(54)

Evaluation of surgically induced astigmatism after coaxial phacoemulsification through 1.8 mm microincision and standard phacoemulsification through 2.75 mm incision

Ocena astygmatyzmu indukowanego chirurgicznie po koaksjalnej fakoemulsyfikacji przez mikrocięcie 1,8 mm i standardowej fakoemulsyfikacji przez cięcie 2,75 mm

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Summary: Improvements in technology connected with cataract surgery have made it possible to decrease significantly the size of corneal incision created during phacoemulsification. Recently, coaxial phacoemulsification through a 1.8 mm microincision (C-MICS) has been introduced. This technique is perceived as the next step in development of phacoemulsification.

Purpose: To compare surgically induced astigmatism (SIA) after coaxial 1.8 mm microincision cataract surgery (C-MICS) and standard phacoemulsification through 2.75 mm incision, calculated with three mathematical methods.

Material and methods: A consecutive, prospective series of 55 eyes of 55 patients who underwent uneventful C-MICS with foldable IOL implantation using 1.8 mm temporal clear corneal incision were included in group 1.

Reference group (group 2) included 55 eyes of 55 patients who underwent uneventful phacoemulsification through 2.75 mm temporal clear corneal incision with a foldable IOL implantation. SIA was calculated using three methods.

Results: All patients had uneventful surgery and were examined before the surgery and one month postoperatively. There was a significant postoperative increase in corrected distance visual acuity in both groups ($p<0.01$), and the visual outcomes in both groups were similar ($p>0.05$).

In vector analysis, mean SIA was 0.42 ± 0.30 in group 1 and 0.77 ± 0.55 in group 2. In vector decomposition, the mean SIA (C90) in group 1 was 0.24 ± 0.29 and 0.49 ± 0.54 in group 2 ($p<0.05$). In Naeser's polar values method, ΔKP-0 was -0.06 ± 0.43 in group 1 and -0.21 ± 0.84 in group 2 ($p>0.05$).

Conclusions: 1.8 mm coaxial MICS induces a significantly smaller value of SIA than standard 2.75 mm phacoemulsification.

Key words: Surgically induced astigmatism, microincision, coaxial MICS, standard phacoemulsification.

Streszczenie: Wstęp: rozwój urządzeń i technik stosowanych w chirurgii zaćmy umożliwił znaczące zmniejszenie wielkości cięcia operacyjnego w fakoemulsyfikacji. W ostatnim czasie wprowadzono fakoemulsyfikację przez mikrocięcie o szerokości 1,8 mm. Technikę tę powszechnie uznaje się za kolejny krok w rozwoju chirurgii zaćmy.

Cel pracy: ocena astygmatyzmu indukowanego chirurgicznie (SIA) po koaksjalnej fakoemulsyfikacji zaćmy przez mikrocięcie 1,8 mm (C-MICS) oraz standardowej fakoemulsyfikacji przez cięcie 2,75 mm, który obliczano trzema metodami matematycznymi.

Materiał i metody: badana grupa (grupa 1.) liczyła 55 oczu 55 pacjentów, którzy zostali poddani koaksjalnej fakoemulsyfikacji przez skroniowe mikrocięcie w czystej rogówce o szerokości 1,8 mm (C-MICS), z wszczepieniem zwijalnej soczewki wewnątrzgałkowej.

Grupa porównawcza (grupa 2.) liczyła 55 oczu 55 pacjentów, którzy poddani zostali standardowej fakoemulsyfikacji przez cięcie w czystej rogówce, o szerokości 2,75 mm, z wszczepieniem zwijalnej soczewki wewnątrzgałkowej. Astygmatyzm indukowany obliczono trzema metodami matematycznymi.

Wyniki: u wszystkich pacjentów zabieg był niepowikłany, chorych badano przed zabiegiem oraz miesiąc po zabiegu. U pacjentów w obu grupach stwierdzono istotną poprawę skorygowanej ostrości wzroku ($p<0,01$), wyniki czynnościowe były zbliżone ($p>0,05$).

