Photorefractive keratectomy for myopic anisometropia: A retrospective study on 18 children

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INTRODUCTION

Uncorrected myopic anisometropia in childhood frequently leads to amblyopia.

Traditional treatments to correct refractive errors in children with myopic anisometropia include the use of spectacles and contact lenses together with amblyopia occlusion therapy; contact lenses, while achieving better vision quality and reducing amblyogenic stimuli compared to glasses, are expensive, frequently lost by children, and can give rise to intolerance (1, 2).

Correction of the refractive error with excimer laser is a promising alternative therapy that has been explored over recent years. Few studies have been published regarding the correction of myopic anisometropia under topical anesthesia in pediatric patients (3-6).

This retrospective study presents the results obtained by treating unilateral myopia in awake, autofixating pediatric and adolescent patients, with photorefractive keratectomy (PRK).

METHODS

Eighteen young patients (9 male and 9 female, 18 eyes) with medium to high unilateral myopia were included in
this study; the mean age of the patients at the time of re-
fractive surgery was 10.1 years (range 7–17). All patients
underwent PRK between 2002 and 2006 for myopic anis-
ometropia.
Inclusion criteria were anisometropia of at least 3 diopters
(D); stability of refractive error for a minimum of 2 years;
reduced compliance with glasses or contact lenses; am-
blyopia in the eye with greater refractive error (best spec-
tacle-corrected visual acuity [BSCVA] less than 3 lines of
logMAR in the amblyopic eye compared to the other); un-
der age 18 at time of surgery; minimum follow-up of 18
months.
Patients presenting pathologies or abnormalities of the
cornea, lens, or posterior segment were excluded.
Preoperative and postoperative evaluations included un-
corrected visual acuity (UCVA) and BSCVA, transformed
to logMAR for data analysis and back converted after log-
MAR analysis as Snellen mean); manifest refraction and
cycloplegic retinoscopy (one drop of cyclopentolate and
1% tropicamide three times every 15 minutes); ocular
alignment (prism and cover testing in all gaze positions); a
stereoscopic examination (synoptophore, Bagolini test,
Worth 4 dot test, Titmus, and TNO stereotests); corneal
pachymetry and topography; anterior and posterior seg-
ment inspection; and intraocular pressure measurement.
In order to increase concentration and fixation of patients
≤11 years of age: 1) the day before surgery the patients
and their parents were shown a short film illustrating all
the steps of the surgical procedure, and each stage was
fully explained by a doctor and orthoptist; 2) at the same
meeting the patient was instructed on the importance of
maintaining fixation by means of simulations with video
games; 3) on operation day the patients were stimulated
and engaged throughout surgery by the surgeon’s expla-
nations and descriptions of the surgical procedure.
In all patients PRK procedures were performed with a
Technolas excimer laser model 217-C from Bausch and
Lomb. Epithelium was removed by alcohol delamination.
Both cycloplegic and manifest refractions were used to
calculate surgical parameters and the correction target;
the treatment objective in all patients was the reduction of
anisometropia to under 2 D. The same surgeon (A.M.)
performed all the procedures.
All surgical procedures were conducted under topical
anesthesia induced by the instillation of 2% oxybupro-
caine or 2% lidocaine ophthalmic solution. Written in-
formed consent was provided by all patients or their par-
ents in the case of minors. All procedures were carried
out in accordance with the Declaration of Helsinki.
After laser treatment, the patients were kept in a semi-
dark room for 24 hours, they wore contact lenses until the
corneal epithelium healed, and were medicated for 1
week with three drops daily each of netilmicin sulphate,
for 2 weeks with three drops daily each of fluo-
rometholone, and for 1 month with six drops daily of sodi-
um hyaluronate ophthalmic solution.
The patients were examined daily until the corneal ep-
ithelium healed, after which they were seen 1 week, 2
weeks, 1 month, 3 months, 6 months, 1 year, and every
year thereafter. Postoperative data reported in Results
and Tables refer to the last office visit.
Statistical evaluation was performed using t-test; p values
< 0.05 were considered statistically significant.

