“Lucian Blaga” University Sibiu

PhD Thesis

“Surgically induced astigmatism after surgical treatment of cataract”

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THESIS ABSTRACT

I. GENERAL PART

A highly performing visual acuity represents one of the most important human qualities that are most afraid he could lose and which ensures him a higher quality of life. Cataract is an eye health problem that primarily affects the elderly population worldwide.

Cataract represents a major eye health problem that affects primarily the elderly population worldwide. The progress that has been made in the field of physiopathology of corneal wound healing, in the techniques and instrumentations used, contributed, especially in recent decades, to a revolution in this area, reducing the risk of postoperative complications to a minimum and allowing early anatomical and functional rehabilitation after surgery.

I.1. OPERATIVE INDUCED ASTIGMATISM

Operative induced astigmatism is the astigmatism greater than one diopter, which is present at 6-8 weeks postoperatively. This type of astigmatism can be with or against the rule, according to the more refractive corneal meridian, the vertical or the horizontal. It is a form of regular astigmatism which is mainly due to abnormalities in the cornea and that is related to the process of healing and scar reshuffling taking place in the surgical incision.

I.2. PHYSIOPATHOLOGY OF CORNEAL HEALING

In the case of a perforating corneal injury, either by accident or by surgery, the healing process requires the restoration of two main functions of this tissue: that of external barrier of the eye, by forming a scar tissue, and that of optical function, by remodeling of this tissue. The quality of the scar tissue formed is responsible for restoring the optical function of the cornea and the scar reshuffling occurs well after the injury. The first response that occurs in a corneal aggression of this type is represented by the corneal epithelial-endothelial remodeling, followed by the repair of the other tissues.

Primary cicatricial response

It is provided by the epithelial-endothelial barrier restoration and its goal is a swift coaptation of the wound.

⇨ *Epithelial wound healing*

The healing process of an epithelial wound can be divided into three overlapping phases[11]:

- In the first phase there is a loss of normal anchoring structures of the epithelium namely that of the hemidesmozoms [12], of the desmosomes [13] and that of collagen type VII [14]. The main phenomenon that occurs is the formation of the pseudopods (lamelipodia and filopodia) as a result of cellular migration and that occurs up to covering the whole area of the defect. It also increases the cellular water content, allowing coverage of larger areas. This phase of cell migration is independent of the cell proliferation phenomenon, but during the epithelial healing process the two processes complete each other.
- In the second phase occurs the cellular proliferation with the main purpose to repopulate the epithelial defect area and also with the layering and cell differentiation [20]. This process also restores cell number and cell mass.
- A very important role in this process have the limbic stem cells, which on one hand can auto regenerate themselves and on the other hand can give birth to young cells that have the ability to auto differentiate themselves. These cells contribute to maintain the corneal epithelial homeostasis [24] and have a longer life than the central corneal epithelial cells [26].

  Due to the regenerative properties of the limbic stem cells, during the epithelial healing process there is a wave of mitosis which starts at the periphery of the cornea and moves towards the center continuing until the wound is healed and the epithelium regains its normal thickness [9].

  During an injury, corneal epithelial cell proliferation is intimately linked to the process of cell differentiation. On the other hand, migration and cell proliferation are dependent on a metabolic support provided by the glucose present in the aqueous humor and in the epithelial glycogen stores [31].

- In the third phase, newly formed cells undergo a differentiation process in order to form the specific structure of the corneal epithelium. If transitory attachments are formed during cell migration, after the defect is completely covered, occurs the formation of permanent

anchorage units. An important role in this process has the extracellular matrix proteins: fibronectin, fibrinogen / fibrin, laminin and tenascin [32].

⇨ *Stromal healing*

Corneal stromal wound healing is slower than other connective tissues, probably because it is avascular. This phase of stromal healing includes synthesis, dividing and forming of new bonds of collagen (cross-linking), phenomena that have as a result the consolidation and remodelation of the wound [7]. Keratinocytes apoptosis is the earliest stromal event that occurs immediately after epithelial injury [7] and continues at least for one week after the occurrence of corneal injury [42].

Proliferation and migration of intact keratinocytes starts at 12-24 hours after injury, followed by activation of fibroblasts and miofibroblasts, responsible for repopulating the affected stroma [12].

While the healing of the superficial stromal layer is provided through an epithelial contribution, its deeper layers are repaired by collagen synthesized by endothelial cells.

Recently, through the studies that were done in this area, the role of the metalloproteinase in the modulating of the corneal scarring was high lightened. It was thus demonstrated that MMP-1 (interstitial collagenase), MMP-2 (gelatinases-A), MMP-3 (stromelysin-1) and MMP-9 (gelatinases B) participate not only in the epithelial repairing but also in the stromal remodeling [50].

⇨ *Repairing of the Bowman membrane*

This membrane does not recover but it is repaired with defect. [51].

⇨ *Repairing of the Descemet membrane*

Healing and scarring of this is made by fibroblasts, which present an endothelial morphology, thus forming a neodescemet. It occurs in three weeks after injury and reaches maximum thickness in about six months [52].

⇨ *Repairing of the endothelium*

In the first 24 hours after the creation of a wound in a cornea, endothelial cells at the wound edge withdrawal. One day after the injury begins the process of endothelial

proliferation, which will form a continuous layer, which by sliding over, will cover the fibronectin fibrin clot that impregnates the epithelial plug [54].

Secondary cicatricial response

Its aim is to restore the optical function and tissue resistance, which is achieved by remodeling of the scar tissue, in order to restore partial transparency and mechanical resistance of the corneal tissue affected. This process takes place in three stages, as following:

- ⇨ *Cleaning the scar tissue by activating the fibrinolytic collagenolytic system*

  Synthesized enzymatic systems by the cells that migrate from the epithelial and stromal wound, participate in cleaning or extracellular remodeling. Intracellular cleaning system is provided by polymorphonuclear, macrophages and cheratocite by their phagocytic function.
- ⇨ *Reorganization of epithelial architecture*

  At the edges of the wound occurs a proliferation of the cheratocites, which in turn reject the epithelial plug, starting from the 2nd day after the occurrence of the injury. Along with the restoration of epithelial architecture also takes place the nerve regeneration, based on neurites formation, which subsequently will differentiate into nerve endings.
- ⇨ *Base membranes reconstruction*

  Base membrane remodeling is an integral part of the corneal epithelium healing [24]. This base membrane has a very important role in the formation of stable cell adhesions [24].
- ⇨ *Remodeling of the extracellular cicatricial matrix*

  An important role in reshaping the cornea scar tissue has the cheratocites. These contain highly specialized proteins, such as crystalline, which helps maintain the transparency of the corneal tissue [23].

