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Research Article

Changes of Eye Axial Length in Children with Hyperopia and Anisometropia after Femtosecond Laser Assisted Laser *In Situ* Keratomileusis: 3-Years Outcomes

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Abstract

Purpose: Analysis of axial length (AL) change in children with hyperopia and anisometropia in 3 years after femtosecond laser assisted laser *in situ* keratomileusis (FS-LASIK).

Material and Methods: The study included 33 patients at age 5 to 16, divided into 2 groups. Group 1 was comprised of children with moderate hyperopia (up to +5.00 D), group 2 - with high hyperopia (+5.0 D or more). All patients with anisometropic amblyopia and no positive results of traditional treatment methods were subject to FS-LASIK.

Results: The mean AL significantly increased in both groups over time. Three years after the surgery in Group 1 the AL of the operated (amblyopic) eye increased on average by 0.56 mm and was 22.41 mm, the AL of the fellow eye increased on average by 1.09 mm and was 23.47 mm. In Group 2 the mean AL of operated eye increased by 0.29 mm and averaged 21.52 mm, the mean AL of the fellow eye increased by 0.91 mm and averaged 23.32 mm.

Conclusion: Change in refraction of the amblyopic eye with initial moderate and high hyperopia after refractive surgery results in AL change as the child grows. This has to be considered when predicting the refractive effect of the surgery.

Keywords: *Hyperopia; Anisometropic Amblyopia; Eye Axial Length; Refractive Surgery in Children*

Abbreviations

AL: Axial Length; FS-LASIK: Femtosecond Laser Assisted Laser *In Situ* Keratomileusis; SE: Spherical Equivalent Refraction; UDVA: Uncorrected Distance Visual Acuity; CDVA: Corrected Distance Visual Acuity

Introduction

Correction of congenital ametropia, complicated by amblyopia in children is an urgent medical and social problem. It is well known that such biometric features of the eye as the axial length, are the most important factors affecting refractogenesis. Distortion of the ratio between these indicators is one of the causes of ametropia. Every year more than 4000 children in Russian Federation are diagnosed with visual disability; 21% of people with sight disability develop visual impairment in childhood [1]. Prevalence of ocular pathology in children and teenagers is 23% higher than the prevalence for adult population; it amounts to 13167.6 per 100 thousand children and demonstrates a steady growth trend [2].

Amblyopia is a significant public health problem [3]. Anisometropia of 1.0 diopter appears to be the threshold for developing amblyopia [3,4]. Hyperopic anisometropia is one of the most frequent refraction anomalies that lead to amblyopia development in children [5].

When traditional conservative methods result ineffective for complex refractive impairments in children, refractive surgery can be used if medically indicated [6,7]. The purpose of the surgery is to reduce the degree of anisometropia, create conditions for treatment of amblyopia and development of binocular functions. However, it is worth noting that the refractive effect, obtained after the surgery can change in the future, as with the growth of the child the length of anteroposterior axis is also changing. We have not found other publication on this problem in any literature available.

Purpose of the Study

Analysis of axial length (AL) change in children with hyperopia and anisometropia in 3 years after femtosecond laser assisted laser *in situ* keratomileusis (FS-LASIK).

Materials and Methods

The study included 33 patients (66 eyes) aged 5 to 16 years with hyperopia and anisometropia. Standard methods of examination were performed for all children in the follow-up period. The AL study was performed on IOL-Master (Carl Zeiss, Meditec AG, Germany), refraction measurements were made on auto kerato-refractometer (RC-5000 Tomey, Japan). At least three examinations were performed, then the average value was calculated for statistical processing. Visual acuity was converted to LogMAR scale from the decimal notation.

Patients were divided into 2 groups. Group 1 included 12 children aged 7 to 14 years with low to moderate hyperopia and spherical equivalent refraction (SE) up to +5.0 D. Group 2 included 21 patients aged 5 to 16 years with a high hyperopia with SE +5.0 D or more. In every patient surgery was preceded by traditional amblyopia treatment of 1 - 2 years in duration without consistent visual improvement.

Before the operation, in Group 1, on the amblyopic eye the mean SE was +3.69 D (+2.81 to +4.31). On the fellow leading eye, the mean SE was +1.50 D (+1.06 to +2.18). Anisometropia (SE) was on average 1.5 D (+1.75 to +2.13), uncorrected distance visual acuity (UDVA) was 0.85 LogMAR (0.7 to 1.0) (0.15 decimal), corrected distance visual acuity (CDVA) - 0.5 LogMAR (0.3 to 0.7) (0.3 decimal). In Group 2 on the amblyopic eye SE was +5.88 D (+5.0 to +7.0). On the fellow eye SE - +2.0 D (+1.0 to +3.5). Anisometropia was on average 3.88 D (2.0 to 3.5), UDVA – 1.0 LogMAR (0.7 to 1.3) (0.1 decimal), CDVA - 1.0 LogMAR (0.5 to 1.0) (0.1 decimal).

