

Topography of inferior oblique muscle's insertion to the sclera

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Background. Object's localization on the surface of the eyeball is traditionally performed by measuring the distance to other objects. These measurements are made in linear values straight on the eyeball surface. However, the size of the eyeball in every individual is different depending on the age and refraction. When using only linear measurements, it is impossible to localize correctly any given object on the eyeball surface without regard to the eye's size. As a rule, all distances are given for an average size eye of an adult, 12 mm in radius. Since the sizes of eyeballs of patients, especially of children, are varied depending on the age and refraction, corresponding tables of distances should be done for different eyeball sizes when localizing the zones of insertion of extraocular muscles.

The purpose of the present paper was to specify the localization of inferior oblique muscle's insertion to the sclera using spherical coordinate system.

Materials and Methods. 20 eyes of 18 patients were examined. Radius of the eyeballs ranged from 9.5 to 12.5 mm. The examinations were performed during strabismus surgeries. To transform the linear values into spherical coordinates, Computed Software for Calculating the Coordinates of Objects on the Surface of the Eyeball Model was used. To map out anatomical formations on the eyeball surface, we created a map of the eyeball surface in rectangular cylindrical projection of ophthalmographical spherical coordinate system (OSCC).

Results. Inferior oblique muscles insertion sites are localized between 80° and 120° longitude and between 25° and -90° latitude. However, the major area of inferior muscle insertion is between 80° and 115° longitude and between -10° and -85° latitude. Herewith, the anterior border of insertion area is mainly located within the range between 100° and 115° longitude and posterior borders are located between 80° and 100° longitude. As for latitude, it is mainly in the area between -10° and -30° for anterior borders and -55° and -85° for posterior borders. The relative longitude of the insertion site is also widely ranged, from minimal (No 5, 14, 20) to maximal (No 8, 16, 17) values.

Conclusions. The use of ophthalmographic spherical coordinate system enables to standardize the localization of inferior oblique muscle insertion sites without regard to the size of the eyeball.

The possible localization of the inferior oblique muscle insertion to the sclera was admeasured within the range mainly between 80° and 115° longitude and -10° and -85° latitude.

Key words: localization of inferior oblique muscle insertion, Spherical coordinate system, mapping of the eyeball surface

Background

Previously, we have demonstrated the necessity to standardize the topography of insertion of extraocular muscles to the sclera. That is also true of inferior oblique muscle. However, according to literature data, the site of insertion of inferior oblique muscle to the sclera is varied significantly in different authors [1, 2, 3, 4, 5, 6, 11]. Considering the fact that the size of eyeballs is different in different patients [1, 8], it is important to define the borders of possible site localization of inferior oblique muscle insertion to the sclera regardless the size of the eyeball.

To localize the objects on the eyeball surface, it is easy to use Spherical coordinate system (SCS). Coordinates in SCS are specified by longitude (θ°) and latitude (φ°), and they do not depend on the eyeball size [9]. We shall consider the insertion of inferior oblique muscle to the sclera.

The purpose of the present paper was to standardize the localization of inferior oblique muscle's insertion to the sclera using spherical coordinate system.

There were two tasks as follows:

1. To standardize the localization of inferior oblique muscle's insertion to the sclera using ophthalmographic spherical coordinate system.

2. To admeasure the possible localization for the site of inferior oblique muscle's insertion to the sclera.

Methods

The investigation was carried out during strabismus surgeries. The localization of the anterior and posterior borders as well as the midpoint of the insertion site of the inferior oblique muscle was determined. Dividers were used for measurements. Linear distance was measured from the limbus and from medial and lateral limbi of inferior rectus muscle's insertion. A computer programme for calculation of object coordinates on the surface of the human eyeball was used to transform the linear values into

spherical coordinates [10, 11]. Preoperatively, radius of the eyeball was determined according to the data of US and CT (CT was performed in three patients). Radius was thought of as a half of equatorial diameter of the eyeball with accuracy of 0.5 mm.

To map out anatomical objects on the eyeball surface, we created a map of the eyeball surface in rectangular cylindrical projection of ophthalmographic spherical coordinate system (OSCC) [9]. In this projection, parallels are figured with parallel lines and meridians are figured with equally-spaced lines perpendicular to parallels. Map scale depends only on latitude here. Lines of equal distortion coincide with parallels.

Material

Eighteen patients were examined. All patients had different forms of strabismus accompanied by dysfunctions (hyper or hypo-functions) of the inferior oblique muscles. There were 9 boys and 9 girls. Among them, there was one 3-year-old, nine 4-6-year-old and seven 7-16-year-old children and one adult. In primary position (PP), esotropia and exotropia were noted in 12 and 6 children, respectively. A vertical deviation in PP was noted in 3 patients. Excyclodeviation in PP was noted in 8 children. A-pattern was revealed in 1 child; 17 children had V-pattern. Total of 20 eyes (12 right and 8 left eyes) were examined. Both eyes were examined in 2 children; one eye was examined in 16 children. There were 6 eyes with low emmetropy and hypermetropy, 9 eyes with medium and high hypermetropy, 2 myopia and 1 astigmatism eyes. Radius of the eyeballs ranged from 9.5 to 12.5 mm.

