European Journal of Ophthalmology / Vol. 18 no. 5, 2008 / pp. 716-722

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

A. MAGLI[1], A. IOVINE[1], V. GAGLIARDI[1], F. FIMIANI[1], P. NUCCI[2]

[1]Department of Ophthalmology, University of Napoli "Federico II", Napoli
[2]Department of Ophthalmology, San Paolo Hospital, University of Milano, Milano - Italy

PURPOSE. *To evaluate the safety and efficacy of photorefractive keratectomy (PRK) performed under topical anesthesia in children with myopic anisometropia.*
METHODS. *Medium to high unilateral myopia was corrected in 18 patients by PRK. At the time of surgery patients were between 7 and 17 years of age (mean 10 years). All the surgical procedures were performed under topical anesthesia. Pre- and postoperative data regarding visual acuity, eye alignment, and binocular vision were analyzed.*
RESULTS. *The mean correction (SE) obtained with excimer laser was –8.21 D (range: –2.25 to –14.50, SD 3.90). The mean preoperative best spectacle-corrected visual acuity (BSCVA) was 20/70, and the postoperative mean BSCVA was 20/50. A significant difference was observed between the arithmetic mean of the preoperative and postoperative BSCVA (p=0.001). Two of 18 patients improved stereopsis; furthermore, surgery variation strabismus was registered in 33.3% of the patients, following PRK. Patients were followed up for a mean of 39 months.*
CONCLUSIONS. *The treatment of medium to high unilateral myopia with PRK under local anesthesia was found 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. (Eur J Ophthalmol 2008; 18: 716-22)*

KEY WORDS. *Unilateral myopia, Myopic anisometropia, PRK, Photorefractive keratectomy*

Accepted: February 20, 2008

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

1120-6721/716-07$25.00/0

this study; the mean age of the patients at the time of refractive surgery was 10.1 years (range 7–17). All patients underwent PRK between 2002 and 2006 for myopic anisometropia.

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; amblyopia in the eye with greater refractive error (best spectacle-corrected visual acuity [BSCVA] less than 3 lines of logMAR in the amblyopic eye compared to the other); under 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 uncorrected visual acuity (UCVA) and BSCVA, transformed to logMAR for data analysis and back converted after logMAR 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 segment 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 explanations 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% oxybuprocaine or 2% lidocaine ophthalmic solution. Written informed consent was provided by all patients or their parents 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 fluorometholone, and for 1 month with six drops daily of sodium hyaluronate ophthalmic solution.

The patients were examined daily until the corneal epithelium 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 postoperative 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 difference was also found between the arithmetic mean of preoperative and postoperative BSCVA ($p<0.001$). A statistically significant difference was also observed between the preoperative BSCVA and the postoperative UCVA ($p=0.007$).

The mean preoperative cycloplegic refraction in the affected eyes was –8.70 D (spherical equivalent, SE; range –2.25 to –16.75; standard deviation [SD] 3.90). Postoperatively, 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 correction (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 patient (5.6%) exophoria, 1 patient (5.6%) esotropia, and 1

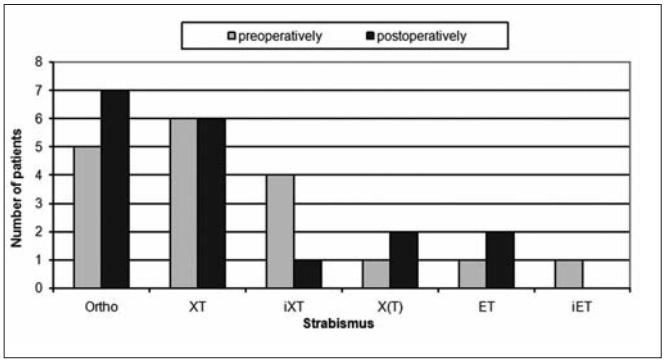

Fig. 1 - *Strabismus before and after photorefractive keratectomy. Ortho = orthophoric; XT = exotropia; iXT = intermittent exotropia; X(T) = exophoria; ET = esotropia; iET = intermittent esotropia.*