Analiza wektorowa wykazała, że średni SIA wyniósł 0,42 ± 0,30 u pacjentów w grupie 1. oraz 0,77 ± 0,55 u pacjentów w grupie 2. Średni SIA (C90) mierzony metodą dekompozycji wektora u pacjentów w grupie 1. wyniósł 0,24 ± 0,29, w grupie 2. zaś – 0,49 ± 0,54 ($p<0,05$). Wartość ΔKP-0 obliczona metodą wartości biegunowych Naesera u pacjentów w grupie 1. wyniosła -0,06 ± 0,43, w grupie 2. zaś -0,21±0,84 ($p>0,05$).

Wnioski: koaksjalna fakoemulsyfikacja zaćmy przez mikrocięcie 1,8 mm indukuje astygmatyzm znacząco mniejszy niż standardowa fakoemulsyfikacja przez cięcie 2,75 mm.

Słowa kluczowe: astygmatyzm indukowany chirurgicznie, C-MICS, standardowa fakoemulsyfikacja.

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Introduction

Improvements in technology connected with cataract surgery have made it possible to decrease significantly the size of corneal incision created during phacoemulsification (1).

Coaxial phacoemulsification performed through a 1.8 mm microincision has been introduced recently. This technique is referred to as coaxial MICS or C-MICS and it is perceived as the next step in development of phacoemulsification.

Alio (2,3) defined MICS technique as any phacoemulsification, which uses an incision of width smaller than 2 mm. It is thought that the main advantage of C-MICS is that this surgical technique is technically similar to standard phacoemulsification and its supposed smaller influence on SIA (4).

It is known that surgically induced astigmatism (SIA) may decrease uncorrected distance visual acuity and require refractive correction, which may decrease patient satisfaction from the surgery.

To date, in order to better evaluate the problem of SIA, many methods of its calculation have been created (5-21). In the literature different methods of calculating SIA may be encountered, therefore, comparison of some of the results is sometimes impossible.

In order to perform an in-depth analysis of SIA and to compare the results with other studies, we decided to use three methods of SIA calculation – vector analysis method, vector decomposition method (C_{90}) and Naeser's polar values method (∆KP-0 and ∆KP-45) (11,13,14).

Purpose

The aim of this study was to analyse with three mathematical methods and compare SIA after uneventful coaxial phacoemulsification performed through the 1.8 mm temporal microincision and standard phacoemulsification performed through the 2.75 mm temporal clear corneal incision.

Material and methods

The study is based on a non-randomised, prospective, consecutive series of patients.

Fifty five eyes of 55 patients who underwent uneventful coaxial phacoemulsification (C-MICS) with a foldable IOL implantation (Akreos® MI60, Bausch & Lomb) through 1.8 mm temporal clear corneal microincision were recruited to the examined group (Group 1). This group consisted of 32 women (58.2%) and 23 men (41.2%) aged from 54 to 84 years old (mean = 73.3, SD = ± 8.3 years).

Group 2 (reference group) consisted of 55 eyes of 55 patients who underwent uneventful standard phacoemulsification through 2.75 mm temporal clear corneal incision with a foldable IOL implantation (Akreos Adapt AO, Bausch & Lomb). Group 2 included 33 women (60.0%) and 22 men (40.0%) at the age ranging from 46 to 84 years old (mean = 67.8, SD = ± 9.7 years).

Examinations were performed prior to the surgery and from two weeks to one month postoperatively.

The keratometry was performed using Javal's keratometer in the central part of the cornea, before the surgery and during the final visit. Examinations also included distance corrected Snellen visual acuity (CDVA) and autorefractometry, tonometry and biomicroscopy of the anterior and posterior segment.

Three different methods were used for calculation of surgically induced astigmatism (SIA): vector analysis method, vector decomposition method (C_{90}), Naeser's polar values method (∆KP-0 and ∆KP-45) (11,13,14).

In all patients from both groups, the degree of nuclear and cortical opacification was evaluated according to LOCS II scale and was similar (NI-NII and CII-CIII). Two experienced surgeons (A.S. and W.O.) performed all cataract surgeries under local, topical proxymetacaine hydrochloride (Alcaine) drops, Lidocaine gel 2% and intracameral (Lidocaine 1% solution) anaesthesia. Before the surgery, in all patients pupils were dilated using a solution of Tropicamide and phenylephrine (NeoSynephrine). Hydroxypropyl methylcellulose 2% (Celoftal, Alcon) was used as an ophthalmic viscosurgical device (OVD) and balanced salt solution (BSS) was used as the infusion fluid.