RESULTS
Mean follow-up was 39 months (range 18–65 months).
Demographic data are shown in Table I. Preoperative and
postoperative results regarding visual acuity, cycloplegic
refraction, strabismus, and binocular vision are reported
in Tables II and III.
The mean preoperative UCVA in all myopic eyes was
20/100 (range 20/400–20/50); mean postoperative UCVA
was 20/73 (range 20/200–20/22); the mean preoperative
BSCVA was 20/70 (range 20/200–20/30); mean postoper-
ative BSCVA was 20/50 (range 20/100–20/22).
Preoperative UCVA and postoperative UCVA were found
to be significantly different (p<0.001). A significant differ-
ce was also found between the arithmetic mean of pre-
operative and postoperative BSCVA (p<0.001). A statisti-
cally significant difference was also observed between the
preoperative BSCVA and the postoperative UCVA
(p=0.007).
The mean preoperative cycloplegic refraction in the af-
fected eyes was –8.70 D (spherical equivalent, SE; range
–2.25 to –16.75; standard deviation [SD] 3.90). Postopera-
tively, the mean cycloplegic refraction was –0.50 (range
–2.50 to plano, SD 0.85). The difference between the two
means was clearly significant (p<0.001). The mean cor-
rection (SE) achieved by excimer laser procedure was
–8.21 D (range –2.25 to –14.50; SD 3.34 D).
As regards ocular alignment, preoperatively 5 patients
(27.8%) were orthophoric, 6 patients (33.3%) presented
exotropia, 4 patients (22.2%) intermittent exotropia, 1 pa-
tient (5.6%) exophoria, 1 patient (5.6%) esotropia, and 1
PRK for myopic anisometropia

Patient (5.6%) intermittent esotropia. Postoperatively 7 patients (38.9%) were orthophoric, 6 patients (33.3%) presented exotropia, 1 patient (5.6%) intermittent exotropia, 2 patients (11.1%) exophoria, 2 patients (11.1%) esotropia. Of 12 patients in which ocular alignment remained unvaried, 7 were strabismic before and after the surgery: in 5 of the latter, a reduction of the strabismus angle was observed. Figure 1 and Tables II and III report details of the strabismus modifications.

Regarding binocular vision (BV), 9 patients (50%) before PRK did not present BV, 1 patient (5.6%) had fusion, and 8 patients (44.4%) presented a stereopsis <200 seconds of arc. After PRK procedure, 7 patients (38.9%) did not present BV, 1 patient (5.6%) had fusion, 2 patients (11.1%) presented a stereopsis >200 seconds of arc, and 8 patients (44.4%) a stereopsis <200 seconds of arc. In 16 patients (88.9%) the BV remained unvaried after surgery. Two patients (11.1%) who did not have BV preoperatively showed gross stereopsis postoperatively (Fig. 2, Tabs. II and III).

The mean time for complete healing of the corneal defect was 46 hours (range 24–72). The corneal epithelium healed in 24 hours in 5 patients (28%), in 48 hours in 9 patients (50%), and in 72 hours in 4 patients (22%). No intraoperative complications developed. No infection or unexpected refractive results occurred. All the patients

TABLE I - DEMOGRAPHIC DATA AND PREOPERATIVE CORRECTION OF 18 PATIENTS WITH MYOPIC ANISOMETROPIA TREATED WITH EXCIMER LASER

