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# Comparison of surgically induced astigmatism of temporal versus superior clear corneal incisions

## *Porównanie astygmatyzmu indukowanego przez operację w przypadku otwarć od góry i skroni w przezroczystej rogówce*

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**Summary:** Purpose: Comparison of the astigmatism induced by the operation based on the 2.8 mm incisions in the clear cornea, performed by temporal approach and superior approach.

Material and methods: Retrospective analysis was performed on the group of 65 patients (41 women and 24 men), mean age 74.5 ± 7.1 years old. We studied a series of 70 eyes (32 right eyes and 38 left eyes). All of the patients underwent cataract surgery by means of ultrasonic phacoemulsification conducted at the Department of Ophthalmology, Military Health Services Institute in Warsaw, Poland within 2004-2005. Follow-up examinations took place 6 months after operation. There were DBCVA. NBCVA, intraocular pressure, anterior segment of the eye and fundus examined. Curvature of the cornea was measured by means of Javal's ophthalmometry. The results were assumed as significant in view of corneal curvature stabilization. Vector analysis of astigmatism was performed on the basis of method described by Jaffe. There was preoperative astigmatism vector (K1) and post-operative astigmatism vector (K3) calculated, as well as surgically inducted astigmatism (SIA) – vector (K2). From the group of 70 eyes, 19 were excluded from the study, where vector K1 was >1.0 D as well as four eyes, where the main opening site depended on the size and axis of K1 vector. The group of 47 eyes was divided according to the opening site into two subgroups- group I (temporal approach – 2.8 mm) – 25 eyes and group II (superior approach 2.8 mm) – 22 eyes. Statistical analysis was performed based on Statistica package 6.0 PL., using U-Mann-Whitney's test, Chi square Yates' test, Kruskal-Wailis' variance analysis, logistic regression and W Shapiro-Wilk's test.

Results: Studied groups were homogeneous with respect to age structure, sex, number of operated eyes and pre-operative size of corneal astigmatism vector K1 ($p>.05$). The mean values of SIA in group I and II were respectively: 0.63± 0.28 and 1.00 ± 0.54 and were statistically significant ($p<.05$). The mean values of K3 post-operative vector measured 6 months following the operation was: 0.54± 0.35 in the group I and 0.96 ± 0.43 in the group II. Differences between two groups show statistical significance ($p<.05$). Size of SIA has crucial influence on generating post-operative astigmatism >1.0 D ($p=.03$).

Conclusions: Clear corneal temporal approach 2.8 mm is more beneficial method comparing to superior approach of the same width, because of the scale of SIA.

**Słowa kluczowe:** analiza wektorowa, astygmatyzm indukowany operacją, otwarcie skroniowe.

**Key words:** vector analysis, surgically induced astigmatism, clear corneal temporal incision.

### Introduction

The goal of modern cataract surgery is a quick eyesight rehabilitation, to restore capability to work and function in society by patient. Removal of the cataract with simultaneous implantation of intraocular lens and limitation of iatrogenic damage to eyeball structures during surgery enable the success of this goal.

Flexible materials that are used in production of intraocular lenses have revolutionized cataract surgery. Thanks to wider usage of them, it is possible to do cataract surgery through incision in the clear cornea, which size was diminished to 2.0 mm in coaxial phacoemulsification and to 1.0 mm with application of bimanual technique. The successful diminishing of the main incision led to decrease in SIA. The size of the incision is not the only factor that has the influence on SIA, not without the meaning remains the type and mode of the post-surgical wound closure. At full length of the second plane of triplane opening, magnifies as a consequence the size of healing plane and the size of deforming forces in the cornea during healing (1, 2). Hydration or edema of the wounds during the surgery can cause corneal deformation (3, 4, 5) and even the very opening directly after it is done can change the configuration of the corneal surface in the case of thin cornea (5).

