Orthokeratology

- **Time:** May 9, 2012
- **Place:** Sunrise Eye Clinic
Influence of Overnight Orthokeratology on Axial Elongation in Childhood Myopia

Tetsuhiko Kakita/IOVS. 2011;52:2170-2174

METHODS
- 105 subjects (210 eyes)
- OK group: 45 patients (90 eyes)
- Control (spectacles) group: 60 patients (120 eyes)
- Axial length was measured at baseline and after 2 years

RESULTS
- At baseline
  - SE: $2.55 \pm 1.82 \text{ D (OK)} / 2.59 \pm 1.66 \text{ D (control)}$
  - axial length: $24.66 \pm 1.11 \text{ mm (OK)} / 24.79 \pm 0.80 \text{ mm (control)}$
- The increase in axial length: $0.39 \pm 0.27 \text{ mm (OK)} / 0.61 \pm 0.24 \text{ mm (control)}$

CONCLUSIONS
- OK suppressed axial elongation in myopic children.
- OK can slow the progression of myopia to a certain extent.
# Mean Changes in Axial Length (AL) in Orthokeratology (OK) Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Control (mm)</th>
<th>OK (mm)</th>
<th>Difference (mm)</th>
<th>Reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LORIC (2006)</td>
<td>0.54</td>
<td>0.29</td>
<td>0.25</td>
<td>46</td>
</tr>
<tr>
<td>CRAYON (2009)</td>
<td>0.57</td>
<td>0.25</td>
<td>0.32</td>
<td>56</td>
</tr>
<tr>
<td>ROMIO (2011)</td>
<td>0.63</td>
<td>0.36</td>
<td>0.27</td>
<td>43</td>
</tr>
<tr>
<td>TO-SEE (2011)</td>
<td>0.36</td>
<td>0.18</td>
<td>0.18</td>
<td>50</td>
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<tr>
<td>Kakita (2011)</td>
<td>0.61</td>
<td>0.39</td>
<td>0.22</td>
<td>36</td>
</tr>
<tr>
<td>MCOS (2011)</td>
<td>0.70</td>
<td>0.47</td>
<td>0.23</td>
<td>33</td>
</tr>
</tbody>
</table>
Emmetropization (正視化)

- Zero-out refractive errors
- Mechanisms
  - Genetic
  - Visual experience
    - Active feedback
      - Responsible areas
      - Fovea
      - Peripheral Retina
  - End result:
    - Emmetropization
    - Myopia: Short habitual viewing distance
Responsible areas for active feedback

- **Fovea**
  - Small area

- **Peripheral retina**
  - **Theory**
    - Defocus in peripheral retina (RPRE, relative peripheral refractive errors) controls ocular growth rate
    - Relative peripheral hyperopia $\rightarrow$ myopia
    - Relative peripheral myopia $\rightarrow$ hyperopia
  - **Concepts** dates back 40 years ago
    - Hoogerheide, 1971
  - **Recent interest**
    - Shiedemann, 2002 $\sim$ present
Role of peripheral refraction

- Identify patients at risk of developing myopia
- Propose treatments
  - Toberner, 2009
    - Conventional lens designs induce significant relative hyperopia in periphery
  - Design spectacles to introduce peripheral myopia
    - Ex. RRG lens (Radial Refractive Gradient Spectacles)

The “Image Shell” With Correction

Positive Curvature of Field

Spectacle or Contact Lenses
Peripheral retina can play an important role in modulating overall eye growth and axial refraction

- Infant monkeys
  - Diffuser with central aperture
    - Central vision intact
    - Developed ametropic axial refractive errors
  - Ablation of central 10° diameter of retina (intact periphery)
    - Result in emmetropia
  - Hyperopic defocus beyond 10° of fovea (intact central 10°)
    - Result in myopia
Peripheral refraction after OK in myopes
Queirós/Optom Vis Sci 2010;87:323-329

- 28 eyes, 24.6 ±6.3 yo
- Paragon, CRT
- Open-field Grand Seiko Auto-refractometer
- Studies change in off-axis refraction induced by OK
  - Central 40°: myopia ↓
  - At 25°: no effect on M
  - Beyond 25°: myopia ↑
How does ortho-k retard axial elongation in myopia?

