DOI 10.26724/2079-8334-2024-4-90-139-143
UDC 617.7

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ASSESSMENT OF THE INFLUENCE OF BIOMETRIC FEATURES OF THE EYE ON THE SUCCESS OF OPERATION IN HORIZONTAL STRABISMUS

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In the course of this study, a comprehensive clinical, laboratory and instrumental prospective examination of 28 patients aged 1.0 to 38.0 years (mean age 7.79±7.43 years) with horizontal strabismus was conducted at the Batygoz Clinic in 2022-2023. Patients were divided into 3 groups: esotropia (n=9, 32.1 %), exotropia (n=8; 28.6 %) and infantile esotropia (n=11; 39.3 %), as well as into 3 age groups according to the type of postoperative deviation, development of the eyeball and binocularity. It was found that the distance to the limbus (d), the width of the attachment of the internal rectus muscle (a, b, c) positively correlated with the likelihood of surgical success (p=0.058; p=0.026; p=0.019; p=0.058). On the other hand, the axial length and the angle of strabismus for near vision were negatively correlated with the probability of surgical success (p=0.031; p=0.021). It was found that the axial length and anatomy of the extraocular muscles are among the factors influencing the success of surgical intervention for horizontal strabismus.

Key words: strabismus, horizontal strabismus, biometric examination, esotropia, exotropia, infantile esotropia, postoperative abnormalities.

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ОЦІНКА ВПЛИВУ БІОМЕТРИЧНИХ ОСОБЛИВОСТЕЙ ОКА НА УСПІХ ОПЕРАЦІЇ ПРИ ГОРИЗОНТАЛЬНІЙ КОСООКОСТІ

У ході виконання цього дослідження у 2022–2023 році у клініці «Батигьоз» було проведено комплексне клініко-лабораторне та інструментальне проспективне обстеження 28 пацієнтів віком від 1,0 до 38,0 років (середній вік 7,79±7,43 роки) з горизонтальною косоокістю. Пацієнти були поділені на 3 групи: езотропія (n=9, 32,1 %), екзотропія (n=8; 28,6 %) та інфантильна езотропія (n=11; 39,3 %), а також на 3 вікові групи за типом післяопераційного відхилення, розвитку очного яблука та бінокулярності. Було виявлено, що відстань до лімбу (d), ширина прикріплення внутрішнього прямого м'яза (a, b, c) позитивно корелює з ймовірністю успіху хірургічного втручання (p=0,058; p=0,026; p=0,019; p=0,058). З іншого боку, осьова довжина і величина кута косоокості для близької відстані негативно корелювали з ймовірністю успіху хірургічного втручання (p=0,031; p=0,021). Встановлено, що осьова довжина та анатомія екстраокулярних м'язів є одними з факторів, що впливають на успіх хірургічного втручання при горизонтальній косоокості.

Ключові слова: косоокість, горизонтальна косоокість, біометричне обстеження, езотропія, екзотропія, інфантильна езотропія, післяопераційні відхилення.

Strabismus is defined as any binocular misalignment. It is traditionally considered an eye disorder affecting children, with a prevalence of 0.8 % to 6.0 % [3, 8, 11]. In children, the most common type of strabismus is horizontal strabismus, which includes esotropia and exotropia. Ideally, strabismus treatment should begin immediately after diagnosis to develop binocular visual function and ensure visual acuity. However, there are cases that, for various reasons, are not treated in childhood or develop in adulthood (especially paralytic types) [2, 12].

Early detection and prompt treatment of strabismus in children is vital as it can improve their long-term visual and sensorimotor outcomes. Strabismus has been reported to be the most common cause of childhood amblyopia. Children with overt strabismus may also be susceptible to psychosocial consequences such as low self-confidence and self-esteem anxiety.

Surgical treatment of strabismus may affect the ocular tissues and lead to changes in refraction. Previous studies have shown that surgical treatment of the horizontal rectus muscle of the eye may lead to a change in refraction towards myopia; however, these changes were not stable and disappeared spontaneously [4, 14].

Several studies have demonstrated that in most patients, changes in refraction or astigmatism are temporary and have no clinical significance, although in some cases these changes have been shown to be permanent [10, 13].

Most of the optical irregularities are caused by second-order aberrations, which are a refractive error. In contrast, higher-order aberrations account for a small part of optical irregularities. However, they can play a significant role in reducing the quality of retinal images [7]. Notably, patients who have undergone strabismus surgery sometimes suffer from poor visual quality even though they have not experienced any change in refraction and visual acuity. There is little information in the literature on changes in corneal topographic and measurements (aberrometry) after strabismus surgery.

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The purpose of the study was to evaluate the influence of biometric features of the eye on the success of horizontal strabismus surgery.