The surgical technique is a significant factor from the iatrogenic influence on SIA. It stems from the cooperation of the surgeon with the technical applications in particular equipment and anatomical relations of the eye with the surrounding structures of the orbit and eyelid. The technical solutions of nowadays emulsifiers from one side allow for minimal ultrasound energy exposure and from the other side they decrease the flow of fluids through the anterior chamber via decrease in aspiration time. The surgical technique is therefore the optimal application of both parameters. Because the connection between them is inversely proportional, decrease of ultrasound energy causes simultaneous prolongation of the aspiration time and operating time as well, and on the contrary, increase in ultrasound energy


ISSN 0023-2157 Index 362646

makes the aspiration time shorter as well as the entire operation. Consequences for the endothelial cells in both cases could be similar. Accessibility of the eye during cataract surgery depends on the depth of the orbit, prominence of the upper orbital ridge and tension of the circular muscle (1, 3, 4, 5, 6).

From the other side surgeon should avoid tension in sagittal and transverse axis of the main incision because of the damage to the cornea, which consequently have the influence on SIA. From that point the main incision has the paramount importance on the size of SIA. Amongst the many authors there is a common belief, the opening that induced astigmatism is at least in the clear temporal cornea (1, 4, 6). It comes from the best access to the eye and the greatest distance from corneal apex (3, 7). Temporal incision is not difficult for bimanual surgeons, but for surgeons with dominant one hand it is difficult to perform on the non-dominant side. From that point the operation is modified by the incision from top after changing the position or from nose without the change (3). In both cases the distance from the corneal apex is shorter and tensions in the sagittal axis of the opening could be greater in relation to clear corneal temporal incision, depending on orbit anatomy (3, 6).

The goal of this paper is the comparison of SIA in patients operated for cataract with 2.8 mm clear corneal temporal incision and 12 o'clock incision in 6 months observation.

## Materials and methods

Retrospective analysis of 70 eyes (32 right eyes and 38 left eyes) was done in 65 patients (41 females and 24 males) in the mean age of 74.5 ± 7.1 years. Patients underwent operations for cataracts with ultrasound phacoemulsification method in the Department of Ophthalmology, Military Health Service Institute in Warsaw in the years 2004-2005.

Pre-surgical examination included best corrected distance visual acuity – DBCVA and near best corrected visual acuity-NBCVA, aplanation tonometry, evaluation of the anterior and posterior segment of the eye. The power of the intraocular lens was calculated with SRK II formula based on keratometric measurements with Javal's ophthalmometer and ultrasound measurements of eye length performed with the contact method.

Phacoemulsification was performed using droplet and intra chamber anesthesia with 0.5% Xylocaine augmented with NLA. Triplane main incision 2.8 mm was done in clear temporal cornea or at 12 o'clock position. Additionally in the area of clear cornea two ancillary incisions were done.

The anterior chamber was instilled with 0.5% Xylocaine and Adrenaline and later filled with viscoelastic (Viscoat, Provisc) as a softshell method. Ultrasound phacoemulsification was performed after anterior, circular capsulorhexis 5-6.0 mm, hydrodissection and hydrodelineation were done. The cortex was removed with irrigation and bimanual aspiration. Flexible lenses were implanted into the lens capsule using 2.8 mm opening with the help of applicators. After irrigation of the anterior chamber the corneal wounds were sealed with hydratation.

Control examinations were done in day 1 after surgery and later 1, 2 and 4 weeks after surgery. DBCVA, NBCVA, intraocular pressure, anterior chamber and fundus were evaluated each time. During the first 4 weeks after surgery all patients received antibiotic with steroid and NSAID into the conjunctival sac. After 6 months from surgery control examinations were done adding measurements of corneal parameters with Javal's ophthalmometer. The results were significant for stabilization of corneal curvature after cataract surgery and included in further analysis.