I.3. CHARACTERISTICS AND IMPLICATIONS OF CORNEAL SCARRING IN CATARACT SURGERY

Anatomical and functional rehabilitation early after cataract surgery, with the best visual acuity without optics correction, represent the major desideratum which is expected by both the doctor and the patient. Much attention is paid to surgical incision and its manner of closure, especially for the purpose of reducing the corneal scar, with minimal adverse effects.

Improvements made in surgical techniques of cataract extraction by phacoemulsification method, especially in recent decades, have allowed smaller surgical incisions, first with one suture and afterwards without sutures. For this reason, we thought it appropriate to take into consideration the peculiarities of the healing of an unsutured wound compared with a sutured one.

It was demonstrated that sutured wounds and adjacent unsutured ones, from the same cornea, showed different patterns of healing [64]. Unsutured wounds showed a delayed and abnormal healing, unlike the sutured ones that showed progression to a normal anatomy of the region [65].

I.4. ETIOLOGY OF THE OPERATIVE INDUCED ASTIGMATISM

Etiological factors that may be associated with operative induced astigmatism after cataract surgery is: preoperative astigmatism, factors related to the surgical act and factors related to pesudofak.

⇨ *Preoperative astigmatism*

Preoperative astigmatism of greater value may be associated with increased values of postoperative astigmatism [71]. Reducing this astigmatism during cataract surgery may improve postoperative visual outcome. [73] Pre-existing astigmatism can be corrected during cataract surgery using different methods which include: relaxing peripheral incisions, choice of incision location, implantation of toric artificial lens [76,77].

⇨ *Factors related to the incision*

- Type of wound – sutured or unsutured

In case of a suture wound operative astigmatism is dependent on the length, depth and tightness of the suture [78]. Sutures placed close to each other lead to a tissue compression and cause according to the rule astigmatism. The sutures that are wider and the ones which are tighter cause an against the rule astigmatism.

- The tightening degree of the sutures

A wide suture allows the cornea to flatten, reducing the curvature in the vertical meridian and with against the rule astigmatism [80]. If the suture is too tight the cornea stretches vertically and the curvature in this meridian grows, with according to the rule astigmatism [80].

- Suture material

In case of sutured wounds, surgically induced astigmatism differs also on the suture material used, resorbable or non resorbable. Thus, in the case of the non resorbable sutures, as long as the wires remain in place, the power and the cylinder axis remain constant. After their removal, postoperative astigmatism diminishes, due to reducing the tension created in the wound by this type of sutures. If the case of non resorbable sutures the value and the axis of the cylinder can also vary and the healing is associated with a local inflammatory reaction.

- The location of the incision in relation to the limbus

The more scleral the incisions are the lower is the operative induced astigmatism. A more corneal incision determines a more important and against the rule astigmatism and vice versa [86]. In contrast to these considerations, it was demonstrated that in the case of small incisions, the effect of anatomical location is less important [84]. For this reason, nowadays, the most common incisions made with the cataract extraction by phacoemulsification technique are the ones in clear cornea.

⇨ *Factors related to the pseudofak*

Surgically induced astigmatism can be influenced by the position of the pseudofak in the posterior chamber, by the shape, size and material of which the artificial implant is made.

II. PERSONAL RESEARCH

II.1. INTRODUCTION

Cataract is a major public health problem being responsible for much of the decreases of visual acuity at the population worldwide. Everywhere in the world the extraction of cataract represents the largest workload in the surgical departments of ophthalmology.

The improvements that were brought lately in surgical technique focused on the rapid recovery of the patient, both anatomically as well as functionally. In this regard, the reduction or even the prevention of postoperative astigmatism was one of the aims pursued by cataract surgeons worldwide.

Due to the use on a larger scale of foldable crystalline artificial implants, the surgical incision in clear cornea has lately become the main approach in this type of surgical intervention.
For these reasons and bearing in mind the latest trends in the surgical field, I considered appropriate that in this clinical study to make a detailed assessment of surgically induced astigmatism after cataract surgery, taking into consideration the corneal incision and its characteristics, this actually being the main risk factor in the development of this type of astigmatism.

II.2. PURPOSE OF THE WORK

This paper aims to assess a group of cases operated of cataract surgery by the phacoemulsification method with implantation of foldable artificial lens in terms of surgically induced astigmatism, of the etiologic factors incriminated in its appearance and of the methods of prevention and treatment.

II.3. MATERIAL AND METHOD

Thesis material

The material of this thesis is represented by a group of 592 patients diagnosed with primitive cataract primitive which have been operated between 2009 and 2011 at Optilens Clinic in Cluj-Napoca. The surgical method consisted of cataract extraction by means of phacoemulsification

and implantation of foldable artificial lens of posterior chamber. I selected cases of primitive cataract primitive, present in male and female patients, coming from rural or urban environment, ages between 40 and 90 years.

Method of work

I conducted a prospective study for each case, which included:

- ⇨ *Personal data of the pacient:* age, sex, source environment
- ⇨ *Clinical preoperative evaluation:* lab exams, cardiologic examination with ECG.
- ⇨ *Ocular preoperative evaluation:* patient history and medical history, visual acuity, biomicroscopy of anterior pole, pachimetry, direct ophthalmoscopy, intraocular pressure measurement, measuring the number of endothelial cells, keratometria, ocular biometry, determination of the power of the artificial implant lens diopter.
- ⇨ *Postoperative evaluation:* determination of visual acuity with / without optical correction, refractometry, comments from the patient himself (satisfaction, sensitivity to light).
- ⇨ *Criteria for inclusion of the cases in the study:* primitive cases of cataract, senile and pre-senile.
- ⇨ *Criteria for exclusion of the cases from the study:* ocular (pre-existing eye disorders or contemporary to the surgery, other ocular surgery history, eye trauma) and general (diabetes, autoimmune inflammatory disorders, etc.)