Materials and methods. This study includes a comprehensive clinical, laboratory and instrumental prospective examination of 28 patients aged 1.0 to 38.0 years (mean age 7.79±7.43 years) with horizontal strabismus was conducted at the "Batygoz" Clinic for the period of 2022–2023. Patients were divided into 3 groups: esotropia (n=9, 32.1 %), exotropia (n=8; 28.6 %) and infantile esotropia (n=11; 39.3 %). Cohort examinations were prospective. Inclusion criteria for the study: first surgery for strabismus, patients diagnosed with horizontal strabismus, complete orthoptic examination, patient age from 1 to 38 years; obtaining written consent from the patient to participate in the examinations (or from legal representatives).

Exclusion criteria from the study: the presence of paralytic, restrictive and vertical strabismus, patients who have previously undergone surgery for strabismus; refusal to participate in the study.

The clinical characteristics of the examined patients were based on the study of complaints, clinical, laboratory and somatic anamnesis. The results of ophthalmological, orthoptic and biometric examination were studied in all patients. The data were recorded before and after surgery in the third month in patients who underwent strabismus surgery. In addition to the routine examination, axial length and keratometry parameters were assessed. During surgery, the limbal-medial and lateral muscle attachments were recorded at the superior (a), middle (b) and inferior (c) distances. The width of muscle attachment was recorded (d). The location of the muscles was recorded as oblique or flat depending on their orientation throughout the orbit before attachment.

At the third month after surgery, keratometric measurements were performed using an autorefractometer/autokeratometer (Nidek ARK 510-A Auto Refractometer and Auto Keratometer Nidek Co., LTD., Aichi, Japan) on a sitting position with the patient's forehead positioned on the device appropriately and taking measurements.

The axial lengths of both eyes were measured using an ultrasonic biometric device Automotic ECHOSON A B scan Pachymeter at Rs 112000 / piece n Noida, Uttar Pradesh, based on the distance starting from the anterior surface of the central cornea of the eyes and ending at the anterior surface of the retina. All measurements were performed by the same physician. Statistical processing of the obtained data was carried out by analyzing the results using Microsoft Excel spreadsheet programs, generated in accordance with the objectives of the conducted studies.

Results of the study and their discussion. The surgeries performed on the patients were classified as bilateral medial rectus recession, bilateral medial rectus recession+bilateral inferior oblique recession, bilateral lateral rectus recession, recession-resection, recession-resection+inferior oblique recession.

The patients were divided into a successful group (postoperative deviation <10 PD for esotropia; from <10 PD esotropia to <10 PD exotropia for patients with exotropia); partial successful group (at least one of the deviations of the angle of strabismus for distance or near was <10 PD for esotropia and <10 PD for exotropia); and a unsuccessful group (postoperative deviation was >10 PD for esotropia and >10 PD for exotropia). For postoperative esodeviation, the residual angle of strabismus at near and far distances should be 10 PD or less; for exodeviation, respectively, it should be less than 10 PD–successful; if the angle of strabismus at near or far distance is 10 PD or less–partially successful; more than 10 PD was considered unsuccessful. The operation was successful in 13 (46.4±9.4 %) patients, partially successful in 10 (39.4±9.2 %), and unsuccessful in 5 (14.4±6.7 %) (Fig. 1).

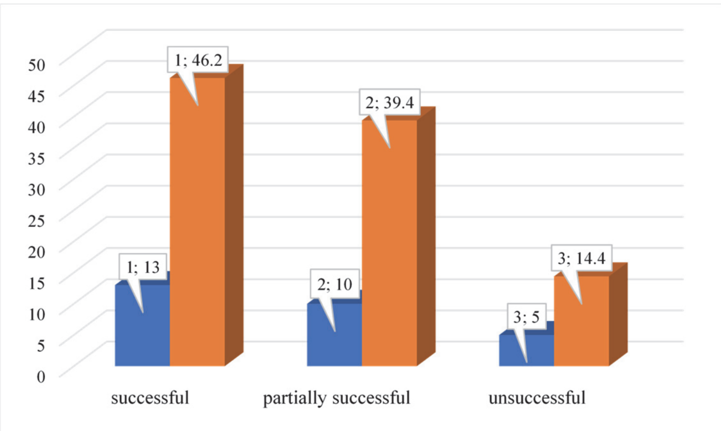

Fig. 1. Results of the surgeries performed.

Patients were also divided into 3 age groups based on the type of postoperative deviation, eyeball development, and binocularity: 6 (21.4±7.8 %) patients were 2 years of age or younger, 10 (35.7±9.1 %) were 2–8 years of age, and 12 (42.9±9.4 %) were 8 years of age or older.