The vector analysis of astigmatism was performed with Jaffe's method, developed later by other authors (8, 9, 10, 11, 12). Based on pre-surgical measurements of corneal curvature the vector of pre-surgical astigmatism $K_1$ was calculated. Six months after surgery similarly the vector of post-surgical astigmatism $K_3$ was calculated. The vector of astigmatism inducted by surgery $K_2$ was the geometric sum of vectors $K_1$ and $K_3$ and was calculated with the method proposed by Jaffe (10).

From the group of 70 eyes, 19 eyes, in which vector of pre-surgical astigmatism $K_1$ was $>1.0$ D were eliminated, as well as 4 eyes in which the place of the main opening depended on the size and vector axis $K_1$. The group of remaining 47 eyes divided into two groups depended on the placement of the main opening: group I (clear temporal corneal incision-25 eyes) and group II (12 o'clock clear corneal incision –22 eyes). Demographical data of both groups are shown in Table I.

Statistical analysis was performed with packets Statistica 6.0 PL using tests U Mann-Whitney, Yates Chi², ANOVA rank Kruskal-Wallis, logistic regression and W Shapiro-Wilk.

## Results

Studied groups were homogenous for age structure, sex, number of operated eyes and pre-surgical size of the vector of

| Dane demograficzne<br>Demographic data | Otwarcie<br>Opening | | p |
|---|---|---|---|
| | Grupa I<br>Group I | Grupa II<br>Group II | |
| Wiek (lata) / Age (y) | | | |
| Średnio ± SD<br>Mean ± SD | 76.0 ± 6.6 | 73.6 ± 6.8 | .258* |
| Zakres / Range | 56-90 | 57-84 | |
| Płeć (n) / Sex (n) | | | .836† |
| Kobiety / Female | 13(23) | 11(20) | |
| Mężczyźni / Male | 10(23) | 9(20) | |
| Oko (n) / Eye (n) | | | .846† |
| Prawe / Right | 14(25) | 12(22) | |
| Lewe / Left | 11(25) | 10(22) | |
| $K_1$ | | | |
| Średnio ± SD<br>Mean ± SD | 0.47 ± 0.23 | 0.52 ± 0.30 | .550¤ |
| Zakres / Range | 0.11-0.83 | 0.06-1.00 | |

**Tab. I.** Dane demograficzne badanych grup.
**Tab. I.** Demographic data of examined groups.

* Test U Manna-Whitneya / U Mann-Whitney's test
† Test Chi² Yatesa / Ch-square Yates' test
¤ ANOVA rang Kruskala – Wallisa / Kruskal – Wallis' ANOVA

corneal astigmatism $K_1$ (p>.05) (Table I). Mean value $K_1$ was 0.47 ± 0.23 (group I) and 0.52 ± 0.30 (group II) (Table I).

**Surgically induced astigmatism-SIA-$K_2$**

The mean values SIA in group I and II were 0.63 ± 0.28 and 1.0 ± 0.54 respectively and were significantly statistically different (p<.05) (Figure 1, Table II). In 88.0% of operated eyes in group I SIA was smaller than 1.0 D and in 48.0% was smaller or equal 0.6 D, only in 12.0% of eyes was greater than 1.0 D. In group II SIA <1.0 D was in 50.0% and <0.6 D in 22.7% of operated eyes and in as high as 50.0% of operated eyes SIA was greater than 1.0 D (Figure 2). The surgical methods used are reproducible, distribution of vector $K_2$ in group I and II fits within the criteria of normal distribution (p>.05) (Figure 2). Upper confidence interval for mean value in group I (CI 0.51-0.74) is at the same time lower interval border for group II (CI 0.75-1.23) in 95% probability (95% CI).