II.4. OPERATING PROTOCOL

Preoperative patient preparation

Preoperative anesthesia: 2% lidocaine solution injected into the inferior fornix, topical anesthetic with solution Benoxi, administered 2 drops every 1 minute.

Surgery

Cataract lens extraction was performed by the method of phacoemulsification and implantation of foldable artificial lens of posterior chamber. Surgical incision was made in clear cornea, in a single plane.

Incision was made close to limb, at the level of the vascular arch. The dimensions of the incisions were 2.75 mm, 2.2 mm and 1.8 mm. The incisions were located supero-temporal, supero-nasal, superior and temporal.

Intraoperative complications

During surgery are there can be possible intraoperative complications, such as: posterior capsule rupture with vitreous loss, dislocation of the nucleus or of nuclear fragments in vitreous, dislocation of the Descemet membrane, etc. None of these complications were present in the patients in the study group.

Post surgery

Immediately after the surgery local instillations have been carried out with an antibiotic and an anti-inflammatory steroid, usually in a fixed combination (TOBRADEX, Netildex, Betabioptal), a short term mydriatic (Tropicamide, Mydrum) and eye dressing for 24 hours.

II.5. STATISTICAL CALCULATION

Statistical analysis was performed using ANOVA.

ANOVA statistical analysis techniques are used when comparing more than two groups of patients. Anova statistical analysis is also known as *analysis of variance*. The larger the number of comparative groups (more than two groups) the more diversify the grades of independent variables.

II.6 RESULTS

The next stage of our study consisted of conducting a distribution of patients according to parameters in the study, in order to further establish a detailed analysis of postoperative functional results. This distribution was carried out as follows:

a. Distribution of cases by environment of origin
b. Distribution of cases by group age
c. Distribution of cases according to clinical type of cataract

d. Distribution of cases according to the evolutionary stage of cataract and preoperative visual acuity
e. Distribution of cases after ocular biometry
f. Distribution of cases by preoperative astigmatism
g. Distribution of cases according to the size of the corneal incision
h. Distribution of cases according to the location of the corneal incision
i. Distribution of cases by postoperative astigmatism
j. Distribution of cases by the pre-operative versus post-operative astigmatism
k. Distribution of cases by astigmatism in six weeks as compared to that of 6 months postoperatively
l. Global distribution of postoperative astigmatism compared with the preoperative one
m. Distribution of cases by postoperative visual acuity
n. Distribution of cases by spherical postoperative equivalent

The main concerning parameter was the corneal astigmatism, which was calculated preoperatively based on the on K1 and K2 values, and postoperatively was determined through auto-refractometry print. For this purpose, a comparative study was made between postoperative and preoperative astigmatism, taking into account its distribution by groups of values, the orientation of the cylinder axis and the clinical form of astigmatism (with or against the rule). I conducted a comparative study on three groups of patients that were formed according to the size of the corneal incision. A comparative study was also was performed on groups of patients divided according to the location of the corneal incision and the value of the preoperative astigmatism.

Another important parameter in the study was the postoperative visual acuity without and without optical correction and also the postoperative spherical equivalent. The evolution of the visual acuity was checked at the two post surgery examinations, at six weeks and at six months postoperative.

The value of the postoperative spherical resulted from the determination of the ocular refraction and registered automatically along with the conduction of auto-refractometry. Final results have been found stable at 6 months postoperative.

⇨ ***DISTRIBUTION OF CASES AFTER THE PREOPERATIVE ASTIGMATISM VALUES***

Most pre-existing astigmatism values were situated between 0.00 -> ± 0.75 diopters (70.78%). Values between ± 1.00 -> ± 2.00 diopters have been at a rate of 27.53% of the total. Less present were the cases with values over 2,00 diopters (1,69%).