All patients were operated using burst mode of phacoemulsification and "stop and chop" technique of dividing the nucleus. Surgical settings were the same in all patients from both groups – aspiration flow was set at 25 cm^3/min and vacuum at 400 mmHg. In all eyes from the same group, the same type of metal keratome was used, all incisions were self-sealing and sutureless. Exclusion criteria were: previous intraocular surgery, corneal disorders and a history of ocular trauma.

In the C-MICS group a trapezoidal 1.8 mm metal keratome (E7600, Bausch & Lomb) was used to create a self-sealing 1.8 mm wide clear corneal incision temporally. Continuous curvilinear capsulorrhexis was created with micro-forceps (Bausch & Lomb) under protection of an OVD. A 20-gauge MVR blade was used to create two side-ports for bimanual aspiration and irrigation tips, in the clear cornea, 90 degrees away from the main incision. Phacoemulsification and aspiration were performed and a single-piece acrylic foldable lens (MI60®, Bausch & Lomb) was implanted through the main incision with an injector (1.8 mm Viscoject, Medicel) in a wound-assisted manner.

Similarly, in the conventional coaxial phacoemulsification group, a self-sealing 2.75 mm wide clear corneal incision was created temporally with a 2.75 mm ClearCut™ Dual Bevel (Alcon) metal slit knife. Continuous curvilinear capsulorrhexis was done with Utrata forceps under protection of an OVD. Two side-ports were created with a 20-gauge MVR blade in the clear cornea, 90 degrees away from the main incision, for bimanual aspiration and irrigation tips. Phacoemulsification and aspiration were then performed and a single-piece acrylic foldable lens (Akreos Adapt AO) was implanted with an injector (AI-28, Bausch & Lomb) through the main incision.

Postoperative treatment was the same in all patients and included topical combination of neomycin-polymyxin B-dexamethasone (Maxitrol) eyedrops 4 times daily for 3 weeks after the surgery.

Statistical analysis was performed using parametric tests. Changes of pre- and postoperative values in the same group were compared using two-tailed Student t test for two paired samples and statistical significance between two groups was determined using two-tailed Student t test for independent samples. All calculations were performed for the significance level $\alpha = 0.05$ using Microsoft Excel and Addinsoft XLStat 2008 software. A P value less than 0.05 was considered statistically significant. Individual vectors in vector analysis were drawn using Polar Plotter v.1.7 add-in for Microsoft Excel.

Results

All examined patients from both groups underwent uneventful surgery – there were no corneal burns nor any other complication observed in any patient. Preoperative CDVA in coaxial MICS group was 0.33 ± 0.28, whereas in standard phacoemulsification group it was 0.28 ± 0.22. No statistical significance in mean CDVA between the two groups was found ($p>0.05$). Postoperative CDVA in coaxial MICS group was 0.92 ± 0.19 and in standard phacoemulsification group it was 0.95 ± 0.14. In both groups CDVA increased significantly after the surgery ($p<0.001$). We found no significant difference in postoperative CDVA between the two groups ($p>0.05$), visual results were similar.

Values of pre- and postoperative astigmatism are shown in Tables I and II. With-the-rule astigmatism predominated in both groups before and after the surgery. In C-MICS group there was no difference between mean pre- and postoperative astigmatism ($p>0.05$), whereas in standard phaco group postoperative astigmatism was significantly higher in comparison to preoperative values ($p<0.05$).

Values of surgically induced astigmatism calculated with different methods are shown in Table III.

Technique/ Technika	Astigmatism/ Astygmatyzm	Preoperative/ Przedoperacyjny		Postoperative/ Pooperacyjny	
		n	%	n	%
Coaxial MICS	With-the-rule/ Prosty	29	52.73	33	60.00
	Against-the-rule/ Odwrotny	19	34.55	18	32.73
	Oblique/ Skośny	7	12.73	4	7.27
Standard Phaco	With-the-rule/ Prosty	32	58.18	35	63.64
	Against-the-rule/ Odwrotny	20	36.36	14	25.45
	Oblique/ Skośny	3	5.45	6	10.91

Tab. I. Percentage of types of pre- and postoperative astigmatism in both groups (D).
Tab. I. Udział procentowy poszczególnych rodzajów astygmatyzmu przed zabiegiem i po zabiegu (D).

