Abstract

The purpose of this article is to evaluate the role of the corneal incision in the development of the induced astigmatism after the cataract surgery made by phacoemulsification method.

Material and method: I have conducted a retrospective study using cases from the Optilens Clinic of Ophthalmology, Cluj-Napoca, between 2009 and 2011, including 169 patients with primitive cataract. The dimensions of the incisions were of 2.75 mm, 2.2 mm and 1.8 mm with different locations, depending on the preexisting astigmatism or on the surgeon’s preferences.

Results: The chart regarding the global analysis of the postoperative astigmatism values sum, showed a decrease from the preoperative astigmatism values sum (92,25 and 106,502). Postoperative, there has been a prevailing against-the-rule astigmatism (62.5%) comparative with preoperative, when the with-the-rule astigmatism was dominant (58.9%).

Conclusions: The postoperative astigmatism after cataract surgery may compromise the functional visual result, and the corneal incision’s role in the astigmatism’s release it’s not inessential.

Keywords: Induced astigmatism, corneal incision, refractive stability

Scope

The purpose of the modern cataract surgery it’s to gain rapid restoration of the visual function as well as a derogated incidence of the complications and of the postoperative refractive errors.

Along time there were numerous studies about postoperative astigmatism induced by cataract surgery, at firs based on the intracapsular extraction, and later, on the extracapsular extraction.

Introduction

A good quality of vision is one of the most precious requests of human life, which he fears the utmost that he can lose. Cataract is a major public health issue, especially in developed countries, as long as it is responsible for a large part of the total of visual acuity decreases around the world.

All over the world, the extraction of cataract represents the highest volume of work in the surgical departments of ophthalmology. The surgical extraction technique of cataract has developed progressively over time, going from intracapsular extraction to the extracapsular one. In 1949, Rayner has implanted the first artificial crystalline after the removal of cataract [1]. The extracapsular extraction of the cataract...
crystalline, with the insertion of an intraocular lens, was one of the most widely used methods, starting from 1982 until recently [2]. But this requires a larger incision with a slower postoperative recovery and less predictable postoperative functional results.

A variant of extracapsular extraction is the one through phacoemulsification, in which the removal of the cataract is made with the help of an ultrasonic device, followed by the insertion of an intraocular lens. The advanced technology led to increased use of phacoemulsification, but this required a substantial investment in the necessary surgical equipment [2]. The major advantage of the technique is the small incision, with much reduced complications and more predictable postoperative functional results.

The changes in the corneal curvature after the cataract surgery were recognized over time and the described for the first time by Donders in 1864 [3]. The surgery induced astigmatism is the astigmatism with more than one diopter, according or against the rule, which is present from six to eight weeks postoperative. This is a factor which could compromise the postoperative functional visual results [4]. The underlying factors of this type of astigmatism are pre-existing astigmatism, the presence of suture, the nature of the suture wire, location, size and configuration of the incision [5].

With the development of foldable crystalline implants, the incision in the cataract extraction through phacoemulsification, has developed from scleral incision to incision in clear cornea [6]. This method is blood free, offers easy access with good visibility of the anterior chamber during the surgical intervention. Current phacoemulsification techniques include incision with a single suture and the ones that are not sutured.

Currently, small corneal incision, not sutured, is preferred by most surgeons. Reducing the size of the incision induces the smallest postoperative astigmatism [7,8,9].

Due to recent technical improvements in the technique of phacoemulsification and in the types of artificial crystalline implant, especially the foldable ones, the extraction of cataract has transformed itself in a real refractive surgical procedure [10].

Thus, the goal of the modern cataract surgery is the rapid recovery of the visual function and a decreased incidence of postoperative complications and refractive errors.

There are a few options regarding the modulation of postoperative astigmatism during the cataract surgery, one of them being the manipulation of the incision regarding location, length, and its construction, so that it reduces the preexisting astigmatism, while performing an incisional surgery [10,11,12].

The Article’s Purpose

It’s to evaluate a group of cases operated of cataract with phacoemulsification method, in terms of the induced astigmatism, as well as the corneal incision’s role in the apparition of this type of refractive error.

Material and Method

A randomized retrospective study was conducted, on a group of 169 patients, operated of cataract, through phacoemulsification method with folded artificial crystalline implant in the anterior chamber, during a period of three years, between 2009 and 2011, at Optilens Clinic of Ophthalmology in Cluj-Napoca.