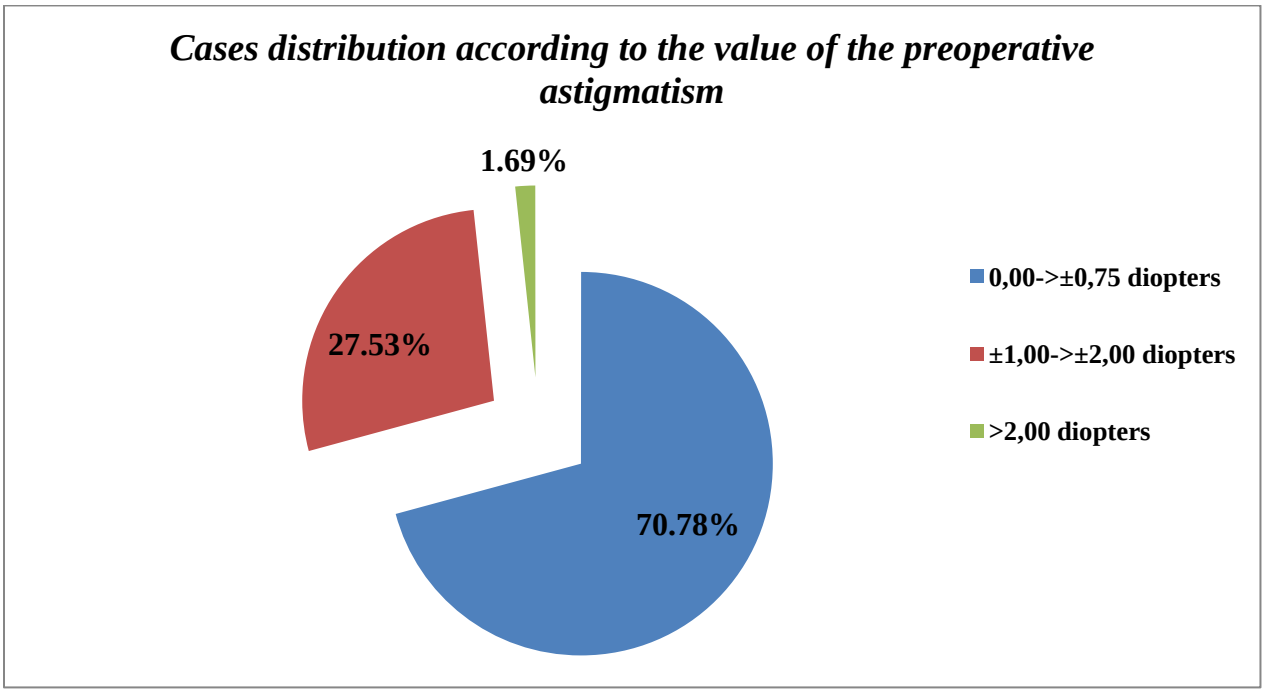

Figure no. 1

Regarding the clinical form of the preoperative astigmatism, most cases were those with with the rule, which represented 54,77% of the total. Against the rule astigmatisms were present in a percentage of 42.31% of the total and a percentage of 2, 92% of all cases were neutral from the astigmatic point of view.

⇨ ***DISTRIBUTION OF CASES ACOORDING TO TE SIZE OF THE CORENAL INCISION***

The sizes of the incisions in clear cornea were of 1.8 mm, 2.2 mm and 2.75 mm. Thus, from this point of view, the selected cases were divided into three groups. As it results from Table 1, the three groups had a very close number of cases, 198 cases with corneal incision of 1.8 mm, 202 cases with incision of 2.2 mm incision in the two cases and 192 cases with incision of 2,75 mm.

Incision	1,8 mm	2,2mm	2,75 mm
No. of cases	198	202	192

Table no. 1

⇨ ***DISTRIBUTION OF CASES ACCORDING TO THE LOCATION OF THE INCISION***

Incision location	Supero - temporal	Supero-nasal	Temporal	Superior
No. of cases	292	198	57	45

Table no. 2

As noted in the table below. 2, the most corneal incisions were made supero-temporal (292 cases), followed by supero-nasal locations (198 cases). A smaller number of incisions have been made in the temporal location (57 cases) and in 45 cases the chosen location was the superior one.

⇨ ***DISTRIBUTION OF THE POSTOPERATIVE ASTIGMATISM AFTER SIX WEEKS***

At the examination performed six weeks after surgery, postoperative astigmatism values ranged between 0.00 -> ±0.75 diopters, represented 69.60% of the total. A percentage of 29,22% of all cases was represented by the astigmatism values between ±1.00 -> ±2.00 diopters and only 1,18% of cases had values greater than 2.00 diopters.

In terms of percentage terms at six weeks after surgery, the against the rule astigmatism was present in proportion of 70,10% and the with the rule one was present in proportion of 29,90% of the total.

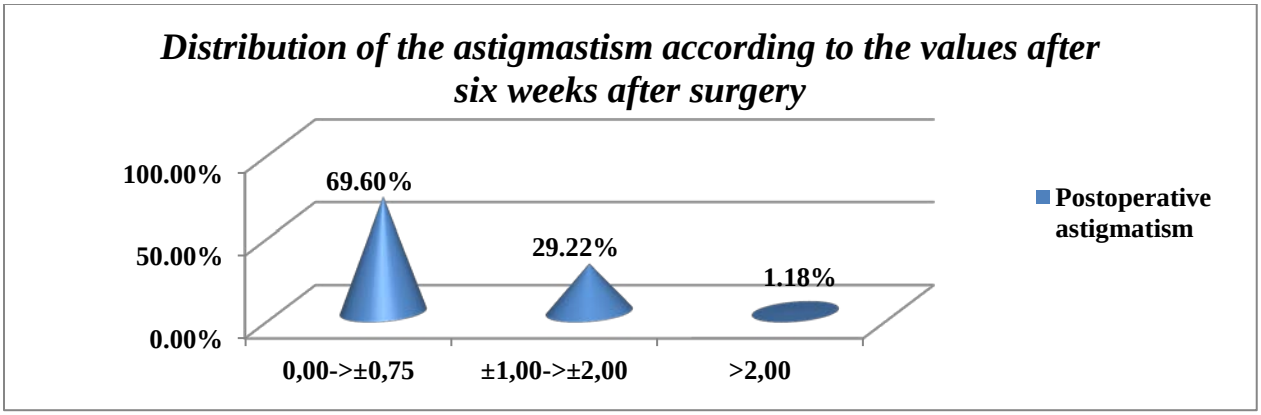

Figure no. 2

⇨ ***DISTRIBUTION OF THE PREOPERATIVE ASTIGMATISM SIX MONTHS POST SURGERY***

After six months post surgery, the astigmatism between 0.00 -> ±0.75 diopters were 69,77% of the total. The ones ranged between ±1.00 -> ±2.00 diopters have been present in proportion of 29,39%, and the ones higher than 2.00 diopters represented only 0,84% of the total.