Visual acuity could be assessed in 17 patients (60.7±9.2 %). The mean uncorrected visual acuity was 0.65±0.28 (hand movement (HM)–1.0) for the right eye and 0.64±0.30 (HM: 0.05–1.0) for the left eye. The mean corrected visual acuity was 0.80±0.25 (HM–1.0) for the right eye and 0.79±0.26 (HM: 0.05–1.0) for the left eye.

When assessing the type of refraction in 56 eyes of patients, it was found that 7 eyes (25.0±8.2 %) were emmetropic, 18 eyes (64.3±9.1 %) were hypermetropic, and 3 eyes (10.7±5.9 %) were myopic. Astigmatism was present in 19 eyes (67.6±6.5 %) (Table 1).

Table 1

Refraction type assessment

Refraction type	Number of eyes (n=56)		Mean error of refraction
	Abs.	%	
Emmetropia	7	25.0±8.2	-
Hypermetropia	18	64.3±9.1	4.38 D (+0.50–+8.50)
Myopia	3	10.7±5.9	–2.87 D (–0.50– –5.25)
Astigmatism	19	67.6±6.5	2.12 D (+0.25–+4.00)

Anisometropia was present in 3 patients (10.7±5.9 %), it was not detected in 25 (89.3 %). The predominant position of the squinting eye was right-sided in 10 patients (35.7±9.1 %), left-sided in 11 patients (39.3 %), and alternating in 7 patients (25.0±8.2 %). The preoperative near deviation angle was 41.75±14.79 PD without correction and 33.83±13.06 PD with correction. The preoperative distance deviation angle was 35.40±13.48 PD without correction and 28.38±12.80 PD with correction. Stereopsis examination was performed in 21 patients. Stereopsis was present in 12 of these patients (57.1 %), while stereopsis was not detected in 7 (42.9 %).

Preoperative keratometry was performed in 21 patients. The average value for the right eye was 43.63±1.48, for the left eye it was 43.64±1.51. There was no statistically significant difference in the keratometry values between the two eyes, p=0.82. Axial length measurement was performed in 24 patients. The mean value of axial length for the right eye was 22.44±1.18, for the left eye–22.36±1.22. There was no statistically significant difference between the right and left eyes, p=0.194. No significant difference was found between the success rates of deviation types (p>0.05). In 9 (32.1 %) cases with esotropia, in 8 (28.6 %) cases with exotropia and in 11 (39.3 %) cases with infantile esotropia.

During the operation, the distance from the limbus to the attachment site of the medial rectus muscle of the right eye was a=5.81±1.01, b=5.19±0.57, c=6.06±0.73, the width of the muscle attachment d=9.49±1.00. In the left eye, a=5.96±0.70, b=5.15±0.45, c=6.28±0.81 and d were measured as 9.43±1.07 (Table 2).

Table 2

Average value of the internal rectus muscle (IR) external rectus muscle (LR) of the right and left eyes

Outside diameter (OD)	Mean±standard deviation (min–max) mm (n=56)
For right eye	
IR a	5.81±1.01 (4.0–3.50)
IR b	5.19±0.57 (3.50–7.0)
IR c	6.06±0.73 (4.50–7.50)
IR d	9.49±1.00 (7.5–11.5)
LR a	7.52±1.74 (5.0–9.0)
LR b	6.52±0.94 (5.0–8.50)
LR c	7.85±1.04 (6.0–9.50)
LR d	9.34±1.11 (7.5–11.0)
For left eye	
IR a	5.96±0.70 (4.0–3.50)
IR b	5.15±0.45 (3.50–7.0)
IR c	6.28±0.81 (4.50–7.50)
IR d	9.43±1.07 (7.5–11.5)
LR a	7.14±1.79 (5.0–9.50)
LR b	6.19±0.80 (4.50–7.5)
LR c	7.48±1.06 (5.50–9.50)
LR d	9.58±1.00 (7.5–11.5)

The distance from the insertion site of the lateral rectus muscle to the limbus, measured intraoperatively, was a=7.52±1.74, b=6.52±0.94, c=7.85±1.04, and d=9.34±1.11 in the right eye, while in the left eye was as following: a=7.14±1.79, b=6.19±0.80, c=7.48±1.06, and d 9.58±1.00.

The distance between the superior limbus and the insertion site (“a”) of the medial rectus muscle in 13 patients was 5.50 mm from the limbus of the right eye in 10 patients and 6.00 mm in 6 patients (Fig. 2).