	Preoperative		Postoperative		
	Mean	SD	Mean	SD	p
Coaxial MICS	0.63	0.48	0.68	0.47	> 0.05
Standard Phaco	0.64	0.51	0.82	0.51	< 0.01

Tab. II. Pre- and postoperative astigmatism in both groups (D).
Tab. II. Astygmatyzm przed- i pooperacyjny u pacjentów w obu grupach (D).

SIA calculation/ Obliczenia SIA	Group 1 C-MICS	Group 2 standard Phaco/ standardowa fakoemulsyfikacja	P
Vector Analysis/ Analiza wektorowa	0.42 ± 0.30	0.77 ± 0.55	p<0.05
Vector decomposition (C-90)/ Dekompozycja wektora (C-90)	0.24 ± 0.29	0.49 ± 0.54	p<0.05
Naeser's method (ΔKP-0)/ Metoda Naesera (ΔKP-0)	-0.06 ± 0.44	-0.21 ± 0.84	p>0.05
Naeser's method (ΔKP-45)/ Metoda Naesera (ΔKP-45)	-0.03 ± 0.27	0.01 ± 0.40	p>0.05

Tab. III. Values of surgically induced astigmatism (Mean ± SD).
Tab. III. Wartości astygmatyzmu indukowanego chirurgicznie (Średnia ± SD).

The mean SIA calculated by vector analysis in coaxial MICS group was 0.42 ± 0.30 and in standard phacoemulsification group was 0.77 ± 0.55. The difference was significant ($p<0.05$) (Fig. 1). This suggests that because the width of corneal incision in standard phacoemulsification is higher, it induces a higher value of SIA than a microincision in coaxial MICS. Individual vectors in vector analysis of SIA for both groups are shown in figure 2. In C-MICS group SIA calculated by vector analysis was smaller than 1.00 D in 94.5% of eyes (n = 52) and SIA smaller than 0.50 D was present in 63% of eyes (n = 35). In standard phaco group these values were different. SIA calculated by vector analysis was smaller than 1.00 D in 69% of eyes (n = 38) and SIA smaller than 0.50 D was present in 38% of eyes (n = 21) (Fig. 3).

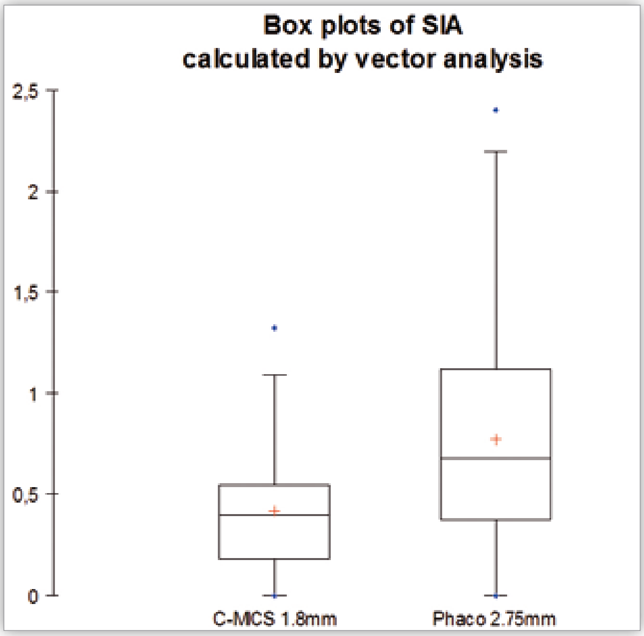

Fig. 1. Box plots of SIA calculated with vector analysis in both groups (Mean ±SD) (D).
Ryc. 1. Wykresy SIA obliczonego analizą wektorową w obu grupach (Średnia ±SD) (D).