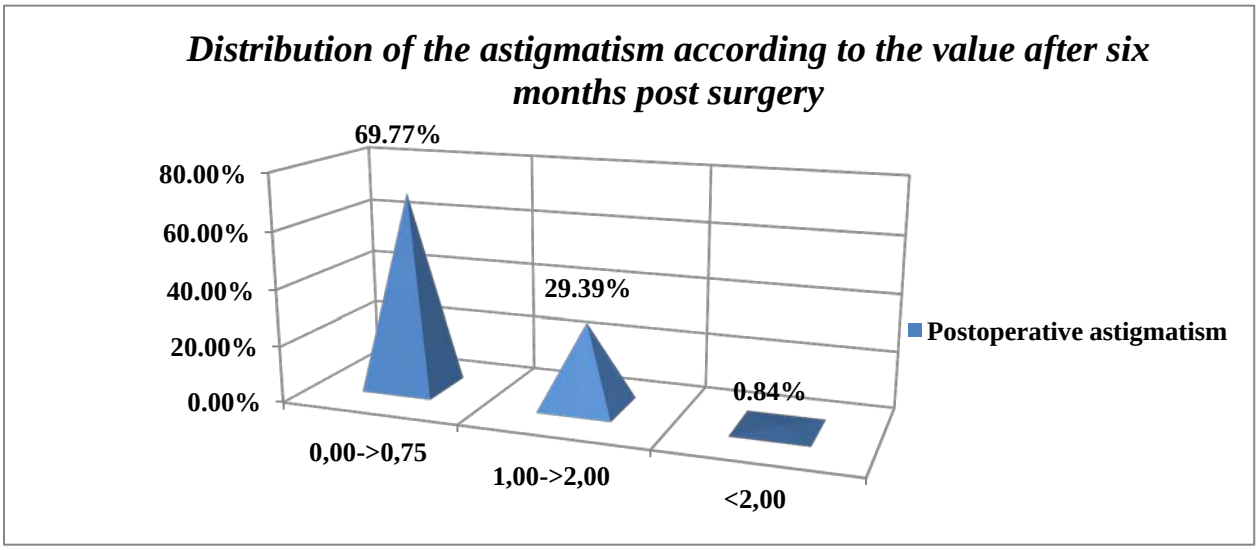

Figure no. 3

In terms of percentage, at the 6 months post surgery evaluation, the against the rule astigmatism represented 71,29% and 28,71% of the total.

⇨ ***THE ASTIGMATISM AT SIX WEEKS POST SURGERY IN COMPARISON WITH THE PREOPERATIVE ONE***

Preoperative astigmatism values ranging from 0.00 -> 70.94 ±0.75 diopters represented 70,94% of the total and ones of the postoperative astigmatism after 6 weeks represented 69,59% of the total. Astigmatism values between ±1.00 -> ±2.00 diopters have been present at a rate of 27,36% preoperatively and at a rate of 29,22% of the total six weeks posto surgery. Preoperative, the astigmatism greater than 2.00 diopters was present in an amount of 1,70%, and after 6 weeks post surgery the proportions reached 1,19% of the total.

⇨ ***ASTIGMATISM AT SIX MONTHS POST SURGERY IN COMPARISON WITH THE PREOPERATIVE ONE***

The values ranged between 0.00 -> ±0.75 diopters had a share of 70,94% preoperatively and of 69,76% six months postoperatively (Figure 26). Preoperative, the astigmatism values between ±1.00 -> ±2.00 diopters represented 27,36% of the total and after six months post surgery the same values represented 29,39% of the total. Astigmatism greater than 2.00 diopters represented 1,70% preoperative and 0,85% six months postoperatively.

⇨ ***DISTRIBUTION OF CASES ACCORDING TO THE ASTIGMATISM SIX WEEKS POST SURGERY IN COMPARISON WITH THE ASTIGMATISM SIX MONTHS POST SURGERY***

Values ranged between 0.00 -> ±0.75 diopters were present in a ratio of 69,59% at six weeks post surgery and at a rate of 69,76% at 6 months post surgery. Similarly, the astigmatisms between ± 1.00 -> ± 2.00 diopters represented 29,22% of the total six weeks post surgery and 29.39% six months post surgery. Astigmatisms greater than 2.00 diopters were present in a very small proportion in both cases, representing 1,19% at six weeks post surgery and 0,85% six months after surgery.

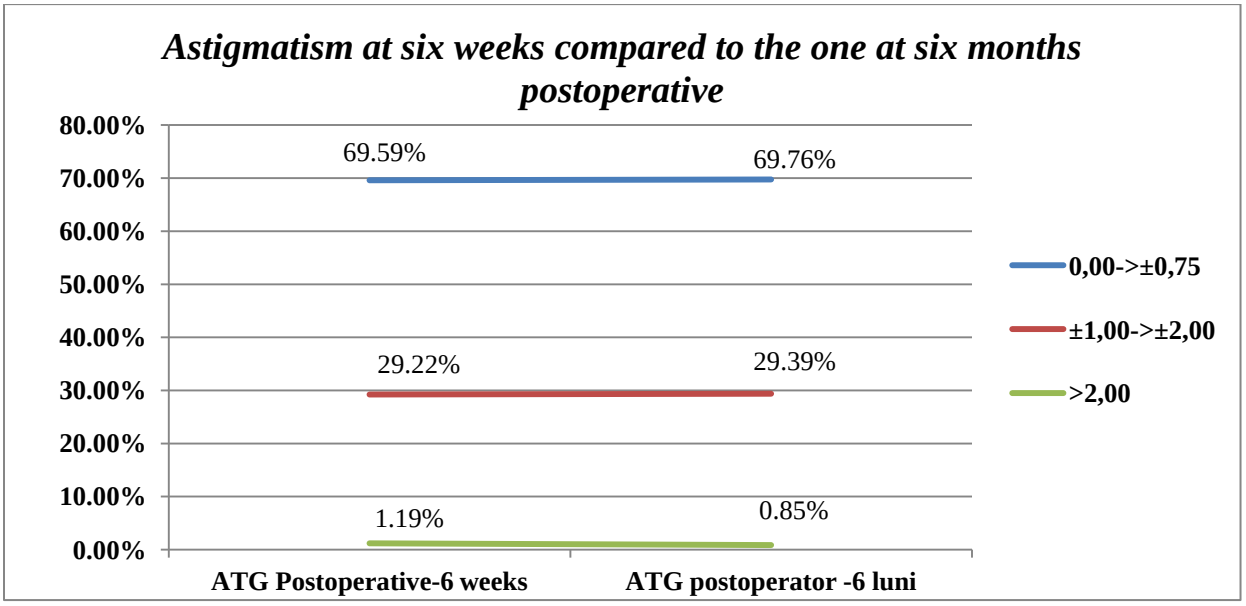

Figure no. 4

⇨ ***DISTRIBUTION OF CASES ACCORDING TO THE VISUAL ACUITY AT SIX WEEKS AFTER SURGERY***

The best optical visual acuity without optical correction, six weeks after surgery, was found in 283 cases, representing 52,20% of the total. In the remaining 309 cases the best visual acuity was obtained with the help of optical correction, these cases representing 47,80% of the total.

⇨ ***DISTRIBUTION OF CASES ACCORDING TO THE VISUAL ACUITY SIX MONTHS POST SURGERY***

At the six months examination postoperative, the best visual acuity with optical correction was obtained in 296 cases, representing 50% of the total. The other half of the cases the best visual acuity was obtained with optical correction.