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age at treatment, yrs</th>
<th>Sex</th>
<th>Follow-up, mo</th>
<th>Preoperative correction</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>9</td>
<td>F</td>
<td>23</td>
<td>-10.00 –1.00 x 70</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>F</td>
<td>18</td>
<td>-16.00 –1.50 x 35</td>
</tr>
<tr>
<td>3</td>
<td>17</td>
<td>F</td>
<td>24</td>
<td>-8.00 –2.75 x 25</td>
</tr>
<tr>
<td>4</td>
<td>9</td>
<td>M</td>
<td>36</td>
<td>-8.50 –1.50 x 10</td>
</tr>
<tr>
<td>5</td>
<td>9</td>
<td>M</td>
<td>34</td>
<td>-4.00 –0.50 x 110</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>M</td>
<td>39</td>
<td>-10.00 –2.00 x 20</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>M</td>
<td>40</td>
<td>-3.75 –2.50 x 5</td>
</tr>
<tr>
<td>8</td>
<td>7</td>
<td>M</td>
<td>48</td>
<td>-14.00 –1.75 x 135</td>
</tr>
<tr>
<td>9</td>
<td>7</td>
<td>F</td>
<td>52</td>
<td>-12.00 –0.50 x 20</td>
</tr>
<tr>
<td>10</td>
<td>8</td>
<td>F</td>
<td>27</td>
<td>-6.75 –1.00 x 8</td>
</tr>
<tr>
<td>11</td>
<td>9</td>
<td>F</td>
<td>54</td>
<td>-9.00 –1.50 x 20</td>
</tr>
<tr>
<td>12</td>
<td>9</td>
<td>M</td>
<td>24</td>
<td>-3.50 –0.50 x 10</td>
</tr>
<tr>
<td>13</td>
<td>16</td>
<td>F</td>
<td>34</td>
<td>-4.25 x 5</td>
</tr>
<tr>
<td>14</td>
<td>8</td>
<td>M</td>
<td>65</td>
<td>-11.50 –1.50 x 170</td>
</tr>
<tr>
<td>15</td>
<td>8</td>
<td>F</td>
<td>50</td>
<td>-6.00</td>
</tr>
<tr>
<td>16</td>
<td>15</td>
<td>F</td>
<td>50</td>
<td>-7.25 –1.25 x 160</td>
</tr>
<tr>
<td>17</td>
<td>9</td>
<td>M</td>
<td>48</td>
<td>-5.75</td>
</tr>
<tr>
<td>18</td>
<td>11</td>
<td>M</td>
<td>36</td>
<td>-7.00 –1.25 x 20</td>
</tr>
</tbody>
</table>
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tolented the laser procedure well and achieved good centration with self-fixation. There was no decentration greater than 1 mm. Mean decentration was 0.19 mm (range 0–0.65). This occurred in 10 out of 18 patients (56%). No decentration occurred in the remaining 8 patients (44%). No patients developed +2 or +3 corneal haze. Patients 2, 8, and 14 reported low grade corneal haze (+1) lasting up to 6 months following the procedures:

