Original article

Evaluation of predictability and refractive changes in pediatric pseudophakia

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ABSTRACT

Objective: Evaluate the predictability of the postoperative refraction and refractive changes in pediatric pseudophakia.

Methods: Prospective, longitudinal follow-up on patients under the age of 15 years operated on for a cataract with intraocular lens, with 5 continuous years of follow-up. The patients were divided into 4 groups according to age at the time of the surgery: group 0 to 2 years old, from 3 to 5 years old, from 6 to 8 years old, and 9 years and over. Error prediction and refractive change were studied. Statistical analysis was performed using the Student t and ANOVA test.

Results: A total of 60 eyes were included (44 patients). No significant differences were found between the unilateral and bilateral group. The prediction error in the 0–2 years group was 1.5 ± 1.8 D, significantly higher than in the other groups (ANOVA P = 0.01). Refractive change in 5 years of the group of 0–2 years was −4.7 ± 3.4 D (ANOVA p = 0.0002), while in the other groups it was significantly lower, with no differences between them.

Conclusions: The 0–2 years group was less hyperopic than expected, 100% within the accepted of 2 standard deviations, but with a high variability. The refractive change observed in this group coincides with previous reports that the largest growth and increase in axial length occurs during the first 2 years. The calculation and use of an IOL in children has a better immediate refractive prediction, and at long term in those older than 2 years of age.

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Evaluación de la predictibilidad y cambio refractivo en pseudofaquia pediátrica

RESUMEN

Objetivo: Evaluar la predictibilidad de la refracción postoperatoria y la evolución refractiva en pseudofaquia pediátrica.

Métodos: Trabajo prospectivo, longitudinal, en operados de catarata con lente intraocular, menores de 15 años, con 5 años continuos de seguimiento. Los pacientes fueron divididos según la edad en años al momento de la cirugía: grupos de 0 a 2 años, de 3 a 5 años, de 6...
Predictibilidad
Cambio miópico

a 8 años y de 9 o más años. Se estudiaron error de predicción y cambio refractivo. Se realizó el análisis estadístico aplicando t de Student, test de Anova.

Resultados: Se incluyeron 60 ojos (44 pacientes). Sin diferencias significativas entre grupo unilateral y bilateral. El error de predicción fue de 1,5 ± 1,8 D en el grupo de 0 a 2 años, significativamente mayor que en los otros grupos (ANOVA p = 0,01). El cambio refractivo a los 5 años del grupo de 0 a 2 años fue de −4,7 ± 3,4 D, (ANOVA p = 0,0002) mientras en los otros grupos fue significativamente menor y sin diferencias entre grupos.

Conclusiones: El grupo de 0 a 2 años resultó menos hipermetrópe de lo esperado, con un 100% dentro de lo aceptado de dos desviaciones estándar, pero con alta variabilidad. El cambio refractivo observado en este grupo coincide con trabajos previos en los que el mayor crecimiento y el aumento de la longitud axial ocurre durante los primeros dos años. El cálculo y utilización de una LIO en niños tiene mejor predicción refractiva inmediata y, a largo plazo, en mayores de 2 años de edad.

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Introduction

In the past 10 years the correction of aphakia in children with intraocular lenses has become widespread. However, in contrast with adults, it is difficult to achieve the goal of precise and stable correction with time because in children the eye is in anatomic and refractive development.

The factors to be considered in the refractive evolution of the human eye from birth up to adulthood include ocular axial growth, corneal curvature reduction and changes in the dioptric power of the lens.1

From birth to adulthood, the eye grows 7 mm with an overall refractive power reduction of about 30 D in order to maintain emmetropia.2 In 1995, Gordon et al. reported that the biggest axial length growth occurs in children under 2 years of age. Between 2 and 3, the growth ratio diminishes to 0.4 mm per year and between 5 and 15 the axial length increases only 1 mm until it reaches adult length.3

In what concerns the corneal curvature, it is greater in young children than older ones and diminishes significantly during the first year of life,3 predominantly in the first 6 months1 and, after the first year of life corneal curvature diminishes only slightly.4

The third factor that modifies the overall refractive power of the human eye is the dioptric power of the lens. A normal lens significantly diminishes its dioptric power from birth to adulthood, with the biggest refractive change taking place in the course of the first year of life.1

A number of studies have demonstrated that the expected changes in axial length and corneal curvature continue in aphakic pediatric eyes.5 Due to these changes, substituting in children a diminishing dioptric power lens by a fixed power lens produces a progressive change of the overall dioptric power.