FS-LASIK was performed using an IntraLase FS 60 kHz femtosecond laser (AMO, USA) and a MicroScan 500Hz excimer laser (Optosystems, Troitsk, Russia). Only amblyopic eyes were laser treated. The refractive effect was calculated individually in each case based on the data of refraction under cycloplegia and on the value of anisometropia.

All the studies were performed after the patients' parents signed informed consent form in accordance with the ethical standards of the Helsinki Declaration. All parents agreed to laser surgery, follow-up dynamic monitoring and examination of their children. The exclusion criteria were severe somatic and eye diseases. Analysis of AL data was performed before the surgery and 3 years postoperatively. Mean follow-up was 3 years.

Statistical analysis was done using Statistica 10 (StatSoft, USA) and Office Excel 2007 (Microsoft, USA). Given the small number of samples in groups, descriptive statistics indicators were used: number of observations (n), median (Me), threshold of variability of the target population in the range from the lower to upper quartiles (P25 - P75); statistical significance was estimated using nonparametric Mann-Whitney criteria (*pm*-u) for independent groups and Wilcoxon (*pw*) for conjugate groups. Differences in between samples were considered statistically significant at *pm*-u, $pw < 0,05$.

Results

There were no complications during or after the operation.

Three years postoperatively in Group 1 SE of the treated eye was +0.25D (-0.63 to +0.50), on the fellow eye +0.81 D (-0.25 to +1.37). Anisometropia (in SE notation) was 0.81 D and decreased on average by 0.69 D. UDVA was 0.35 LogMAR (0.2 to 0.7) (0.45 decimal), CDVA - 0.17 LogMAR (0.07 to 0.3) (0.65 decimal). In Group 2 SE of the treated eye - +0.25 D (-1.05 to +0.75), on the fellow eye - +0.62 D (0.25 to 1.87). Anisometropia (in SE notation) was 0.62 D and changed on average by 3.26 D, UDVA - 0.4 LogMAR (0.3 to 0.7) (0.4 decimal), CDVA - 0.3 LogMAR (0.15 to 0.5) (0.5 decimal).

Three years after FS-LASIK the AL values demonstrated statistically significant changes in all groups. In Group 1 the AL of the operated eye increased by average of 0.56 mm, of the fellow eye - by 1.09 mm. In Group 2 the AL of the operated eye increased by average of 0.29 mm, of the fellow eye - by 0.91 mm. The comparative analysis of AL changes between groups demonstrated statistically significant changes in AL values of the operated eye. Data for the AL of the operated eye in groups are presented in table 1 and figure 1, 2 data for the AL of the fellow eye - in table 2.

Groups	Pre-op	3 years post-op	Change	p_w
Group 1 (n = 24) up to +5.0 D	21.85 (21.55; 22.2)	22.41 (21.94; 22.74)	0.56 (0.39; 0.54)	0.0022
Group 2 (n = 42) more than +5.0 D	21.23 (20.82; 21.85)	21.52 (21.08; 22.22)	0.29 (0.26; 0.37)	0.00006
p_{m-u}	0.23	0.01		

Table 1: *Axial length (mm) in treated eyes in groups, Me (P_{25}; P_{75}).*
Note: n: Number of Eyes; mm: Millimeter; D: Diopter; Me: Median; P_{25}: Lower Quartile; P_{75}: Upper Quartile; p_{m-u}: Mann-Whitney U-test; p_w: Wilcoxon Test.

Groups	Pre-op	3 years Post-op	Change	p_w
Group 1 (n = 24) up to 1.5 D	22.38 (22.21; 22.63)	23.47 (22.77; 24,01)	1.09 (0.56; 1.38)	0.0096
Group 2 (n = 42) up to +3 D	22.41 (21.94; 22.8)	23.32 (23.02; 23.77)	0.91 (1.08; 0.97)	0.00006
p_{m-u}	0.85	0.79		

Table 2: *Axial length (mm) in fellow eye in groups, Me (P_{25}; P_{75}).*
Note: n: Number of Eyes; mm: Millimeter; D: Diopter; Me: Median; P_{25}: Lower Quartile; P_{75}: Upper Quartile; p_{m-u}: Mann-Whitney U-test, p_w: Wilcoxon Test.

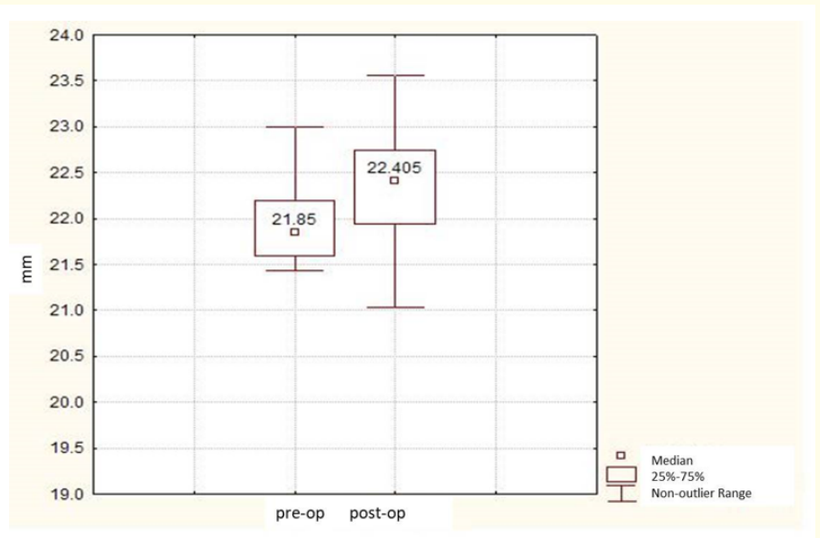

Figure 1: *AL of the operated amblyopic eye in the group 1 before and 3 years after FS-LASIK.*