### TABLE II - PREOPERATIVE DATA

<table>
<thead>
<tr>
<th>Patient</th>
<th>Cycloplegic refraction, diopters, SE</th>
<th>UCVA</th>
<th>BSCVA</th>
<th>Binocular vision</th>
<th>Strabismus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>–10.50</td>
<td>20/200</td>
<td>20/50</td>
<td>Stereopsis &lt;200 sec of arc</td>
<td>XT</td>
</tr>
<tr>
<td>2</td>
<td>–16.75</td>
<td>20/300</td>
<td>20/100</td>
<td>Stereopsis &lt;200 sec of arc</td>
<td>iXT</td>
</tr>
<tr>
<td>3</td>
<td>–9.50</td>
<td>20/50</td>
<td>20/70</td>
<td>Stereopsis &gt;200 sec of arc</td>
<td>Ortho</td>
</tr>
<tr>
<td>4</td>
<td>–9.25</td>
<td>20/200</td>
<td>20/70</td>
<td>No BV</td>
<td>iXT</td>
</tr>
<tr>
<td>5</td>
<td>–4.25</td>
<td>20/50</td>
<td>20/30</td>
<td>Stereopsis &lt;200 sec of arc</td>
<td>X(T)</td>
</tr>
<tr>
<td>6</td>
<td>–11.00</td>
<td>20/200</td>
<td>20/100</td>
<td>No BV</td>
<td>XT</td>
</tr>
<tr>
<td>7</td>
<td>–5.00</td>
<td>20/70</td>
<td>20/50</td>
<td>Stereopsis &lt;200 sec of arc</td>
<td>Ortho</td>
</tr>
<tr>
<td>8</td>
<td>–15.00</td>
<td>20/200</td>
<td>20/200</td>
<td>No BV</td>
<td>XT</td>
</tr>
<tr>
<td>9</td>
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<td>20/300</td>
<td>20/70</td>
<td>No BV</td>
<td>ET</td>
</tr>
<tr>
<td>10</td>
<td>–7.25</td>
<td>20/200</td>
<td>20/70</td>
<td>Fusion</td>
<td>iET</td>
</tr>
<tr>
<td>11</td>
<td>–9.75</td>
<td>20/200</td>
<td>20/100</td>
<td>No BV</td>
<td>Ortho</td>
</tr>
<tr>
<td>12</td>
<td>–3.75</td>
<td>20/100</td>
<td>20/50</td>
<td>No BV</td>
<td>XT</td>
</tr>
<tr>
<td>13</td>
<td>–2.25</td>
<td>20/300</td>
<td>20/100</td>
<td>Stereopsis &lt;200 sec of arc</td>
<td>Ortho</td>
</tr>
<tr>
<td>14</td>
<td>–12.25</td>
<td>20/200</td>
<td>20/100</td>
<td>No BV</td>
<td>XT</td>
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<tr>
<td>15</td>
<td>–6.00</td>
<td>20/400</td>
<td>20/200</td>
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<td>XT</td>
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<tr>
<td>16</td>
<td>–8.00</td>
<td>20/300</td>
<td>20/100</td>
<td>Stereopsis &lt;200 sec of arc</td>
<td>Ortho</td>
</tr>
<tr>
<td>17</td>
<td>–5.75</td>
<td>20/200</td>
<td>20/33</td>
<td>No BV</td>
<td>iXT</td>
</tr>
<tr>
<td>18</td>
<td>–8.00</td>
<td>20/200</td>
<td>20/40</td>
<td>Stereopsis &lt;200 sec of arc</td>
<td>iXT</td>
</tr>
</tbody>
</table>

SE = Spherical equivalent; UCVA = Uncorrected visual acuity; BSCVA = Best spectacle-corrected visual acuity; XT = Exotropia; iXT = Intermittent exotropia; ortho = Orthophoric; BV = Binocular vision; X(T) = Exophoria; ET = Esotropia; iET = Intermittent esotropia