The axial growth ratio of the eye is relatively high following the normal curve in children operated before 12 months of life for monocular aphakia1,6 and bilateral cataracts.5 The ocular growth has significant optical implications with profound effects on refraction which could potentially give rise to significant myopic changes.7

Refractive results in pediatric cataract surgery with IOL are highly variable in all age groups, particularly in infants under 2 years of age and in those having axial lengths under 19 mm.8 In children over 2 years of age, variability and proportions of myopic changes diminishes with age.9 Refractive changes tend to follow the logarithmic regression curve, as achieved by McClatchey and Parks10 in aphakic patients and Gordon and Donzis1 in phakic children. However, in pseudophakic patients McClatchey et al. found slightly smaller refractive growth than in aphakic patients with large myopic changes, as an optical phenomenon caused by the presence of IOL.11 The adequate power of the IOL to be placed in children is a complex task because in addition to progressive refractive changes there are no specific formulae for calculating IOL in pediatric eyes. The formulae usually applied are those designed for adults, to which the difficulty of establishing the axial length and keratometry in children using equipment designed for adults must be added, in addition to poor patient cooperation.

The IOL power selection is based on the results of various studies which describe myopic changes.12,13 The younger the child at surgery time the greater the myopic change will be. In order to reduce the need to change the IOL, these eyes must be under-corrected, producing initial hypermetropia which gradually becomes emmetropia or moderate myopia in the adult age.14

This paper compares the refractive evolution between bilateral and monocular pseudophakia and studies the prediction error and refractive change according to patient age at surgery time.

Subject, material and methods

A prospective, longitudinal study which included pediatric patients under 15 years of age with cataract surgery plus IOL insertion in the Ophthalmology Service of HUM, with a post-surgery follow-up of at least 5 years, i.e., patients with complete records for the prospective work initiated in 2003. An informed consent was signed by parents or representatives of patients. The analysis was carried out with the GraphPad® Instat 3 Software INC. (La Jolla, California, USA) application.

The study excluded patients with a follow-up under 5 years as well as those with post-surgery complications such as endophthalmitis, pseudophakic glaucoma, IOL position modifications and opacifications.
Keratometry was carried out with the Topcon® OM-4 keratometer (Medical Systems (TMS), Oakland, NJ, USA) and biometry was of the contact type with the Ultrascan Imaging System Alcon surgical® mode A echograph (Irvine, CA, USA), carried out under sedation in children under 6 years of age and with the SRK-II formula in all the eyes. The same surgeon (OA) carried out cataract surgery in all the patients. The surgery technique applied in children under 6 years of age was bimanual phacoaspiration with Burato cannules, with previous anterior continuous curved capsulorhexis with tweezers, posterior capsulorhexis with tweeters, anterior vitrectomy and insertion of IOL in sac or, if sac was incomplete, inserting in sulcus with optical capture. In children over 6 years of age the technique was phacoaspiration with previous anterior curved capsulorhexis, insertion of IOL in sac or sucrose with optical capture. No posterior capsulorhexis or vitrectomy was performed.

The patients were divided in to group A for monocular cataracts and group B for bilateral cataracts and according to age at surgery time. Post-surgery refractions were calculated by means of retinoscopy carried out by a single experienced specialist. Refractive error was assessed at month 3, year 1, year 3 and year 5 after surgery, the expected refractive error (ERE) and the post-surgery refractive error or defect (PRE) expressed in the spherical equivalent. Prediction error in diopters was calculated according to the 2005 publication by Neely et al.8

Prediction error (R)=expected refractive error (R)=post-surgery refraction (R) at month 3.

The refractive change was defined as the refractive error of the latest refraction (5 years post-surgery) minus the initial refractive error (month 3).9

**Statistics**

The refractive error and refractive change results between the monocular and bilateral cataract groups were compared with the non-paired t for student. The prediction error and refractive changes between groups based on age at surgery were compared utilizing the nonparametric Kruskal–Wallis ANOVA test (GraphPad® Instat 3 Software Inc., California Corporation, USA).

**Results**

Overall, the study included 44 pediatric patients, 25 with unilateral cataracts and 19 (35 eyes) with bilateral cataracts. Overall, 60 eyes of which 17 were traumatic cataracts, one complicated, 42 congenital or developmental cataracts. The mean age was of 4.2 ± 3.1 years, range 0.5–12 years. The study comprised 20 males and 24 females. The mean IOL dioptric power was of 24 ± 3.7 R with a range between 11 and 30 R.