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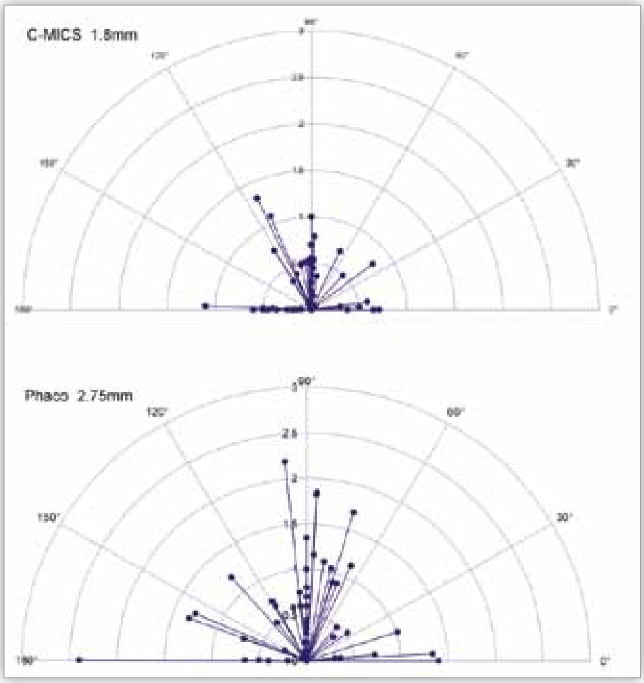

Fig. 2. Individual vectors in vector analysis of SIA in both groups.
Ryc. 2. Poszczególne wektory w analizie wektorowej SIA u pacjentów w obu grupach.

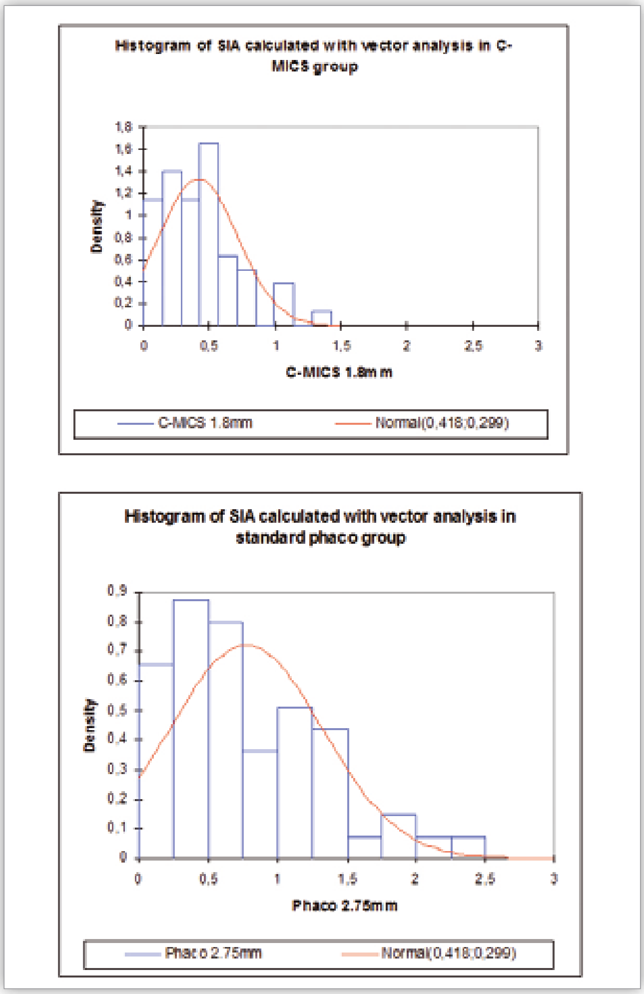

Fig. 3. Histograms of SIA calculated with vector analysis in both groups.
Ryc. 3. Histogramy SIA w analizie wektorowej u pacjentów w obu grupach.