### TABLE III - LAST VISIT POSTOPERATIVE DATA

<table>
<thead>
<tr>
<th>Patient</th>
<th>Cycloplegic refraction, diopters, SE</th>
<th>UCVA</th>
<th>BSCVA</th>
<th>Binocular vision</th>
<th>Strabismus</th>
</tr>
</thead>
<tbody>
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<td>20/70</td>
<td>20/40</td>
<td>Stereopsis &lt;200 sec of arc</td>
<td>X(T)</td>
</tr>
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<td>2</td>
<td>–2.25</td>
<td>20/100</td>
<td>20/60</td>
<td>Stereopsis &lt;200 sec of arc</td>
<td>X(T)</td>
</tr>
<tr>
<td>3</td>
<td>–1.00</td>
<td>20/70</td>
<td>20/50</td>
<td>Stereopsis &lt;200 sec of arc</td>
<td>Ortho</td>
</tr>
<tr>
<td>4</td>
<td>Plano</td>
<td>20/50</td>
<td>20/50</td>
<td>No BV</td>
<td>Ortho</td>
</tr>
<tr>
<td>5</td>
<td>Plano</td>
<td>20/22</td>
<td>20/22</td>
<td>Stereopsis &lt;200 sec of arc</td>
<td>Ortho</td>
</tr>
<tr>
<td>6</td>
<td>–1.75</td>
<td>20/70</td>
<td>20/40</td>
<td>No BV</td>
<td>XT</td>
</tr>
<tr>
<td>7</td>
<td>Plano</td>
<td>20/40</td>
<td>20/40</td>
<td>Stereopsis &lt;200 sec of arc</td>
<td>Ortho</td>
</tr>
<tr>
<td>8</td>
<td>–2.50</td>
<td>20/200</td>
<td>20/100</td>
<td>No BV</td>
<td>XT</td>
</tr>
<tr>
<td>9</td>
<td>Plano</td>
<td>20/50</td>
<td>20/50</td>
<td>Stereopsis &lt;200 sec of arc</td>
<td>ET</td>
</tr>
<tr>
<td>10</td>
<td>Plano</td>
<td>20/50</td>
<td>20/50</td>
<td>Fusion</td>
<td>ET</td>
</tr>
<tr>
<td>11</td>
<td>Plano</td>
<td>20/100</td>
<td>20/100</td>
<td>No BV</td>
<td>Ortho</td>
</tr>
<tr>
<td>12</td>
<td>Plano</td>
<td>20/33</td>
<td>20/33</td>
<td>No BV</td>
<td>XT</td>
</tr>
<tr>
<td>13</td>
<td>Plano</td>
<td>20/70</td>
<td>20/70</td>
<td>Stereopsis &lt;200 sec of arc</td>
<td>Ortho</td>
</tr>
<tr>
<td>14</td>
<td>Plano</td>
<td>20/70</td>
<td>20/70</td>
<td>No BV</td>
<td>XT</td>
</tr>
<tr>
<td>15</td>
<td>Plano</td>
<td>20/70</td>
<td>20/70</td>
<td>No BV</td>
<td>XT</td>
</tr>
<tr>
<td>16</td>
<td>Plano</td>
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<td>20/100</td>
<td>Stereopsis &lt;200 sec of arc</td>
<td>Ortho</td>
</tr>
<tr>
<td>17</td>
<td>Plano</td>
<td>20/22</td>
<td>20/22</td>
<td>Stereopsis &gt;200 sec of arc</td>
<td>iXT</td>
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<tr>
<td>18</td>
<td>Plano</td>
<td>20/22</td>
<td>20/22</td>
<td>Stereopsis &lt;200 sec of arc</td>
<td>XT</td>
</tr>
</tbody>
</table>

SE = Spherical equivalent; UCVA = Uncorrected visual acuity; BSCVA = Best spectacle-corrected visual acuity; X(T) = Exophoria; ortho = Orthophoric; BV = Binocular vision; XT = Exotropia; ET = Esotropia; iXT = Intermittent esotropia
### DISCUSSION

Myopia is a common refractive error in childhood. Traditionally it is corrected by glasses or contact lenses; they achieve better results in bilateral refractive errors than in unilateral ones. Spectacles are often much less well tolerated in unilateral myopia due to the formation of images of different sizes in the two eyes as well as optical aberrations. Aniseikonia causes a loss of binocular vision and amblyopia in the affected eye. Conventional amblyopia therapy included patching of the dominant eye; this is often not accepted by children. Contact lenses, on the other hand, create neither smaller images nor aberrations, and thus eliminate the stimuli that lead to amblyopia. However, they are often lost by children, causing discontinuity of the amblyopia therapy as well as creating an increase in costs to the family. Furthermore, continued use creates lens intolerance in some children (1, 2).

Refractive surgery offers promising results for these patients; the procedure has developed markedly and become much more widespread since the mid 1990s, when surgeons first began to obtain good results in the treatment of unilateral myopia in pediatric patients by means of PRK (7-9). Numerous studies have been carried out over the last decade; these are reported in Table IV. On the whole, these confirmed the good results obtained by the preceding articles both in terms of safety and efficacy in children (10-16).

In our study PRK is conducted under topical anesthesia. Few studies in the literature have adopted this modality for pediatric patients. (3-6) Nucci et al examined 14 eyes of 14 patients aged between 9 and 14 (mean 11.9 years): 11 patients underwent PRK and 3 LASIK, all under local anesthesia. The mean follow-up was 20 months. Mean preoperative refraction was –7.96 D, and postoperatively the mean was –0.67 D. Five out of 14 patients gained one or more lines of vision; no patient lost any. The authors conclude that both PRK and LASIK can be performed safely and effectively under topical anesthesia in cooperative children (3).