The absence of significant differences in the statistical analysis of the prediction error and refractive change (non-paired t for student) between bilateral and monocular cataract groups determined the inclusion of all patients in a single group divided by age at surgery time (Table 1) for analyzing the post-surgery prediction error and refractive change in 5 years.

<table>
<thead>
<tr>
<th>Age</th>
<th>Overall # of eyes</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–2 years</td>
<td>21</td>
<td>35</td>
</tr>
<tr>
<td>3–5 years</td>
<td>22</td>
<td>37</td>
</tr>
<tr>
<td>6–8 years</td>
<td>09</td>
<td>15</td>
</tr>
<tr>
<td>&gt;9 years</td>
<td>08</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>100</td>
</tr>
</tbody>
</table>

In 70% of all eyes (42 eyes) the axial length was under 22 mm: 95.2% in the group of 0–2 years, 68% in the group of 3–5 years, 33.3% of eyes in the group of 5–8 years and 50% of eyes in the group of 9 and more years of age.

The prediction error according to the age group at surgery time (Table 2) was significantly different to the Kruskal–Wallis nonparametric ANOVA multiple comparison test (p = 0.0104) when comparing the 4 groups. However, when comparing only the groups of 2 years or older (groups 2–4) the ANOVA test did not produce significant differences (Table 2).

Refraction changes between different age groups exhibited highly significant differences of p = 0.0002 (ANOVA test) and in the comparison of the group of infants (0–2 years) with each of the other groups. With the Turkey–Kramer test the difference was significant, p < 0.05, while the changes were not significant (p > 0.05) when comparing the groups over 2 years of age (Table 3).

**Discussion**

The small series of pediatric patients of this study who underwent cataract surgery and IOL insertion with five-year follow-up did not exhibit significant differences in the parameters of the study when comparing eyes based on mono- or binocular involvement. The prediction error assessed on the basis of age at surgery evidenced in the group of 0–2 years of age a mean error of 1.5 ± 1.8 R (ANOVA, p < 0.05), which indicates that in this group eyes were less hypermetropic or more myopic than foreseen, even though 100% exhibited refractive results within predictability limits of 2 standard deviations but with high variability. In the group of 3–5 years, 96% of eyes demonstrated predictability within the expected limit, while the 2 groups of all the patients demonstrated 100% predictability and lower variability. Predictability of 100% is recommended within the range of 2 Δ15,16 even though an acceptable standard for adults of 19.9.9% within predictability limits has been proposed. In this study, 98.4% of all eyes were within the predictability limits, indicating errors in the exact prediction of the post-surgery refractive error, which could be caused by the utilization of equipment (biometric rule, keratometer) designed for adults as well as formulae designed for eyes with axial lengths of >22 mm, a prediction difficulty which was previously reported15,17,18 in unusually short eyes <22 mm. In said report, 70% were eyes with axial lengths under 22 mm. In a paper published in 2005, Neely reported that 65% of eyes under 22 mm found a prediction error of 1.16 Δ.8

The refractive evolution assessment revealed increasing myopic changes in all groups. These changes were higher in eyes between 0 and 2 years with surgery, which confirms
reports of higher growth and axial length increase during the first 2 years and that this change diminishes progressively throughout childhood.\textsuperscript{11} The tendency of post-surgery refraction in all age groups, both in monocular and binocular cataracts, was toward negative spherical equivalent values (refractive or myopic changes) with the myopic change in the younger group, which exhibited significant differences with the other groups. This agrees with the articles published by Plager and also by Enyedi et al.\textsuperscript{7,12}

In children and even more in infants under 2 years of age it is still very difficult to select the IOL power because the eye quickly changes size and refractive power in this stage of life. Post-surgery under-correction with IOL should be applied in children to achieve emmetropia of minimum myopia in adult life. On the basis of patient age at surgery, the current logarithmic growth curves\textsuperscript{19,20} calculate the ideal IOL power to be inserted but the theoretical refractive growth will always be subject to individual and familial variations. The refractive results of this report agreed with other published results\textsuperscript{5,8,9,12-14} and support the utilization of IOL in children over 2 years of age, taking into account age, familial refractive history and the binocular or monocular nature of the cataracts for selecting IOL power. In children under 2 years of age it is still difficult to predict the post-surgery refractive condition to which significant myopic changes must be added which will affect the final refractive condition in adulthood and the difficulty of selecting the IOL power.

**Conflict of interests**

No conflict of interests has been declared by the authors.

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