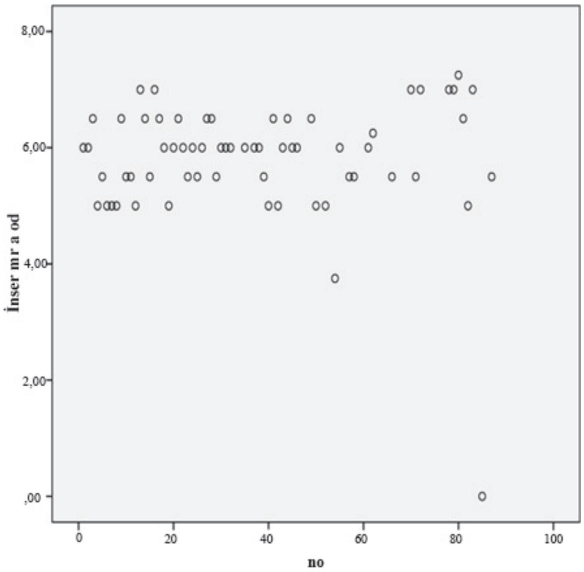

Fig. 2. Distribution of the superior limbus by the distance of the external rectus muscle.

When assessing the correlation between the muscle attachment distance and the limbus with age, no statistically significant difference was found between the age groups. The distance to the limbus increases with age (p=0.077; p=0.089). There was no statistically significant difference in the average axial length between the right and left eyes. When examining the distribution of the axial length of the eye among different age groups, it was found that the axial length of the eye was shorter in younger patients. This difference was statistically significant (p=0.001).

The influence of the preoperative deviation angle on the success of the operation was statistically significant (p=0.021). It was found that the probability of surgical success decreases with increasing deviation angle and increases with increasing distance from the attachment point of the internal rectus muscle (a, b, c) to the limbus (p=0.058; p=0.026; p=0.019). It was also found that with increasing attachment width of the medial rectus muscle (d), the probability of surgical success increased (p=0.058). No statistically significant relationship was found between the distance of the attachment point of the external rectus muscle (a, b, c) from the limbus and its width (d) and the success of surgical intervention. It was found that with increasing axial length, the probability of surgical success decreases. Axial length was found to be inversely correlated with surgical success.

Thus, our data have some similarities with the results of other works. There was no statistically significant difference in the average axial length between the right and left eyes, which coincides with the opinion of most scientists [7, 10, 13]. Hirnschall N, et al with the purpose to evaluate the influence of optical biometry data (axial eye length, anterior chamber depth) on planning strabismus surgery performed prospective study and revealed that taking the axial eye length into account improved the simulation slightly (change of surgical planning: 0.30±1.65 mm). In contrast with our study the authors used simulation software and partial least squares regression. They noted that the simulation model used showed that including the axial eye length is useful for strabismus surgery planning [6]. However, the anterior chamber depth/axial eye length was found to have a significantly greater impact.

According to our data, when examining the distribution of the axial length of the eye among different age groups, it was found that the axial length of the eye was shorter in younger patients. This difference was statistically significant (p=0.001). Our results are consistent with the previously obtained results of studies by various authors who indicated that the direct or oblique orientation of the muscles is not associated with the axial length and the site of muscle attachment, which is confirmed by the data of other authors [1, 4, 14].

It was not found that the probability of surgical success increases in the presence of preoperative stereopsis, mentioned in the publications of some authors [1, 3].

Pera-Vasylchenko AV, et al conducted the work which was devoted to the study of morphological changes in the optic nerve, mainly its intracranial part, in diabetic microangiopathy. It has been shown that diabetic microangiopathy is accompanied by proliferation of capillary endotheliocytes, resulting in narrowing or obliteration of the blood vessels lumen [9]. There are various studies about features of diabetic changes of eyes [5, 10]. Among our patients there were not individuals with diabetes mellitus, so, the microangiopathy was not the critical factors for success of surgery.

Conclusion

The distance to the limbus increases with age (p=0.077; p=0.089). There was no statistically significant difference in the average axial length between the right and left eyes. Examining the distribution of the axial length of the eye among different age groups showed that the axial length of the eye was shorter in younger patients (p=0.001).

When analyzing the obtained data, no relationship was found between the refractive error, the type of deviation, the presence of fusion and stereopsis and the success of surgical intervention (p=0.403; p=0.183; p=0.316; p=0.259). It was found that the distance to the limbus (d), the width of the attachment of the internal rectus muscle (a, b, c) positively correlated with the probability of success of surgical intervention (p=0.058; p=0.026; p=0.019; p=0.058). On the other hand, the axial length and the magnitude of the deviation angle for near vision negatively correlated with the probability of success of surgical intervention (p=0.031; p=0.021). It was established that the axial length and anatomy of the extraocular muscles are some of the factors influencing the success of surgical intervention in horizontal strabismus.

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Стаття надійшла 5.01.2024 р.