Phillips et al (4) used LASIK alone to correct myopic anisometropia in five patients between 8 and 19 years of age (mean 13.1 years); the follow-up was 18 months. Mean preoperative refraction was –9.05 D and mean postoperative refraction was –1.17 D. The vision of two out of five patients improved by one line of vision. The authors conclude that LASIK therapy of both myopia and hyperopia was effective (4). Autrata and Rehurek report their experience in myopic anisometropia treated by PRK on 21 patients. The mean preoperative refraction was –9.05 D and mean postoperative refraction was –1.17 D. The vision of two out of five patients improved by one line of vision. The authors conclude that LASIK therapy of both myopia and hyperopia was effective (4).

Our study confirms the safety of PRK in children between the ages of 7 and 17: no intraoperative or postoperative
complications occurred. At the last office visit none of the 18 patients presented a corneal haze serious enough to lose one or more Snellen lines. Despite the difficulty in fixation that patients with elevated myopic anisometropia experience, we did not observe a decentration greater than 0.60 mm in the 10 patients (56%) in whom it was present. Mean decentration was 0.19 mm: we believe that this result is attributable to the communication strategies, carried out before and during surgery with the aim of increasing the cooperation and concentration of the younger patients (³11 years, 14 patients). Overall, greater cooperation was received from the latter with respect to the older patients.

A significant difference between the UCVA assessed pre- and postoperatively emerges from the data regarding visual acuity; the BCSVA is markedly improved after surgery. This is due to the better correction obtained by refractive surgery with respect to glasses. In this regard, Autrata and Rehurek compared results obtained by conventional myopic anisometropia therapy (glasses and contact lenses) with those obtained by surgical therapies (laser-assisted subepithelial keratectomy, LASEK, and PRK). The authors conclude that PRK and LASEK are sufficient and safe in myopic anisometropia therapy and in amblyopia reduction in children between the ages of 4 and 7. The results for visual acuity and binocular vision obtained by refractive surgery are better than those obtained by traditional therapies (13). In our study, the improvement in BSCVA was inversely proportional to surgical age and the extent of the preoperative error.

Interestingly, in 2 out of the 18 patients (11.1%; Patient 9, age 7, and Patient 17, age 9), the refractive surgery brought about an improvement in their stereopsis. In agreement with Phillips et al (4), we confirm that an improvement in stereopsis is possible in patients under the age of 10 years; despite this, none of the remaining seven patients who did not present BV before surgery and who were under 10 years of age reported improvement in binocular vision.

Few studies exist in the literature to date that report strabismus modifications following excimer laser therapy. Paysse et al study eight patients with myopic anisometropia. Of these, five are orthotropic both before and after surgery; one patient with esotropia reports a reduction in the angle of strabismus; in one patient the esotropia becomes intermittent, and one patient, orthotropic preoperatively, presents flick esotropia postoperatively (15). In our study, strabismus remained unchanged in 2/3 of the patients (12 out of 18); in the remaining third there was some modification, which in five patients was an improvement. However, Patient 18, who had an intermittent exotropia, became exotropic after PRK. This could be attributable to the emergence of a latent tropia due to over-correction of the refraction error by excimer laser.

Our study confirms the findings of Paysse et al (16) and Nucci and Drack (3) that corneal epithelium healing is more rapid in children than in adults. In 18 out of 18 patients (100%), the corneal epithelium healed within 72 hours.

In conclusion, the treatment of unilateral myopia with PRK under local anesthesia was effective and safe in pediatric and adolescent patients. This procedure may improve ocular alignment and stereopsis. Further studies are needed to increase the patient experience and extend follow-up time in order to assess the long-term stability of the results.

None of the authors has a financial or proprietary interest in any material or method mentioned.

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