The primitive cataract cases were selected at female or male patients, with ages between 41 and 90 years old, in different stages of clinical evolution. From the study were excluded, the patients with pre-existing eye diseases or in present time as the operation, with other history of eye surgery or with ocular trauma. As related diseases were also excluded from the study patients with general illnesses which could produce ocular complications, for example, patients with diabetes, etc. There have been cases with underlying conditions such as hypertension, hyperlipidaemia, cardiovascular disease, advanced age specific, but have not been quantified, because they do not influence cataract development or postoperative outcome.

The follow-up period of the patients was for 6-8 weeks postoperative.

The surgical access was made by incisions in clear cornea, with dimensions of 2.75 mm, 2.2 mm and 1.8 mm, with different locations: superior, supero-nasal, supero-temporal and nasal. The incisions site selection was randomly made based on the surgeon’s preference or in some cases on the stepper corneal meridian when the preexistent astigmatism was significant. At the end of the operation, the corneal incision was sealed by stromal hydration.

Preoperative were evaluated: the visual acuity with and without optimal correction, the
magnification, the ophthalmoscopy, the keratometry, the intraocular pressure and the ocular biometry. Postoperative were determined the visual acuity, corrected and uncorrected, the autorefractometry and the keratometry.

The parameters taken into consideration were: the clinical type of cataract, the dimension of the corneal incision, the location of the incision, the preexistent corneal astigmatism, the induced astigmatic changes, the postoperative visual acuity, optimal corrected and uncorrected, and also the postoperative values of the spherical equivalent.

The calculation of the standard errors was made using the Anova formula, settling the sum and the average of the postoperative astigmatism, based on study groups (depending on the dimension of the incision) in relation with two variables.

**Results**

It was made an analysis of the selected cases and a distribution according to the studied parameters.

1. There was a slight predominance of female patients, 58%, compared to the male ones, 42% (Fig. 1).

2. The age of the patients ranged from 40 years and 90 years, and was divided by decades of age. The cases of cataract patients with ages ranging between 61 and 70 years and the ones ranging from 71-80 years were predominant. Fewer cases were discovered at patients with ages over 80 years (Fig. 2).

3. The three forms of clinical primitive cataract: cortical, nuclear and posterior subcapsular, had an almost equal distribution (36%, 31% and 33%).

4. Most existing astigmatism values ranged from 0.00 diopters and 0.75 diopters, 68.7% (1.2% plus 67.5%) (Fig. 3).

5. Regarding the clinical form of preoperative astigmatism, the ones according to the rule prevailed (58.0%), contrary to the rule (40.8%), the remaining 1.2% being neutral astigmic (Fig. 4).

6. The axes of the preoperative astigmatism were mostly in oblique
7. Incisions of 2.2 mm and 2.75 mm had an almost equal distribution (42.0% and 43.2% respectively). Incisions of 1.8 mm were 14.8% of total, being more rarely practiced (Fig. 6).

8. The locations of the incisions were predominantly supero-temporal and superior (43.8% and 47.3%) and more rarely supero-nasal and nasal (4.7% and 4.2%).

9. The analysis of the postoperative astigmatism showed the fact that values between 0.00 -> ± 0.75 diopters were 63.3% (18.3% + 45.5% respectively) of the total, those between 1.00 ± -> ± 2.00 diopters were 35.5% and values over ± 2.00 diopters were only at a rate of 1.2% (Fig. 7).

10. It was taken into consideration a change in the distribution of the postoperative astigmatism’s axes, with a predominance of the straight axes (59.2%), compared with preoperative astigmatism when oblique axes were predominant.

11. There is a reversal of clinical type of astigmatism after surgery, 61.5% against the rule, to 58.0% according to the rules, as preoperatively (Fig. 8).

12. The best AV without correction was found in 39.6% of cases. Regarding the spherical equivalent, the values between 0.00 -> ± 0.75 D had the largest share, with a rate of 64.5% of all cases. Values of ± 1.00 D-> ± 2.00 D ratio were 26.6% and over 2.00 D were 3.0% (Fig. 9).

13. Making an overall analysis of the refractive changes after cataract surgery on the group of cases studied, it was fond that the sum of the postoperative astigmatism’s values was significantly lower (97.25) than the sum of the values of the preoperative astigmatism (106.502). The same aspect was also observed at the average of the values (0.5754 at postoperative astigmatism compared to 0.6301 at preoperative astigmatism), p=0.477.