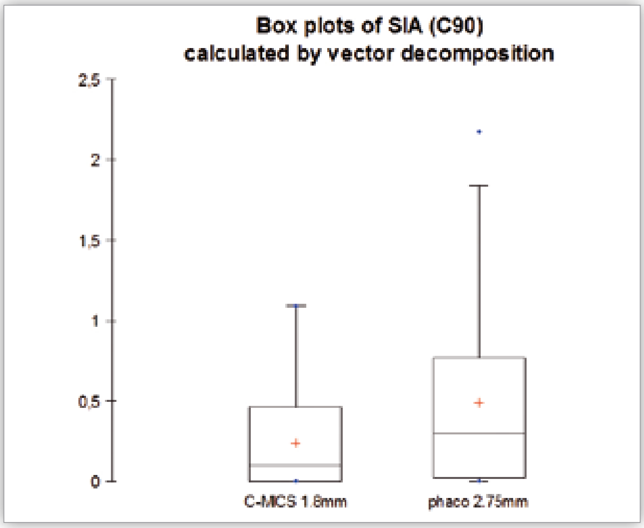

Fig. 4. SIA (C90) calculated with vector decomposition in both groups (Mean ± SD) (D).
Ryc. 4. SIA (C90) obliczony dekompozycją wektora u pacjentów w obu grupach (Średnia ± SD) (D).

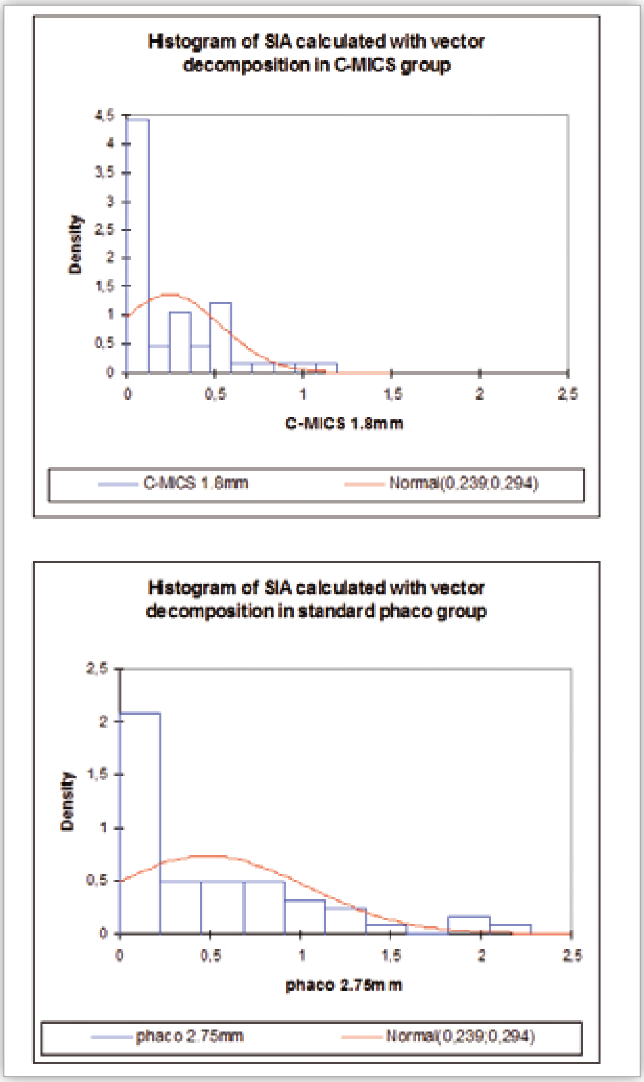

Fig. 5. Histograms of SIA (C90) calculated with vector decomposition in both groups.
Ryc. 5. Histogramy SIA (C90) obliczonego dekompozycją wektora u pacjentów w obu grupach.