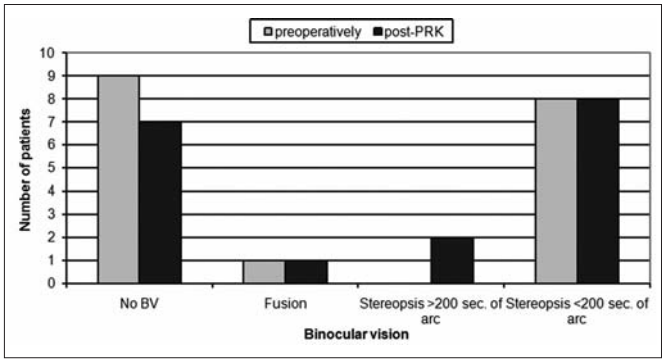

Fig. 2 - *Binocular vision before and after photorefractive keratectomy. BV = binocular vision.*

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

Patient	Age at treatment, yrs	Sex	Follow-up, mo	Preoperative correction
1	9	F	23	–10.00 –1.00 x 70
2	15	F	18	–16.00 –1.50 x 35
3	17	F	24	–8.00 –2.75 x 25
4	9	M	36	–8.50 –1.50 x 10
5	9	M	34	–4.00 –0.50 x 110
6	8	M	39	–10.00 –2.00 x 20
7	8	M	40	–3.75 –2.50 x 5
8	7	M	48	–14.00 –1.75 x 135
9	7	F	52	–12.00 –0.50 x 20
10	8	F	27	–6.75 –1.00 x 8
11	9	F	54	–9.00 –1.50 x 20
12	9	M	24	–3.50 –0.50 x 10
13	16	F	34	–4.25 x 5
14	8	M	65	–11.50 –1.50 x 170
15	8	F	50	–6.00
16	15	F	50	–7.25 –1.25 x 160
17	9	M	48	–5,75
18	11	M	36	–7.00 –1.25 x 20

tolerated 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

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

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

Patient	Cycloplegic refraction, diopters, SE	UCVA	BSCVA	Binocular vision	Strabismus
1	–1.25	20/70	20/40	Stereopsis <200 sec of arc	X(T)
2	–2.25	20/100	20/60	Stereopsis <200 sec of arc	X(T)
3	–1.00	20/70	20/50	Stereopsis <200 sec of arc	Ortho
4	Plano	20/50	20/50	No BV	Ortho
5	Plano	20/22	20/22	Stereopsis <200 sec of arc	Ortho
6	–1.75	20/70	20/40	No BV	XT
7	Plano	20/40	20/40	Stereopsis <200 sec of arc	Ortho
8	–2.50	20/200	20/100	No BV	XT
9	Plano	20/50	20/50	Stereopsis >200 sec of arc	ET
10	Plano	20/50	20/50	Fusion	ET
11	Plano	20/100	20/100	No BV	Ortho
12	Plano	20/33	20/33	No BV	XT
13	Plano	20/70	20/70	Stereopsis <200 sec of arc	Ortho
14	Plano	20/70	20/70	No BV	XT
15	Plano	20/70	20/70	No BV	XT
16	Plano	20/100	20/100	Stereopsis <200 sec of arc	Ortho
17	Plano	20/22	20/22	Stereopsis >200 sec of arc	iXT
18	Plano	20/22	20/22	Stereopsis <200 sec of arc	XT

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

TABLE IV - COMPARISON OF THE PRESENT STUDY WITH PREVIOUS STUDIES ON EXCIMER LASER TREATMENT OF MYOPIC ANISOMETROPIA

Author	Year	Country	No. of patients	Age range, yrs	Follow-up, mo	Surgical technique	Anesthesia	Anisometropia, diopters, SE	BV improvement	Strabismus improvement
Agarwal et al (10)	2000	India	16	5–11	12	LASIK	General	(–9.00 to –23.00)	NR	NR
Nucci and Drack (3)	2001	Italy	14	9–14	20	PRK/LASIK	Topical	(–5.25 to –10.50)	No	No
Astle et al (11)	2002	Canada	27	1–6	12	PRK	General	(–0.75 to –25.00)	Yes	NR
Autrata and Rehurek (5)	2003	Czech Republic	21	7–15	48	PRK	Topical	(–6.75 to –11.75)	Yes	NR
O'Keefe and Nolan (12)	2004	Ireland	6	2–12	24	LASIK	General	(–5.00 to –16.00)	NR	NR
Autrata and Rehurek (13)	2004	Czech Republic	27	4–7	24	PRK/LASEK	General	(–5.25 to –10.50)	Yes	NR
Phillips et al (4)	2004	USA	5	8–19	18	LASIK	Topical	(– 6.50 to –14.50)	Yes	NR
Tychsen et al (14)	2005	USA	35	4–16	29	PTK/PRK/LASEK	General	(–3.25 to –24.25)	Yes	NR
Paysse et al (15)	2006	USA	8	2–11	36	PRK	General	(–10.00 to –21.00)	Yes	Yes
Present study	2007	Italy	18	7–17	33	PRK	Topical	(–2.25 to –16.75)	Yes	Yes