⇨ ***DISTRIBUTION OF CASES ACCORDING TO THE SPHERICAL EQUIVALENT AT SIX WEEKS POST SURGERY***

At six weeks postoperative examination the most spherical equivalent values were between 0.00 -> ±0.75 diopters, representing 63,51% of the total. The values of the spherical equivalent ranged between ±1.00 -> ±2.00 diopters were present in a ratio of 33,95% of the total. The most under-represented values of the spherical equivalent were the ones greater than 2,00 diopters, which were represented in a proportion of 2,54% of the total.

⇨ ***DISTRIBUTION OF CASES ACCORDING TO THE SPHERICAL EQUIVALENT AT SIX MONTHS POST SURGERY***

At the examintion performed at six months postoperative the spherical equivalent values ranging from 0.00 -> ±0.75 diopters represented 65,71% of the total, those between ±1.00 -> ±2.00 diopters were present in the proportion of 33,44% and those greater than 2,00 diopters represented 0,85% of the total.

⇨ ***SURGICALLY INDUCED ASTIGMATISM***

Applying the ANOVA statistical calculus formula, it was made a detailed analysis of the preoperative astigmatism in comparison with the postoperative astigmatism, resulting from this sum, the average and the variation index of the values of the preoperative and postoperative

astigmatism, at the two post surgery examinations. For the calculus of the surgically induced astigmatism (AIC) it was made between the difference between the sum of postoperative astigmatism values (at six weeks and at six months) and the sum of the preoperative astigmatism values.

At six weeks post surgery

Surgically induced astigmatism at six weeks post surgery was: 356 – 412,502 = -56,502

At six months post surgery

Surgically induced astigmatism at six months post surgery was of: 378,25- 412,502= - 34,252

⇨ ***ANALYSIS OF THE POSTOPERATIVE ASTIGMATISM IN COMPARISON WITH THE PREOPERATIVE ON ACCORDING TO THE DIMENSION OF THE CORNEAL INCISION***

1,8 mm incision

As shown in Figure 34, in terms of percentage, the astigmatism with values between 0.00 -> ±0.75 diopters have increased from 76,26% preoperatively to 85,86% at 6 weeks and 6 months post surgery. The values ranged between ±1.00 -> ±2.00 diopters decreased from 21,71% preoperatively to 13,64% at the two postoperative assessments. Astigmatisms more than 2.00 diopters also decreased from 2.03% operatively to 0,50% at both post surgery examinations.

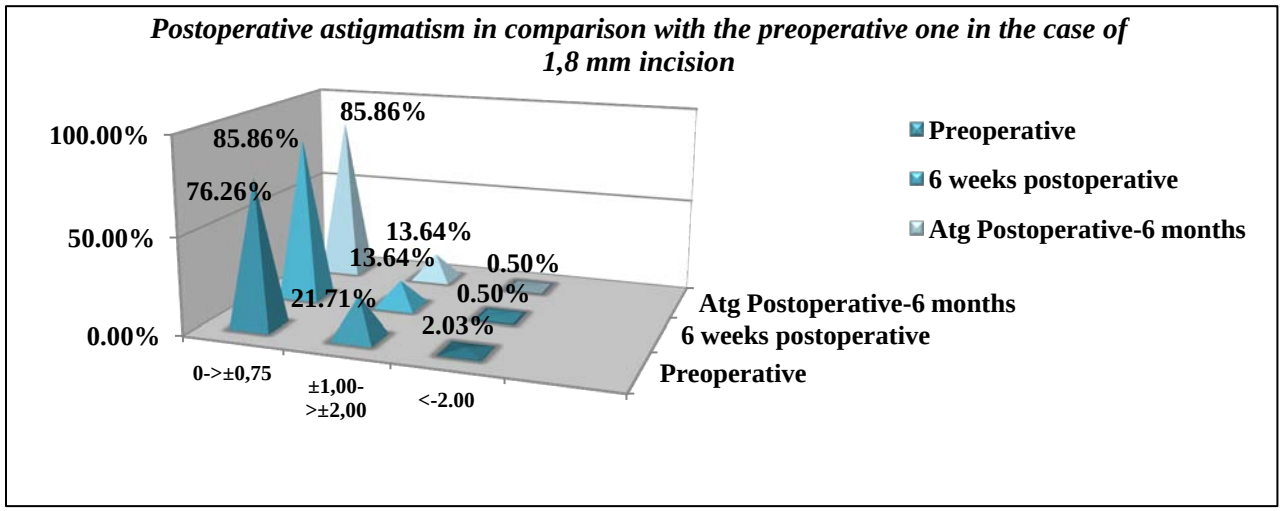

Figure no. 5

Surgically induced astigmatism in the 1,8 mm incision was of:

=> At 6 weeks post surgery: 87 - 129= - 42

=> At 6 months post surgery: 97,25 - 129 = -31,75

2,2 mm incision

In terms of percentage, the astigmatism values ranged between 0.00 -> ±0.75 diopters, were present in a ratio of 69,46% and 70,44% at the two postoperative exams in comparison with the preoperative ones (62 , 56%). Astigmatisms that ranged between ±1.00 -> ±2.00 diopters represented 28,08% and 26,60% of the total at the postoperative exams, therefore the percentage was lower than the ones preoperative (30.02%). Values greater than 2.00 diopters represented 2,46% and 2,95% postoperative, compared to 7,42% preoperative.