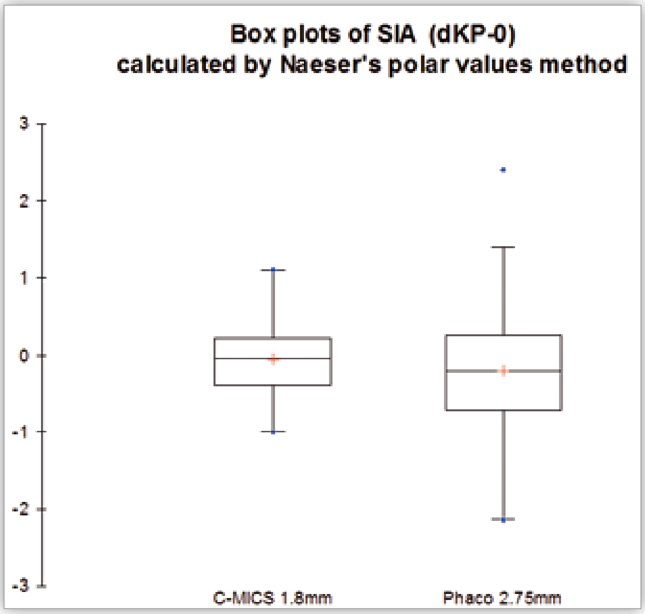

Fig. 6. SIA (ΔKP-0) calculated with Naeser's polar values method in both groups (Mean ± SD).

Ryc. 6. (ΔKP-0) obliczony metodą wartości biegunowych Naesera u pacjentów w obu grupach (średnia ± SD).

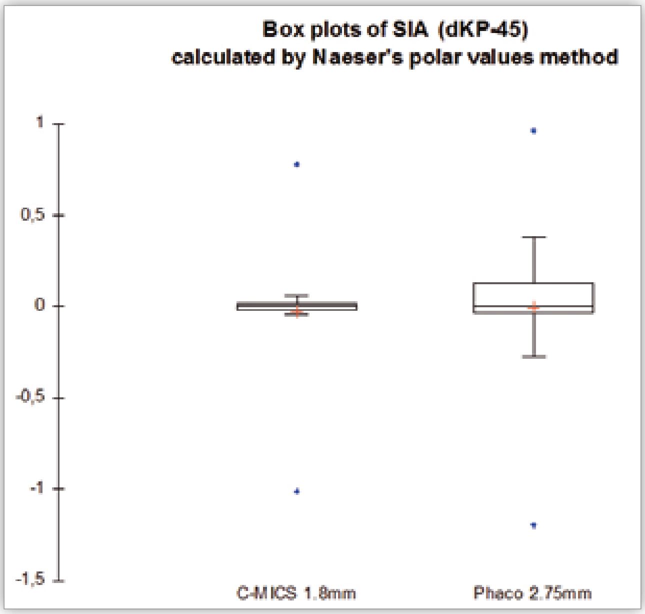

Fig. 7. SIA (ΔKP-45) calculated with Naeser's polar values method in both groups (Mean ±SD) (D).

Ryc. 7. SIA (ΔKP-45) obliczony metodą wartości biegunowych Naesera u pacjentów w obu grupach (średnia ± SD).

In the vector decomposition method, the mean SIA (C_{90}) in the coaxial MICS group was 0.24 ± 0.29 and was significantly smaller ($p<0.05$) than the mean SIA in the standard phacoemulsification group, which amounted to 0.49 ± 0.54 (Fig. 4, 5).

The polar values method assumes that, in case of regular astigmatism, any cylinder can be uniquely characterised by 2 polar values separaded by an arch of 45 degrees and SIA is the difference between pre- and postoperative polar values (13,14).

In Naeser's polar values method, ΔKP-0 was calculated, which takes into account a shift of axis of astigmatism (towards the "against-the-rule" astigmatism, ATR). Positive sign of ΔKP-0 values means a shift of axis toward ATR astigmatism, negative values mean a shift toward "with-the-rule" astigmatism (WTR). We found that ΔKP-0 amounted to -0.06 ± 0.43 in coaxial MICS group and -0.21 ± 0.84 in the standard phacoemulsification group (Fig. 6). The difference in mean ΔKP-0 in Naeser's polar values method between both groups was insignificant ($p>0.05$). Values of ΔKP-0 were concentrated around zero in C-MICS group, whereas values in standard phaco had higher spread. This fact was reflected by a higher SD value in standard phaco group (0.44 in C-MICS and 0.84 in standard phaco), a higher median (-0.05 in C-MICS and -0.20 in standard phaco group) and higher variance (0.19 in C-MICS and 0.69 in standard phaco group).