**Post-surgical corneal astigmatism-$K_3$**

The mean values of post-surgical astigmatism vector 6 months after operation were 0.54 ± 0.35 in group I and 0.96 ± 0.43 in group II. The difference between the groups shows statistical significance (p<.05) (Figure 3, Table III). In 88.0% of the operated eyes in group I post-surgical astigmatism was smaller than 1.0 D, and in 76.0% of the eyes was smaller or equal to 0.6 D, and in 12.0% was greater than 1.0 D. In group II vector $K_3$ < 1.0 D was in 59.1%, smaller or equal to 0.6 D in 27.3% and greater than 1.0 D in 41.9% of operated eyes (Figure 4). The influence on the size of post-surgical vector of astigmatism $K_3$ was verified with logistic regression. SIA has decisive influence on development of post-surgical astigmatism

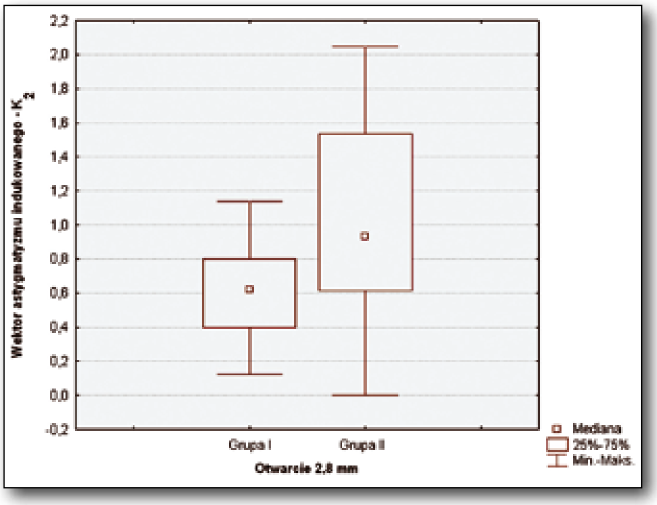


**Fig. 1.** Surgically induced astigmatism in examined groups.
**Ryc. 1.** SIA w badanych grupach.

| SIA | Otwarcie / Opening | | p |
|---|---|---|---|
| | Grupa I / Group I | Grupa II / Group II | |
| Średnio ± SD / Mean ± SD | 0.63 ± 0.28 | 1.00 ± 0.54 | .011* |
| Zakres / Range | 0.12-1.14 | 0.00-2.01 | |

**Tab. II.** Średnie wartości SIA w badanych grupach.
**Tab. II.** Mean surgically induced astigmatism values in examined groups.

* ANOVA rang Kruskala – Wallisa / Kruskal – Wallis' ANOVA

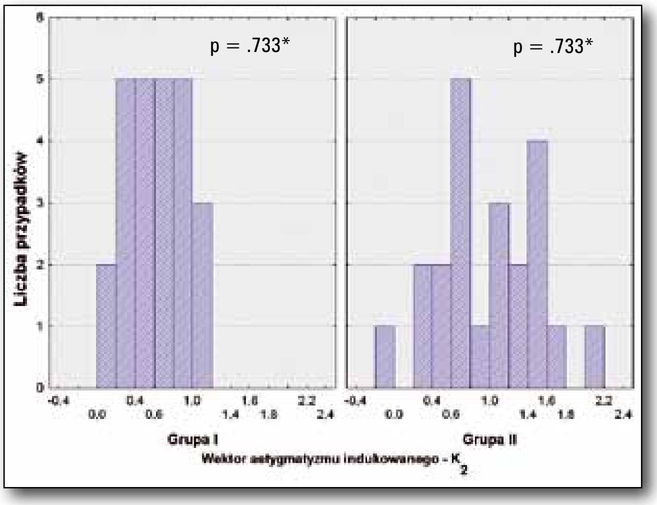


**Fig. 2.** Distribution of surgically induced astigmatism in examined groups.
**Ryc. 2.** Rozkład SIA w badanych grupach.