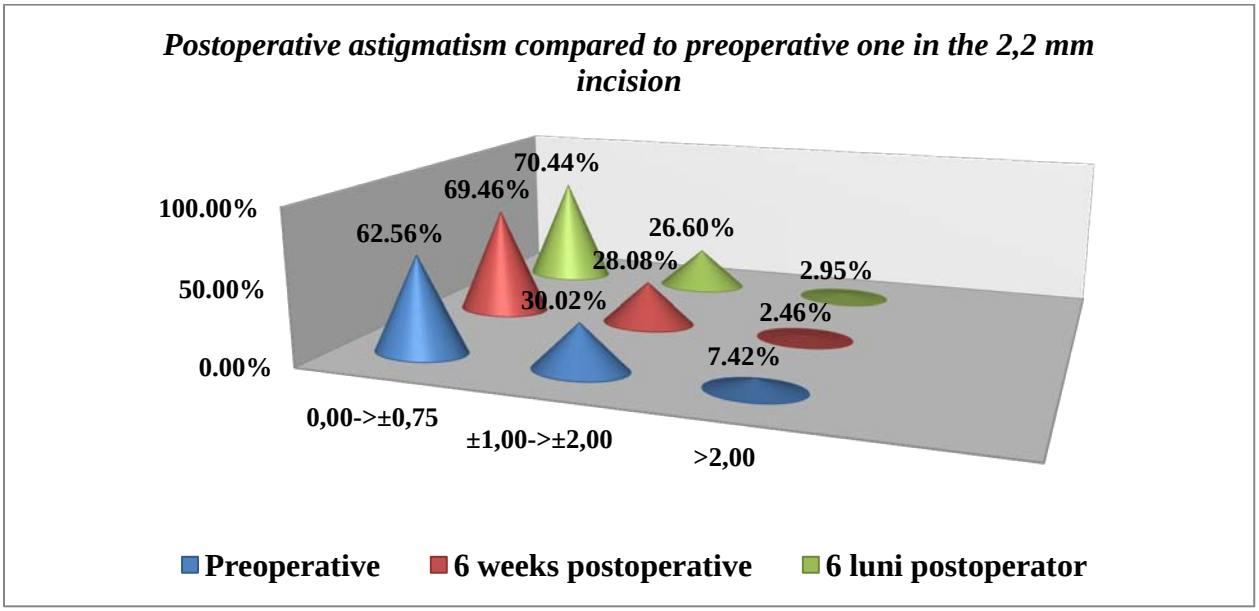

Figure no. 6

Surgically induced astigmatism in the 2,2 mm incision was of:

=> At 6 weeks: 135,25 - 161,5 = -26,25

=> At 6 months: 141,75 - 161,5 = -19,75

2,75 mm incision

In terms of percentage, for this group of incisions, the astigmatism values ranged between 0.00 -> ±0.75 diopters decreased from 73,43% preoperative to 55,21% at six weeks and to 51,56 % at 6 months postoperative. The values of the postoperative astigmatism ranged between ±1.00 -> ±2.00 diopters increased, representing 38,08% and 39,58% of the total at both exams performed after surgery in comparison with the preoperative astigmatism representing 24,48%. The values of the astigmatism greater than 2.00 diopters also increased, from 2,09% preoperative to 6,71% and 8,86% at the two post surgery exams.

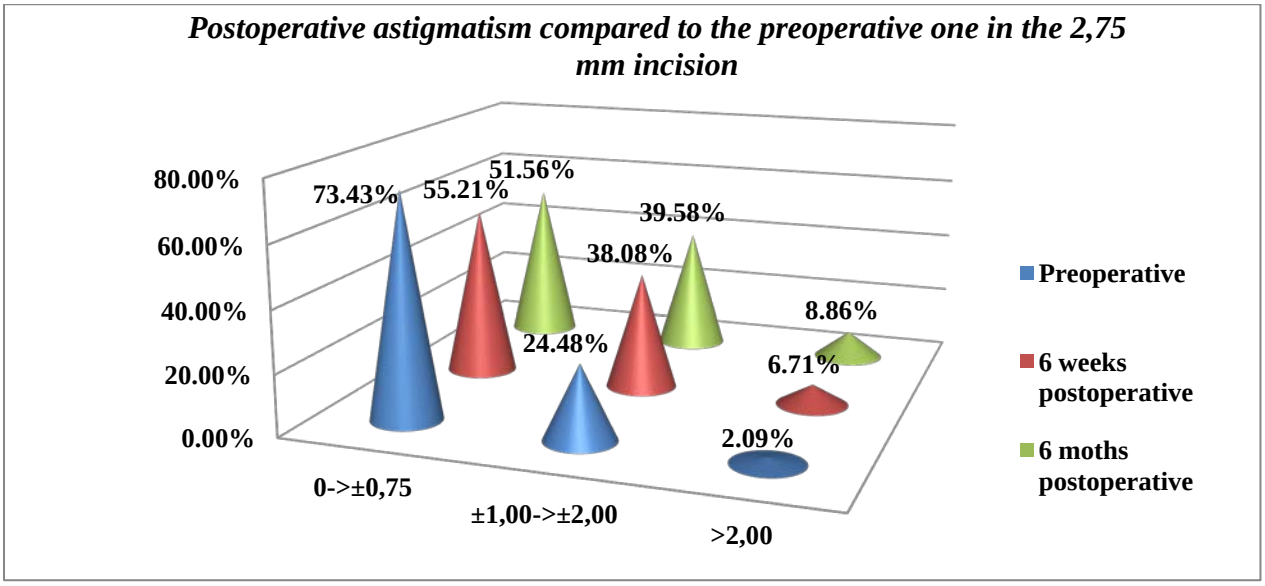

Figure no. 7

Surgically induced astigmatism in the 2,75 mm incision was of:

=> At 6 weeks: 140 - 126,75 = 13,25

=> At 6 months: 148,75 - 126,75 = 22

⇨ ***ANALYSIS OF THE POSTOPERATIVE ASTIGMATISM COMPARED TO THE PREOPERATIVE ONE ACCORDING TO THE LOCATION OF THE CORNEAL INCISION; SURGICALLY INDUCED ASTIGMATISM***

Supero-temporal location

Supero-temporal incision - ATG value	Preoperative - Number of cases	6 weeks postoperative - number of cases	6 months postoperative - number of cases
0->±0,75	237	195	193
±1,00->±2,00	54	96	98
>±2,00	1	1	1

Table no. 3

According to the table no. 3, for this group, there was a decrease of astigmatisms with values ranged between 0.00 -> ±0.75 diopters, at 195 at six weeks postoperative and at to 193 of cases at six months postoperative, in comparison with the 237 cases which existed initially preoperative. The number of values ranged between ±1.00 -> ±2.00 diopters increased in 96 of the cases at six weeks post surgery and in 98 of the cases at six months after surgery, compared to 54 cases preoperative. The number of values greater than 2 diopters remained the same as before surgery (1 case).