14. The astigmat analysis based on the location and dimension of the incision.

a) Supero-temporal location
In the case of the 1.8 mm incision in this location, the sum of the postoperative ATG was significantly lower (20.252) from the preoperative ATG preoperatively (7.75) (Tab. I), \( p = 0.0004 \).

The incision of 2.2 mm in this location, the amount of postoperative ATG was 19.75 compared to the ATG preoperatively, 33.752 (Tab. II), \( p = 0.023 \)

Such a decrease was found in the case of 2.75 mm incision in the supero-temporal location (31.252 preoperative and postoperative 18.25 respectively) (Tab. III), \( p = 0.028 \).

In this location was found an overall reduction of the postoperative astigmatism’s values sum (95.256) compared to the preoperative astigmatism’s values sum (45.75) when taken into consideration all three incision groups (Tab. I,II,III). Within each group of incisions, the largest reduction was found at the 1.8 mm group (from 20.252 to 7.75) (Tab. I). The postoperative astigmatism values average was also low in all three groups of incisions, in this location, as shown in tables above.

b) Superior location

If incision of 1.8 mm in this location there was only a small reduction in postoperative ATG (4.00) than preoperatively (3.75) (Tab. IV), \( p = 0.012 \).

The incision of 2.2 mm in superior location, the sum of ATG was obviously lower postoperatively (43.25) than the preoperative ATG (26) (Tab. V), \( p = 0.012 \).

In this type of incision, when the location was higher, there was a slight increase in postoperative ATG (16.25) than preoperatively (14.25) (Tab. VI), \( p = 0.678 \).

In this location, if taken into consideration all three groups of incisions, the postoperative astigmatism’s values sum was much lower (46.00) than the preoperative astigmatism’s values sum (61.50) (Tab. IV,V,VI). The postoperative astigmatism’s values average decreased for the 1.8mm and 2.2 mm incisions and was slightly elevated for the 2.75 mm incisions (Tab. IV,V,VI).

15. The analysis of the astigmat effect based on location, when the preoperative astigmatism is ≥ 1.00 diopters.
   a) Supero-temporal location
In this location, when pre-existing astigmatism ≥ 1.00 D was, it was observed a sharp decline in the amount of postoperative astigmatism values (9.5) to the sum of preoperative astigmatism (28.502) (Tab. VII), $p = 0.268$

b) Supero-nasal location

In the same situation, when the location was supero-nasal incisions, the postoperative ATG amount was lower (5.5) than the preoperative ATG (10.25) (Tab. VIII), $p = 0.018$

c) Temporal location

In the temporal location, there was also found a reduction in the amount of postoperative ATG (4.75) compared with the preoperative ATG (7.25) (Tab. IX), $p = 0.0407$.

d) Superior location

In the superior location, the sum of postoperative ATG was greatly reduced (8.5) than the existing ATG (16.25) (Table X), $p = 0.253$.

Similarly, in all four groups of locations the average of the postoperative astigmatism’s values has been a lot reduced compared to the preoperative astigmatism’s values average (Tab. VII,VIII,IX,X).

Discussions

In the 169 cases studied, I analyzed postoperative astigmatism after a control at 6-8 weeks after surgery.

1. Postoperatively, there was a slight decrease in astigmatism between 0.00 -> ± 0.75 diopters (63.3% from 68.7% preoperatively postoperatively). There was found a slight increase in astigmatism between ± 1.00 -> ± 2.00 diopters (35.5% postoperatively and 27.8% preoperatively). But there was a decrease in the number of cases of astigmatism ≥ 2.00 D, from 1.2% postoperatively, to 3.6% preoperatively.

2. Postoperatively, the against the rule ATG prevailed (65.1%) and preoperative, the one according to the rule ATG prevailed (58.0).

3. Preoperatively, most astigmatisms were with oblique axes (60.9%) and postoperatively 59.2% of total had straight axes.

4. Regarding the spherical equivalent, the values situated between 0.00 -> ± 0.75 diopters had the largest share (64.5%).

5. The total number of astigmatism with values between 0.00 -> ± 0.75 diopters showed a slight decrease, while the number of astigmatisms ≥ 1.00 diopters of astigmatism, as denoted above, the sum of the postoperative ATG values (97.25) was slightly lower than the preoperative ATG (106.502), $p = 0.477$.

6. In the supero-temporal and superior locations, in most of the cases, there was a reduction of the postoperative ATG, towards the preoperative one, excepting the 2.75 mm incision from the superior location.