Results

We performed the mapping of insertion sites of inferior oblique muscles in twenty eyes of 18 patients. Table 1 presents the data on coordinates of insertion sites using SCS, in particular, anterior border of insertion site, midpoint of insertion site, and posterior border of insertion site. The term "midpoint of insertion site" is not of an exact geometrical meaning here, but an extra point on the eyeball surface where muscle's tendon inserts; this makes it possible to localize the topography more precisely. Therefore, this point is not always just in the middle between the points of anterior and posterior borders.

Figure 1 illustrates the fragment of the map of the eyeball surface in rectangular cylindrical projection of ophthalmographic spherical coordinate system (OSCC) and occupies the eyeball surface area between 60° and 125° longitude and between 35° and -90° latitude. The map demonstrates that the site of insertion of the superior rectus muscle (black point) is located within 25-30° latitude. Topography of superior rectus muscle insertion, like of other rectus muscles, is largely the same in different literature [2, 3, 4, 6, 7]. It is otherwise as for topography of inferior oblique muscle insertion. The data reported differ greatly among themselves [1, 2, 4, 5, 7]. Figure 1 displays the site of inferior oblique muscle insertion according to the various data (dark-grey and light-grey paint) two variants (anterior and posterior) of insertion of superior oblique muscle (grey paint).

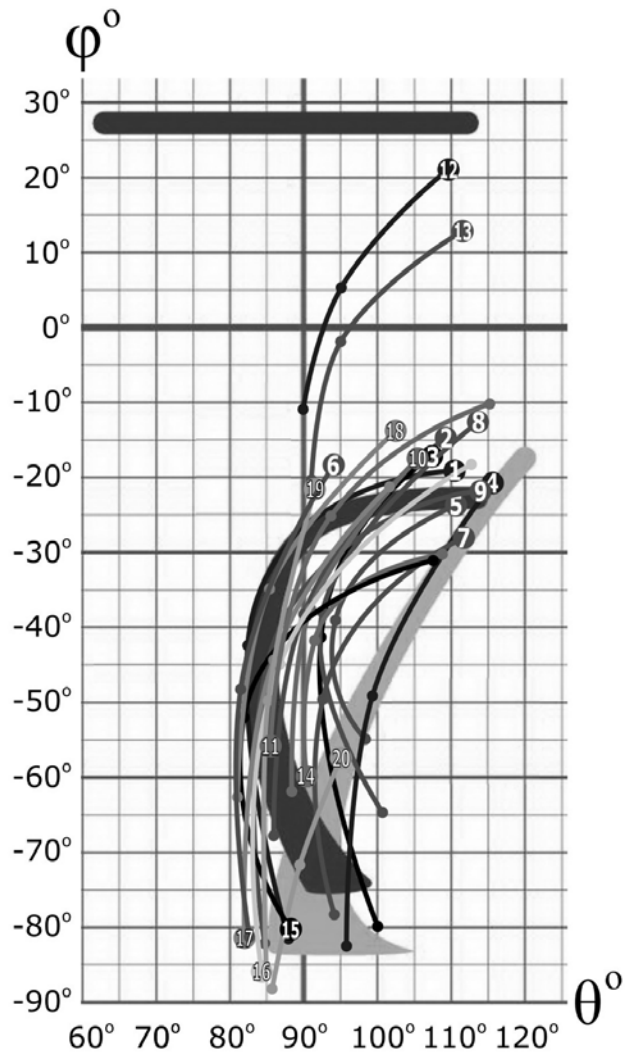


Figure 1

Narrow lines illustrate sites of insertion of inferior oblique tendon to the sclera (the thickness of the tendon is given not to scale). The numbers at one of the ends in these lines coincide with those in Table 1.

As seen from Table 1 and Figure 1, inferior oblique muscles insertion sites are localized between 80° and 120° longitude and between 25° and -90° latitude. However, the major area of inferior muscle insertion is between 80° and 115° longitude and between -10° and -85° latitude. Herewith, the anterior border of insertion is mainly located within the range between 100° and 115° longitude and posterior borders are located within 80° and 100° longitude. As for latitude, it is mainly in the area between -10° and -30° for anterior borders and -55° and -85° for posterior borders. Exceptions are No 12 and 13 as extremely anterior borders and No 20 as an extremely posterior border.

The relative longitude of the insertion site is also widely ranged: from minimal (No 5, 14, 20) to maximal (No 8, 16, 17) values.