- Ortho-k fully corrects the central refraction
- Leaves myopic RPRE
  - Prevent hyperopic RPRE from acting as a stimulus for ocular growth
Refractive methods that alters RPRE

- **Ideal solution**
  - Correct axial myopia
  - Introduces peripheral myopia

- **Current methods**:
  - LASIK/PRK
  - Contact lenses
    - Orthokeratology

- **New frontiers**
  - Spectacles
    - MyoVision (Zeiss) ↓ 30%
  - Dual-Focus Soft Contact Lens
    - MiSight (CooperVision): 70% children → ↓ 30%
Effect of Dual-Focus Soft Contact Lens Wear on Axial Myopia Progression in Children
Nicola S. Anstice / Ophthalmology 2011; 118: 1152-1161

<table>
<thead>
<tr>
<th></th>
<th>With SVD Lens</th>
<th>P</th>
<th>With DF Lens</th>
<th>DF, SVD Difference</th>
<th>Percent Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Period 1: Baseline to 10 Months</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Change in refraction (D)</td>
<td>-0.69±0.38</td>
<td>&lt;0.0001</td>
<td>-0.44±0.33</td>
<td>0.25±0.27</td>
<td>37%</td>
</tr>
<tr>
<td>Eye elongation (mm)</td>
<td>0.218±0.089</td>
<td>&lt;0.0001</td>
<td>0.111±0.084</td>
<td>0.107±0.080</td>
<td>49%</td>
</tr>
<tr>
<td><strong>Period 2: Cross-over to 20 Months</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in refraction (D)</td>
<td>-0.38±0.38</td>
<td>0.003</td>
<td>-0.17±0.35</td>
<td>0.20±0.34</td>
<td>54%</td>
</tr>
<tr>
<td>Eye elongation (mm)</td>
<td>0.144±0.093</td>
<td>&lt;0.0001</td>
<td>0.029±0.100</td>
<td>0.115±0.099</td>
<td>80%</td>
</tr>
</tbody>
</table>

DF = Dual-Focus; SVD = single vision distance.
Decrease in Rate of Myopia Progression with a Contact Lens Designed to Reduce Relative Peripheral Hyperopia

Padmaja Sankaridurg, Earl Smith III / IOVS. 2011;52: 9362–9367

Correction

Treatment

![Graph showing change in myopia progression with contact lenses](image)

<table>
<thead>
<tr>
<th>Novel Contact Lens Group</th>
<th>Spectacle Group</th>
<th>P</th>
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<tbody>
<tr>
<td>(n = 45)</td>
<td>(n = 40)</td>
<td></td>
</tr>
<tr>
<td>Age, y</td>
<td>11.6 ± 1.5</td>
<td>10.8 ± 1.9</td>
</tr>
<tr>
<td>Girls/boys, %</td>
<td>51.49</td>
<td>45.5</td>
</tr>
<tr>
<td>Parental myopia, %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>37.8</td>
<td>32.5</td>
</tr>
<tr>
<td>≥1 parent</td>
<td>62.2</td>
<td>67.5</td>
</tr>
<tr>
<td>Baseline M, D</td>
<td>-2.21 ± 0.79</td>
<td>-1.99 ± 0.62</td>
</tr>
<tr>
<td>Baseline J0, D</td>
<td>0.04 ± 0.19</td>
<td>0.18 ± 0.16</td>
</tr>
<tr>
<td>Baseline 115, D</td>
<td>-0.01 ± 0.14</td>
<td>-0.03 ± 0.13</td>
</tr>
<tr>
<td>Baseline axial length, mm</td>
<td>24.57 ± 0.77</td>
<td>24.57 ± 0.93</td>
</tr>
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Conclusions