7. When the preexisting ATG was significant, ≥ 1.00 diopters, the corneal incision was made on the steeper corneal meridian. In all of these cases, postoperative ATG was lower than the preoperative one.

The modern objective of the cataract surgery is to obtain an uncorrected, optimal visual acuity. An astigmatism, whether preexisting or induced by sutures, can restrict the best uncorrected visual acuity.

In our study, there hasn’t been a significant increase in the number of postoperative astigmatisms
with values higher than 1.00 diopters, and the number of astigmatisms ≤0.75 diopters was slightly lower than the preoperative ones. The increased usage of phacoemulsification and artificial foldable crystalline implants allowed smaller incisions in cataract surgery [13,14]. Reducing the size of the incision induces a smaller astigmatism after cataract surgery [9,13,15]. On the other hand, the approach through a clear cornea, as it was introduced by Fine [16], showed a decrease of the surgical induced astigmatism. The small incision in cataract surgery shows a rapid and stable eye recovery, by preventing the refractive changes in the corneal curvature [17]. Bilinska and his collaborators proved that a surgical induced astigmatism can be minimized with a without suture incision in a clear cornea [18].

The best visual acuity without correction is the main goal, pursued not only by the surgeon but also by the patient. In our case study the most of the preoperative astigmatisms were against the rule, and regarding the orientation of the axes, the predominant ones were the ones with straight axes. There are discussions concerning the clinical type of postoperative astigmatism after cataract surgery. Some scientists [19] consider that a with-the-rule astigmatism gives the visual acuity a larger range and depth and it’s better tolerated. Others believe that a myopic against-the-rule astigmatism give an uncorrected visual acuity similar to the corrected one, compared to the with-the-rule astigmatism [19]. The visual acuity can be improved if the astigmatism's magnitude is reduced, even if axes changes occur.

The analysis of the effects of the astigmatism based on the location and the size of the incision shows a slight increase only in the 2.75 mm incision in the superior location. The decrease of the preoperative ATG magnitude when the incision was effected on the more astigmat meridian is in accordance with literature data regarding the flattening of this meridian following the postoperative scaring. The different effect of the small corneal incisions can be useful through their location, depending on the preexisting astigmatism. Temporal incisions are advised for a negligible astigmatism, while nasal and superior incisions are preferred when the steep axes are situated at approximately 180° and 90° [20].

From all these facts is deduced that the size, the architecture and the location of the incision influence the induced astigmatism. Therefore the incision represents more than a way of access into the anterior chamber, the incision itself being an important step of the intervention that affects the ocular integrity and the corneal stability [21]. The usage of small incisions has a lot of benefits, including a rapid healing of the wound and less induced corneal distortion [13,15,22]. The best corneal incision in cataract surgery is the one that prevents leaking and has a minimal influence on the shape of the cornea.

On the other hand Kohnen and co-authors studied on corpses the minimal incision for artificial crystalline implant [9]. They found that the incision's sizes were with approximately 11% larger after the insertion of the foldable artificial crystalline implant. They have noted the break of the Descemet and the corneal stroma on the side edges, especially in smaller and closer incisions [9,23]. Therefore, an appropriate size of the incision on clear cornea before the implantation is important for preventing the corneal alteration through an uncontrolled extension of the wound.

Dunne et al [24] reported a residual astigmatism of approximately 0.5 diopters from 66% to 83% presenting an against-the-rule astigmatism. This residual astigmatism does not resolve itself even after cataract surgery [25,26]. Bae et al [27] reported the fact that eyes with pseudofak have a residual astigmatism with diopters of 0.47, which is assumed to be due to the posterior capsule left in place or to the artificial crystalline implant.

On the other hand it must be taken into consideration the fact that individual variation can be generated, for example, a particular case, the steepness may increase along the meridian of incision, so the accuracy and predictability limits can be explained through these observations [10].

By reducing the time for the visual stability, a small incision in a clear cornea can restore the patient's independence, it fastens his return to work and it eliminates the need of multiple examinations [8]. In addition, minimizing the corneal damage, the postoperative complications reduce, conducting to a more rapid visual recovery.

**Conclusions**

Induced astigmatism after a cataract surgical cure may compromise the optimal functional rehabilitation, dissatisfying both the patient and surgeon.

Among the etiological agents responsible of its occurrence, a major role has the surgical incision and
its correct management may reduce or even avoid the induced postoperative refractive errors.

References