* Test W Shapiro – Wilka / W Shapiro – Wilk's test

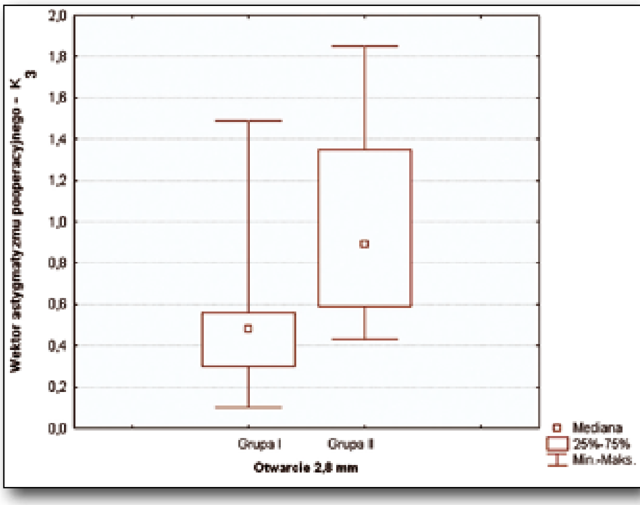


**Fig. 3.** Postoperative values of astigmatism vector $K_3$ in examined groups.
**Ryc. 3.** Pooperacyjny wektor astygmatyzmu $K_3$ w badanych grupach.

| Astygmatyzm pooperacyjny $K_3$ / Preop. astigmatism $K_3$ | Otwarcie / Opening | | p |
|---|---|---|---|
| | Grupa I / Group I | Grupa II / Group II | |
| Średnio ± SD / Mean ± SD | 0.54 ± 0.35 | 0.96 ± 0.43 | .000* |
| Zakres / Range | 0.10-1.49 | 0.43-1.85 | |

**Tab. III.** Średnie wartości wektora $K_3$ w badanych grupach.
**Tab. III.** Mean vector $K_3$ values in examined groups.

* ANOVA rang Kruskala – Wallisa / Kruskal – Wallis' ANOVA


ISSN 0023-2157 Index 362646

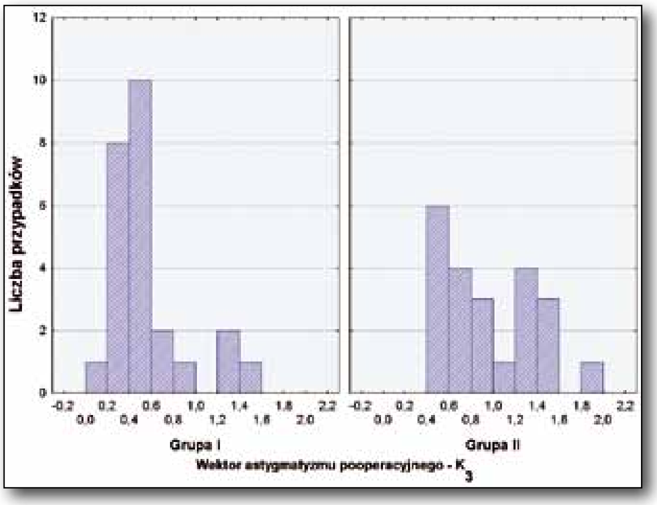


**Fig. 4.** Distribution of vector $K_3$ in examined groups.
**Ryc. 4.** Rozkład wektora $K_3$ w badanych grupach.

greater than 1.0 D (p=.003). On the other hand the influence of the vector $K_1$ on post-surgical astigmatism >1.0 D is statistically non-significant (p=.426), which was also postulated in this work (Table I).

### Discussion

The best advantage of the clear corneal temporal incision for bimanual surgeons is no doubt the best access to the eye during surgery (13). The capability of independent use of hands allows to solve other different surgical situations in the most efficient and uncomplicated way, therefore it should be the goal in the training of cataract surgeons. On the other hand elongation of the studies would lose its value if done only for the purpose of medical art.

