of a two part series is a background discussion of contact lens prescribing characteristics and resultant data collected during an orthokeratology study. Specifically examined were the effects of the base curve-cornea relationship, lens position and temporal factors. Though each was noticed to be involved in the results obtained, their failure to account for all changes observed suggest that other mechanisms need be considered.

Kerns, R.L.

Research in orthokeratology. Part VI: statistical and clinical analyses

J Am Optom Assoc, 1977. 48(9): p. 1134-47.

In this paper, the rationale, statistical methods and results of this study are given. Specifically, it is shown that contact lenses produce clinical effects on the eye which are statistically significant. Moreover, the orthokeratology procedure was found to produce more corneal and refractive change than conventional contact lens wear. Variability and predictability of data are discussed along with pertinent clinical considerations. Certain factors and their influence on corneal change are examined and quantified.

Kerns, R.L.

Research in orthokeratology. Part V: Results and observations--recovery aspects

J Am Optom Assoc, 1977. 48(3): p. 345-59.

In this paper, the recovery profiles of changes produced by a defined orthokeratological technique are presented and discussed. The manner and degree in which the eye responds after the removal of contact lenses was shown to be highly individualistic in nature. Even so, certain trends were evident. It was found that the alterations produced by orthokeratology were rarely permanent; however, complete recovery was usually not observed.

Kerns, R.L.

Research in orthokeratology. Part IV: Results and observations

J Am Optom Assoc, 1977. 48(2): p. 227-38.

Changes in unaided visual acuity, corneal integrity and lens position are differentially affected by contact lens fitting procedures. The effects on these parameters, from contact lenses fitted by defined conventional and orthokeratological techniques, are given and compared to each other and to a group of non-contact lens wearers. General trends and variability of data are discussed in conjunction with pertinent clinical observations for the three groups.

Marquardt, R. and H.W. Roth

[Orthokeratology. Technique - possibilities - limits (author's transl)]

Klin Monatsbl Augenheilkd, 1977. 171(1): p. 84-9.

The cornea is because of its refraction, its structure and accessibility the easiest variable component of the optic eye system. Flat fitted, barely flexible contact lenses exercise by their small central clearance a considerable pressure on the corneal apex and will therefore bring about a reversible clearance of the central corneal topography. Orthokeratology therapeutically uses this effect in order to temporarily reducing, changing or eliminating a refractive error. This is of a particular interest in the case of a keratoconus. Orthokeratology is not without danger because too high pressures have a weakening effect on the corneal trophic and resistance.

Kerns, R.L.

Research in orthokeratology. Part III: results and observations

J Am Optom Assoc, 1976. 47(12): p. 1505-15.

The effects of contact lenses, fitted by defined conventional and orthokeratological techniques, are given and compared to a group of non-contact lens wearers. Data presented include changes in corneal curvature, topography, refraction and astigmatism. General trends and variability of data are discussed in conjunction with pertinent clinical observations for the three test groups.

Rubin, M.L. and B. Milder

Myopia--a treatable "disease"?

Surv Ophthalmol, 1976. 21(1): p. 65-9.

The authors cite various information and misinformation regarding proposed treatments (atropinization, contact lenses, orthokeratology, wearing glasses, not wearing glasses) for the progression of myopia. They conclude that there is insufficient evidence to support the more vigorous approaches to treatment of myopia, and provide some useful explanations for patients and their parents who question the ophthalmologist's decision to treat conservatively.

Patterson, T.C.

Orthokeratology: changes to the corneal curvature and the effect on refractive power due to the sagittal length change

J Am Optom Assoc, 1975. 46(7): p. 719-29.

Little has been published to date on orthokeratology which can explain what changes the eye actually goes through. Many professionals are waiting for this evidence before judging this controversial technique. With orthokeratology the corneal curves are changed and present a definite pattern. There are a number of changes which must occur when the cornea is flattened which reduce the power of the eye beyond that amount of flattening. This paper examines one of these unknowns.