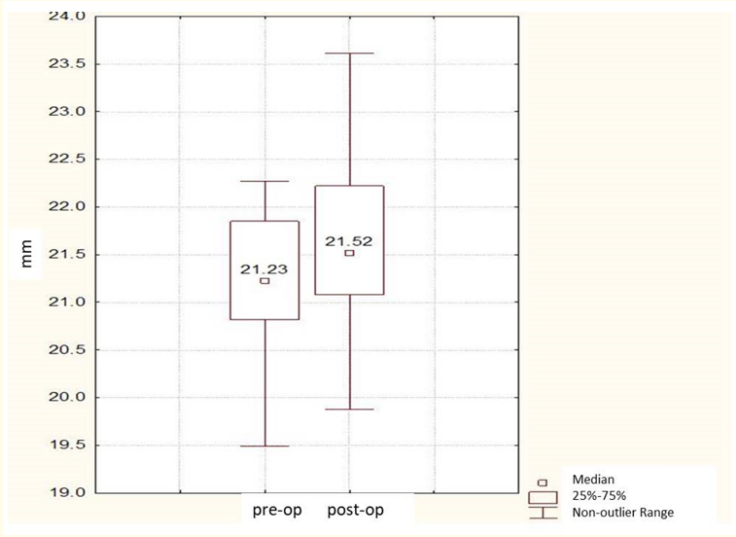

Figure 2: *AL of the operated amblyopic eye in the group 2 before and 3 years after FS-LASIK.*

Discussion

It is known that child's eye reaches 90% of the size of adult's eye by the age of four, normally by the age of 6 - 8 years it becomes emmetropic [8]. According to some authors, in emmetropes the eye grows up to 12 years, in hyperopes - up to 11, in myopes - up to 14 [9]. There is still no consensus on the way child's eye grows with the age. Is this process controlled by genetic factors or is it influenced by environmental factors?

After the analysis of AL data before the surgery we found that children with close to emmetropic refraction of the fellow eye had an average AL value of 22.38 mm (22.21; 22.63). This is consistent with some publications [10]. They note that average AL in 10-year-old children with emmetropic refraction was 21.93 ± 0.67 mm in girls and 22.28 ± 0.5 mm in boys. Some authors reported that in the case of emmetropia by the age of 10 the AL of an eye reaches an average of 22.66 mm [11].

As already noted, in cases with high hyperopia the mean AL usually doesn't change, since excessive amount of cross-links in collagen structures of hyperopic eye can have an inhibitory effect on emmetropic process [12]. We have conducted a preliminary analysis of AL changes in children after FS-LASIK with 1-year observation period [13]. Postoperatively in younger age group of children from 5 to 8 years with preoperatively SE up to +5.0 D the mean AL was 22.18 ± 0.88 mm, and for children with preoperatively SE up to +9.75 D - 20.91 ± 0.84 mm. In older age group of children from 9 to 11 with preoperatively SE up to +5.0 D the AL was 22.22 ± 0.19 mm, and for children with SE up to +9.75 D - 21.00 ± 0.32 mm [13].

Data of this study demonstrates that 3 years after hyperopic FS-LASIK the smallest increase in the AL (by 0.29 mm) of the operated eye was registered in group 2 with preoperatively SE +5.0 D or more. This once again confirms that there are structural specifics of the eye with a high hyperopia [10].

Thus, contrary to the common belief that there is no AL growth in children with high hyperopia, in Group 2 with the mean preoperative SE +5.88 D (+5.0 to +7.0) the mean AL grew by 0.29 over 3 years, and the mean SE of the treated eye by that time on average was

+0.25 D (-1.05 to +0.75). Refractive surgery changes the initial refraction of hyperopic eye, this changing the AL of the eye. The analysis of the long-term results of refractive surgery and its effect of the eye AL is crucially important for evaluation of the feasibility, efficiency and safety of refractive surgery in children. Larger studies and long term follow up are necessary to fully interpret the safety and efficacy FS-LASIK in children.

Conclusion

Three years after the hyperopic FS-LASIK the smallest AL increase was diagnosed in children with hyperopia +5.0 D or more: by 0.29 mm, in children with hyperopia less than +5.0 D the AL increased by 0.56 mm. Change in refraction of the amblyopic eye with initial moderate and high hyperopia after refractive surgery results in AL change as the child grows. This has to be considered when predicting the refractive effect of the surgery.

Conflict of Interest

Authors declare that there is no conflict of interest. There was no sponsorship of the clinical study.

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