Amongst many authors there is a common belief that clear corneal temporal incision is the most advantageous and the least interfering in pre-surgical corneal curvature, and consequently its influence on the size of SIA is the smallest without the consideration of the size of the incision (1-6). Borasio et al. think, that up to 2.6 D of pre-surgical astigmatism with the incision 3.2 mm there is no difference between the clear corneal temporal and the incision in the positive axis of astigmatism (13). Despite the fact that SIA in the group with the incision on axis was 0.63 D and in the group of clear corneal temporal incision was 0.34 D and results were statistically significant, there was no influence on end-point visual acuity in studied groups. Therefore Borasio et al. recommend clear corneal temporal incision with pre-surgical astigmatism of up to 2.6 D (13). SIA in group I in our studies was calculated after 6 months from the operation and was 0.63 D. The short observation period in Borasio's work, which was only 7 weeks is long enough to compare the groups, but it is difficult to accept as final result. SIA in Cohen's et al. studies after 6 months observation was in the clear corneal temporal group 0.47 D but in 12 o'clock and nose incision was 1.05 D (6). The results were based on topographical studies of the central 3.0 mm corneal zone and showed significant difference between the groups. The differences statistically significant affected SIA in the zone between 3-5.0 mm from the corneal center and were 0.5 D and 1.01 D respectively (6). Work by Kohen et al. was done after phacoemulsification from corneo-scleral tunel 3.6 to 3.8 mm, they confirm advantage of clear corneal incision in relation to upper-nasal quadrant incision (6), although it is difficult to compare our studies. The similar trend shows in the work by Barequet et al.[1]. In the group of clear corneal temporal incision SIA after 6 weeks was 0.85 D, but in upper-nasal incision generated astigmatism 1.6 D. After 12 months SIA was 0.81 D and 1.29 D in groups respectively (1). It is important observation by Barequet et al.(1) and Kohen et al.(6) that upper-nasal incision has greater influence on astigmatism induction with-the-rule (WTR) than clear corneal temporal incision (1,6). In the work by Ermis et al. there was no difference in SIA in groups with the upper-temporal incision and upper-nasal incision in transparent cornea 3.3-3.5 mm (3). SIA mean values after 6 months from surgery were 0.78 D and 0.77 D. The authors state statistically significant difference between horizontal component of SIA in the studied groups. In the upper-nasal group it was from 0.38 ± 0.39 in the first week after surgery to 0.24 ± 0.21D after 6 months, which, according to authors, had the influence on fluctuation of astigmatism axis in post-surgical time (3). In comparative studies by Lyhna et al. SIA in the group of clear corneal temporal incision was 0.41 D with the incision size of 4.0 mm, but the corneo-scleral incision from top and the same size generated astigmatism 0.61 D and the results were statistically significant (4). The small difference SIA between studied groups was the result of a shift of the incision of the eye into the sclera 2.5 mm posteriorly from corneal limbus (4). The incision 2.8 mm in clear cornea at 12 o'clock, that we used in our studies caused the induction of astigmatism in the range of 1.0 D. Lyhna et al. think that incision at 12 o'clock inducts against-the-rule (ATR) astigmatism, which is worse tolerated by patients (4). The clear corneal 12 o'clock incision 3.0 mm in children over 6 years old generates astigmatism 0.75 D after 6 months from surgery, but in children between 12-36 months old SIA was 0.00 D after 6 months and 0.17 D after 12 months from surgery (14). Bradfield et al. think that smaller SIA is the result of greater elasticity of the child's cornea, its immaturity and capability to rebuild, that is not available in adults (14).

In refractive cataract surgery the most important element is reproducibility, that has the impact on the shape of corneal surface, SIA and ultimately the quality of final visual ability of the patient after surgery (5). Our studies confirmed, that clear corneal temporal incision as well as 12 o'clock incision 2.8 mm fulfill this criteria (Fig. 2). 12 o'clock incision is not recommended in routine cataract surgery, but it can be useful in small WTR astigmatisms, because of greater SIA (13, 15). The clear corneal temporal incision seems to be universal because of its advantages and is useful in routine cataract surgery as well as in refractive surgery of the lens.

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Praca wpłynęła do Redakcji 09.08.2006 r. (869)
Zakwalifikowano do druku 24.10.2006 r.

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ISSN 0023-2157 Index 362646