In order to check rotation of the cylinder axis, ΔKP-45 was calculated (polar value of SIA at 45 degrees) (Fig. 7). It was found that ΔKP-45 amounted to -0.03 ± 0.27 in C-MICS and 0.01 ± 0.40 in standard phaco group ($p>0.05$). There is almost no induced cylinder rotation in both groups.

Discussion

The development of surgical techniques in modern cataract surgery is connected with the reduction of surgical trauma. It is known that any corneal incisions can alter its curvature and that smaller incisions tend to induce smaller values of astigmatism, therefore, a continuous decrease of the width of corneal incision used for phacoemulsification was an important part of this evolution.

Currently, conventional phacoemulsification requires creating a corneal incision approximately 2.8 mm wide. Alio et al. defined the term MICS as phacoemulsification which is performed through an incision smaller than (2,3). Currently, there are two techniques of phacoemulsification which utilize microincision: bimanual (or biaxial) microincision cataract surgery (B-MICS) and coaxial MICS (C-MICS).

Many factors (e.g. preoperative astigmatism, size and localization of the incision) may influence the final refractive result of the surgery. In addition, the mathematical method used for calculation of SIA influences the obtained value.

The aim of this study was to compare SIA after coaxial 1.8 mm temporal microincision cataract surgery and conventional phacoemulsification through a temporal 2.75 mm clear corneal incision. In all patients from both groups the same surgical settings, the same type of OVD and the same type of irrigating solution were used. All surgeries were uneventful, there were neither intraoperative nor postoperative complications in any case.

In our study, according to vector analysis and vector decomposition, the mean SIA in the C-MICS group and the mean SIA in the conventional phacoemulsification group were significantly different ($p<0.05$), which suggests that due to a higher width of corneal incision in the conventional phacoemulsification (2.75 mm), it induces a significantly higher value of SIA than a 1.8 mm microincision in the C-MICS technique. At the same time, the differences in ΔKP-0 and ΔKP-45 in Naeser's polar values method between both groups was insignificant ($p>0.05$), which suggests that in the examined groups corneal incisions of different width but similar localization induced

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a small value of induced astigmatism and almost no axis shift. Nevertheless, ∆KP-0 was slightly higher in standard phaco group and had a negative value, meaning a slightly higher WTR shift in this group. These results also confirm a known fact that temporal incisions induce WTR shift of astigmatism.

Alio et al. (3) examined 100 eyes and found that SIA after conventional phaco calculated by vector analysis amounted to as much as 1.20 D, which is a significantly higher value than in our conventional phaco group (0.77 D).

Cavallini et al. (22) found 0.72 D of SIA calculated by vector analysis after 2.2 mm coaxial phacoemulsification 1 month postoperatively, which is similar to our results.

In contrast, Morcillo-Laiz et al. (23) found that SIA calculated by vector analysis, 1 month after the surgery, amounted to 0.49 ± 0.38 D after standard 2.8 mm coaxial phacoemulsification (43 eyes) and 0.48 ± 0.37 D after B-MICS (51 eyes). The authors did not find a significant difference between the groups.

Yao et al. (24) conducted a study on 60 eyes and found that SIA after 3.2 mm phacoemulsification amounted to as much as 1.29 ± 0.68 D, whereas SIA after 1.8 mm MICS was significantly smaller and amounted to 0.75 ± 0.38 D. These values are significantly higher than our results.

We found that C-MICS technique is safe, it enables to achieve excellent visual results and it is an excellent alternative to conventional phacoemulsification, which confirms results of other studies (2-4,25-27). Temporal incisions induce WTR astigmatism, which was reflected by negative value of ∆KP-0 (Naeser's method).

Conclusions

To the best of our knowledge, this is the first study in which vector decomposition method and Naeser's polar values method is used to compare 1.8mm microincision in C-MICS technique with the incision used during the standard phacoemulsification.

We found that the amount of SIA induced by both techniques is small, however, 1.8 mm coaxial MICS induces a significantly smaller value of SIA than standard 2.75 mm phacoemulsification and almost no axis shift.

Although standard 2.75 mm coaxial phacoemulsification offers very good clinical results and a small amount of SIA in terms of irrelative values, C-MICS is an excellent alternative inducing even smaller values of SIA which might further increase patients' satisfaction from cataract surgery.

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