- Visual experience after birth affects refractive development and helps most eyes to approximate to emmetropia.
- Animal studies suggest that the control of emmetropization is at the level of retina and CNS.
- Peripheral retina can play an important role in modulating overall eye growth and axial refraction.
- In human eyes, prolate eye shape (i.e. hyperopic relative peripheral refractive error) is associated with myopic progression. Alteration of the peripheral refraction using OK has shown to retard ocular growth.
- With advances in topography and auto-refractor, measurement of peripheral refraction will become more predictable.
- Old and new design of lenses that showed efficacy in altering peripheral refraction (induce relative peripheral myopia) may provide more option for better control of myopic progression.
Procedures of prescribing Orthokeratology

- Over 90% patients with BCVA over then 20/25

- Topical anesthesia
  (central thickness 0.22 mm and peripheral lens thickness)

1. Lens diameter
   cornea diameter – 1mm [0.5 mm each side]
   (9.6mm – 11.6mm)
2. Select AC

AC = astigmatism
-1.5 ≤ average K + 0.4
> -1.75 ≤ average K + 0.35

The difference of flattest k and steepest k
< 0.3D ≤ average K + 0.4
> 0.3D ≤ average K + 0.35

PD = 53mm

KRT. DATA

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<tr>
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<tbody>
<tr>
<td>&lt;R&gt;</td>
<td>D</td>
<td>MM</td>
<td>A</td>
</tr>
<tr>
<td>H</td>
<td>42.25</td>
<td>7.99</td>
<td>170</td>
</tr>
<tr>
<td>V</td>
<td>43.50</td>
<td>7.78</td>
<td>80</td>
</tr>
<tr>
<td>AVE</td>
<td>42.75</td>
<td>7.89</td>
<td></td>
</tr>
<tr>
<td>CYL</td>
<td>-1.25</td>
<td>170</td>
<td></td>
</tr>
<tr>
<td>&lt;L</td>
<td>D</td>
<td>MM</td>
<td>A</td>
</tr>
<tr>
<td>H</td>
<td>42.50</td>
<td>7.96</td>
<td>15</td>
</tr>
</tbody>
</table>
AC too steep
Change trial lens

- Large lens diameter
- Too loose
- Too tight
- Too tight
Conclusions

• Providing acceptable vision during daily life.

• Delay progression of myopia

• High myopia patients benefited more from OK lenses than did the low myopia patients.

• Decrease contrast sensitivity

• Decrease night vision and increase glare
Take Home Messages

- Proper fitting with trial lens system improves the successful rate
- Regular follow and lens care instruction avoid unwanted complications
- Topography is useful to evaluate the cause of unacceptable vision
- Proper fitting with good visual acuity slows the myopia progression before adulthood
- Key of success - centration, centration and centration
MY TWELVE YEARS EXPERIENCE WITH ORTHOKERATOLOGY
Selection of Patient

- Myopia < -4.0
- Astigmatism < -2.0
- Keratometry > 42.0
- Rapid progression myope, early onset myope
角膜屈度與鏡片含蓋率

<table>
<thead>
<tr>
<th></th>
<th>40.0D ～ 42.25</th>
<th>95% ～ 97%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>42.5 ～ 43.75D</td>
<td>93% ～ 95%</td>
</tr>
<tr>
<td></td>
<td>＞ 44D</td>
<td>92% ～ 94%</td>
</tr>
</tbody>
</table>

※ High astigmatism

↑ Size
Follow-Up

Schedule

- Next (few) day(s): with lens on
- One week
- Two weeks
- One month
- Every three months
- VA_{C C} (Lens on) + time record
- Marginal blepharitis
- Wearing days/week
- Inspection of Lens, every visit
Renew Lens

1.5 years ~ 2 years

Original prescription is ok?

↑ Size

Flattening fitting

VA  c  C  ortho-k lens
患者5 ~ 41歳統計資料

1999年8月 ~ 2012年3月

Age: 5 ~ 41歳

Male: 212人, Female: 288人, Total: 500人

Myopia: -1.0 ~ -10.25D

Astigmatism: 0 ~ -4.00D

Loss of following: 96
患者5~41歳統計表

總人數：404人
Birthday: 89.04.07
1st Visit corneal problem ĉ ortho-k lens wearing
2nd Visit ĉ ortho-k lens on
Movement OD + (OS) Seal - Off
Va ĉ C OD : 1.0 x -1.0
Va ĉ C OS : 1.0 x +2.0
Original
Va ĉ C OD : 1.0 x -3.00 / -0.5 x 60°
Va ĉ C OS : 1.0 x -3.25 / -0.5 x 110°
KM
OD : 8.28@14° 8.15@104°
OS : 8.29@170° 8.24@80°
OS : T -3.50 / 848 / 10.6
  