SE = Spherical equivalent; BV = Binocular vision; LASIK = Laser in situ keratomileusis; NR = Not reported; PRK = Photorefractive keratectomy; LASEK = Laser-assisted subepithelial keratectomy; PTK = Phototherapeutic keratectomy

this was no longer detectable at the 1-year office visit. All patients expressed satisfaction with the results obtained.

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). Philips et al 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 –8.93 D, mean postoperative refraction was –1.66 D. Nine eyes gained one line of BSCVA and five eyes gained two lines. Thus the therapy was safe and effective (5).

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 (≤11 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 overcorrection 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.

Reprint requests to:
Prof. Adriano Magli
Dipartimento Scienze Oftalmologiche
Facoltà di Medicina e Chirurgia
Via Sergio Pansini, 5
80100 Napoli, Italy
magli@unina.it

REFERENCES

1. Collins JW, Carney LG. Visual performance in high myopia. Curr Eye Res 1990; 9: 217-23.
2. Freeman MI. Spectacles vs contact lenses in the correction of unilateral axial myopia. Arch Ophthalmol 1992; 110: 180.
3. Nucci P, Drack AV. Refractive surgery for unilateral high myopia in children. J AAPOS 2001; 5: 348-51.
4. Phillips CB, Prager TC, McClellan G, Mintz-Hittner HA. Laser in situ keratomileusis for treated anisometropic amblyopia in awake, autofixating pediatric and adolescent patients. J Cataract Refract Surg 2004; 30: 2522-8.
5. Autrata R, Rehurek J. Clinical results of excimer laser photorefractive keratectomy for high myopic anisometropia in children: four-year follow-up. J Cataract Refract Surg 2003; 29: 694-702.
6. Rybintseva LV, Sheludchenko VM. Effectiveness of laser

in situ keratomileusis with the Nidek EC-5000 excimer laser for pediatric correction of spherical anisometropia. J Refract Surg 2001; 17 (Suppl): S224-8.
7. Singh D. Photorefractive keratectomy in pediatric patients. J Cataract Refract Surg 1995; 21: 630-2.
8. Nano HD Jr, Muzzin S, Irigaray F. Excimer laser photorefractive keratectomy in pediatric patients. J Cataract Refract Surg 1997; 23: 736-9.
9. Alio JL, Artola A, Claramonte P, Ayala MJ, Chipont E. Photorefractive keratectomy for pediatric myopic anisometropia. J Cataract Refract Surg 1998; 24: 327-30.
10. Agarwal A, Agarwal A, Agarwal T, Siraj AA, Narang P, Narang S. Results of pediatric laser in situ keratomileusis. J Cataract Refract Surg 2000; 26: 684-9.
11. Astle WF, Huang PT, Ells AL, Cox RG, Deschenes MC, Vibert HM. Photorefractive keratectomy in children. J Cataract Refract Surg 2002; 28: 932-41.
12. O'Keefe M, Nolan L. LASIK surgery in children. Br J Ophthalmol 2004; 88: 19-21.
13. Autrata R, Rehurek J. Laser-assisted subepithelial keratectomy and photorefractive keratectomy versus conventional treatment of myopic anisometropic amblyopia in children. J Cataract Refract Surg 2004; 30: 74-84.
14. Tychsen L, Packwood E, Berdy G. Correction of large amblyopiogenic refractive errors in children using the excimer laser. J AAPOS 2005; 9: 224-33.
15. Paysse EA, Coats DK, Hussein MA, Hamill MB, Koch DD. Long-term outcomes of photorefractive keratectomy for anisometropic amblyopia in children. Ophthalmology 2006; 113: 169-76.
16. Paysse EA, Hamill MB, Koch DD, Hussein MA, Brady McCreery KM, Coats DK. Epithelial healing and ocular discomfort after photorefractive keratectomy in children. J Cataract Refract Surg 2003; 29: 478-81.