Table 1. Coordinates for inferior oblique muscle's insertion onto the surface of the eyeball in patients examined

No	Eye	Radius r mm	Anterior limbus of insertion site		Midpoint of insertion site		Posteriorlimbus of insertion site	
			θ°	φ°	θ°	φ°	θ°	φ°
1	OD	10	111.2	-19.3	83.5	-43.9	87.0	-82.4
2	OS	11	109.3	-15.3	90.1	-38.5	86.0	-68.2
3	OS	9.5	117.3	-17.5	93.7	-42.8	100.3	-79.8
4	OD	9.5	116.8	-21.6	99.6	-49.4	96.0	-83.2
5	OS	11	111.9	-24.1	94.2	-39.6	98.8	-55.1
6	OS	12.5	94.4	-18.3	82.0	-48.5	83.6	-81.9
7	OD	10	112.2	-28.1	93.1	-49.8	94.1	-78.0
8	OS	10.5	108.6	-13.5	93.7	-38.3	101.0	-65.9
9	OD	11.5	114.1	-22.8	85.3	-45.1	84.9	-83.0
10	OD	11.5	105.9	-18.0	91.5	-37.1	88.1	-62.8
11	OS	11	115.3	-10.7	93.9	-25.1	86.2	-55.5
12	OD	12	109.7	21.4	95.2	5.4	90.1	-11.6
13	OS	10	112.4	13.4	95.3	-2.6	91.6	-20.6
14	OD	10.5	107.9	-30.8	92.0	-42.6	90.2	-59.9
15	OD	10.5	107.7	-31.0	82.2	-52.5	88.3	-85.5
16	OD	10.5	113.3	-18.5	86.7	-45.0	84.4	-86.5
17	OD	10.5	102.2	-21.7	86.5	-44.8	82.0	-81.7
18	OS	12	103.7	-13.9	85.5	-34.7	81.8	-63.2
19	OD	10	92.4	-22.3	85.3	-50.1	85.2	-85.7
20	OD	10	95.6	-57.0	89.8	-71.9	86.0	-88.2

The variety in localization of inferior oblique muscle insertion revealed cannot characterize the normal topography as all children examined had different types of strabismus. However, variable topography of inferior oblique muscle insertion sites can explain great clinical variability of strabismus with lesions of inferior oblique muscles. Obviously, during the evolution process, the site for inferior oblique muscle insertion has not been “defined precisely” despite the rectus muscles.

Conclusions

The use of ophthalmographic spherical coordinate system enables to standardize the localization of inferior oblique muscle insertion sites without regard to the size of the eyeball.

The possible localization of the inferior oblique muscle insertion to the sclera was admeasured within the range mainly between 80° and 115° longitude and between -10° and -85° latitude.

References

1. Avetisov ES, Kovalevskii EI, Khvatova AV. Guidelines for Pediatric Ophthalmology. M.: Meditsina; 1987. 496 p. Russian.
2. Vit VV. Vit VV. [The structure of the human visual system]. Odessa: Astroprint. 2003. 664 p. Russian.
3. Mahkamova H. M. [Anatomical Topographic Features of Extraocular Muscles]. Vestn. ophthalmol. 1970;78-80. Russian.
4. Duke-Elder S. Textbook of Ophthalmology. V.1 St. Louis: Mosby;1941.1080 p.
5. Helveston E M. Atlas of Strabismus Surgery. St. Louis – Toronto – Princeton: The C. V. Mosby Company; 1985. 395 p.
6. Bartels M., Birch-Hirschfeld A., Cords R. Orbita. Nebenhöhlen. Lider. Tränenorgane. Augenmuskeln. Auge und Ohr. Berlin: Verlag von Julius Springer; 1930. 745 p.
7. Sachsenweger R. Augenmuskeldrehungen. Leipzig: VEB Georg Thieme; 1966. 463 p.
8. Akimenko EV, Okunevych TA. [The relationship between eye ball size and the insertion site of extraocular muscles in 1-3-year-old children with concomitant strabismus]. [Medical and medico-pedagogical rehabilitation of children with refraction abnormalities and diseases of oculomotor system. VI scientific practical conference of pediatric ophthalmologists of Ukraine]. Lviv; 2015: 16-18. Russian.
9. Yemchenko VI, Mospan VO, Litovchenko SO et al. [Topography of the human eye surface in spherical coordinates]. Oftalmol Zh. 2005;5:75-80. Russian.
10. Yemchenko VI, Kukharenko DV, Kirilakha NG et al. [A computer programme for calculation object coordinates on the surface of the human eye]. Oftalmol Zh. 2008;4:49-52. Russian.
11. Kukharenko DV, Mospan VO, Yemchenko VI. Pat. 37269 UA, MPK A 61 B 3/00, G 09 B 23/00. [Method of calculating the coordinates of objects on the surface of the eyeball model]; owner — Kukharenko DV — 2008 06807; appl. 19.05.2008; publ. 25.11.2008, Bul. № 22. Ukrainian.