OS : T -3.50 / 853 / 10.6
  
OS : T -4.50 / 858 / 10.6 \(\rightarrow +2.0\)

Trial Lens:
  864\(\rightarrow\) temporal corneal infiltrate

  868\(\rightarrow\) still to tight

Order 870 \(\rightarrow\) OK
Birthday: 91.04.30
Date: 100.02.28

Već C OD: 1.0 x -5.25 / -1.25 x 170°
Već C OS: 1.0 x -4.75 / -2.75 x 170°
KM: OD: 46.02@60° 44.15@150°
     OS: 46.24@87° 43.38@177°
K: Size: 11.6
Lens Order
   OD: -6.25 / 45.00 / 10.8
   OS: -6.25 / 44.75 / 10.8

   OS: poor VA

TVRM
   OS: -5.25 Astigmatism → Tighten → Worse → Enlarge Lens size to 11.2 (97%) ➞ ( TVRM Astigmatism ↓ -2.25 )
改變FK對配適的影響

FK太緊

- 太緊導致矯正區接觸不到角膜，或接觸面積小
- RC下方淚液多
- AC與角膜貼得很緊
- PC翹角小

FK理想

- 矯正區接觸適中
- AC 360度貼合角膜
- PC翹角適中

FK太鬆

- 矯正區接觸面積過大
- RC下方淚液少
- AC無法貼合角膜，淚液堆積，定位不佳
- PC翹起過高

美夢夜戴型角膜塑型片
Dreimlens Overnight Orthokeratology contact lens
過緊的配適

RC出現微笑型氣泡
- RC部分與角膜空隙過大，淚液層無法
  填滿，形成大氣泡
- 矯正區不明顯
- PC過細

解決方法：
- 確定直徑適合
- FK平0.50D
- TP增加-0.50D
- 見「直徑選擇錯誤形成之RC氣泡」
過鬆的配適

- 幾乎看不到RC、PC
- 鏡片偏位
- 中央區接觸明顯
- AC淚液堆積

解決方法:
- 確認直徑正確，是否太小？
- FK 改陡
- 圖見下頁
IV. 最新發展

Dual Axis 雙軸式設計
當藉由角膜地形圖、角膜弧度儀、電腦驗光...等儀器的檢測發現患者具有高角膜散光時，使用標準設計可能看到鏡片定位不佳導致較差的矯正效果

標準設計

Dual-axis設計
雙軸式散光設計

* 雙軸式設計從鏡片的RC弧開始，可依照患者的平K及陡K值，量身訂作符合患者角膜弧度的鏡片。
* 由於此特殊的雙軸設計，RC弧會呈現橢圓形（垂直及水平的寬度不同）

![Dual-Axial Design](image)

Steeper Zone

Spherical
Optical Zone

Flatter Zone

Dual-Axial Design
案例分享

■ 角膜弧度資料

R: -4.75-1.75*180
FK: 42.50 D SK: 45.20 D
Cyl: -2.70 D * 177
L: -5.25-1.75*009
FK: 42.85 D SK: 45.35 D
Cyl: -2.50 D * 008

■ Trial LENS (Stand V.S Dual axis)

■ 標準 (Stand) ： R: FK: 42.50 D TP: -4.50 D DIA: 10.6

L: FK: 43.00 D TP: -5.50 D DIA: 10.6

■ 散光 (Dual axis) ： R: FK: 42.50 D TP: -4.50 D DIA: 10.6，Cyl: -3.00 D

L: FK: 43.00 D TP: -5.50 D DIA: 10.6，Cyl: -2.50 D
配戴比較

右眼
角膜散光：-2.75D

* 第一組配戴標準設計鏡片

左眼
角膜散光：-2.50D

* 第二組配戴 Dual Axis 設計鏡片

右眼

左眼