Surgically induced astigmatism in the supero-temporal localization was of:

=> At 6 weeks: 158,25 - 182 = -23,75

=> At 6 months: 170 - 182 = -12

Supero-nazal location

An analysis of the magnitude of the preoperative astigmatism in comparison with the postoperative one showed that in this group, there was also a decrease in the number of values ranging between 0.00 -> ±0.75 diopters, from 181 cases preoperative to 133 and respectively 132 cases at 6 weeks and 6 months postoperative (Table no. 27). The number of values ranging

between ±1.00 -> ±2.00 diopters has risen postoperative to 64 and 65 cases, from the initially existing 15 cases preoperative.

Values of the astigmatism greater than 2.00 diopters are were present in two cases preoperative and in one case postoperative in each examination.

Supero-nazal incision - ATG value	Preoperative - number of cases	6 weeks postoperative - number of cases	6 months postoperative - number of cases
0->±0,75	181	133	132
±1,00->±2,00	15	64	65
>±2,00	2	1	1

Table no.4

Surgically induced astigmatism in the supero-nazal localization was of:

=> At 6 weeks: 120,75 - 110,75 = 10

=> At 6 months: 123,75 - 110,75 = 13

Temporal localization

As noted in the table no. 30, there were 53 preoperative astigmatism values between ±1.00 -> ±2.00 diopters and 4 values greater than 2.00 diopters. The analysis of the postoperative astigmatism magnitude showed a decline of the latter both at six weeks postoperative (15 cases between 0.00 -> ±0.75 diopters, 37 cases between ±1.00 -> ±2.00 diopter and 5 cases over 2 diopters) and at six months postoperative (13 cases between 0.00 -> ±0.75 diopters, 39 cases between ±1.00 -> ±2.00 diopter and 5 cases over 2 diopters).

Temporal incision - ATG value	Preoperative ATG - number of cases	6 weeks postoperative - number of cases	6 months postoperative - number of cases
0->±0,75	0	15	13
±1,00->±2,00	53	37	39
>±2,00	4	5	5

Table no.5

Surgically induced astigmatism in the temporal localization was of:

=> At 6 weeks: 70,75 - 64,75 = 6

=> At 6 months: 67,5 - 64,75 = 2,75

Superior location:

Superior incision - ATG value	Preoperative ATG – number of cases	6 weeks postoperative - number of cases	6 months postoperative - number of cases
0->±0,75	0	21	22
±1,00->±2,00	42	22	22
>±2,00	3	2	1

Table no. 6

All values of the preoperative astigmatism were higher than then 1,00 diopters, 42 of the cases were ranged between 0,00 -> ±0,75 diopters and 3 cases had values higher than 2 diopters (table no. 33). The analysis of the postoperative astigmatism has demonstrated a decrease of the values from the preoperative ones. Therefore, at six weeks post surgery there were 21 cases of values ranged between 0,00 -> ±0,75 diopters, 22 cases ranged between ±1,00 -> ±2,00 diopters and just 2 cases higher than 2 diopters. At six months postoperative the distribution of the values was approximately the same, 22 cases ranged between 0,00 -> ±0,75 diopters, 22 cases ranged between ±1,00 -> ±2,00 diopters and one case with a value higher than 1 diopter.

Surgically induced astigmatism in the temporal localization was of:

=> At 6 weeks postoperative: 34 - 58,5 = -24,5

=> At 6 months postoperative: 40,5 - 58,5 = -18.

⇨ ***ANALYSIS OF POSTOPERATIVE ASTIGMATISM IN COMPARISON WITH THE PREOPERATIVE ONE ACCORDING TO THE LOCATION AND SIZE OF THE INCISION; SURGICALLY INDUCED ASTIGMATISM***

Supero-temporal location

Supero-temporal incision of 1,8 mm

Expressed in percentages, the number of values ranging between 0.00 ->± 0.75 diopters represented 85,26% of the total, preoperative, 84,21% and 80,00% at the two postoperative examinations. The number of values between ±1.00 -> ±2.00 diopters represented 13,68% preoperative, 15,79% and 20,00% at postoperative examinations . Astigmatisms greater than 2.00 diopters were present only in a very small proportion preoperative (0,76%), missing post surgery.

The surgically induced astigmatism in the case of the supero-temporal location and incision of 1,8 mm was of:

=> At 6 weeks postoperative: 48,25 - 59,75 = -11,5

=> At 6 months postoperative: 51 - 59,75 = - 8,75

Supero-temporal incision of 2,2 mm

The value curve of the astigmatisms ranging between 0.00 -> ±0.75 diopters has a downward trajectory from 78,00% preoperative to 59,00% and 58,00% at the two postoperative examinations. The graphic of the values ranging between ±1.00 -> ±2.00 diopters has a crescent trajectory from 22,00% preoperative to 41,00% and 42,00% postoperative. Values greater than 2.00 diopters lacked both preoperative and postoperative.

The surgically induced astigmatism in the case of the supero-temporal location and incision of 2,2 mm was of:

=> At 6 weeks postoperative: 64,5 - 63,5 = 1

=> At 6 months postoperative: 70,5 - 63,5 = 7

Incizia supero-temporală de 2,75 mm

Astigmatism values ranging between 0.00 -> ±0.75 diopters decreased from 82,29% preoperative to 59,37% at both postoperative examinations. Values ranging between ±1.00 -> ±2.00 diopters increased from 17,71% preoperative to 39,58% at both postoperative examinations. There were no preoperative values greater than 2.00 diopters, and after the surgery they were present in an amount of 1.05% at both examinations.

The surgically induced astigmatism in the case of the supero-temporal location and incision of 2,75 mm was of:

=> At 6 weeks postoperative: 43,75 - 54 = -10,25

=> At 6 months postoperative: 49,5 - 54 = - 4,5

Supero-nazal location

Supero-nazal incision of 1,8 mm

Astigmatism values ranged between 0.00 -> ±0.75 diopters decreased slightly from 94,36% preoperative to 84,50% and respectively to 80,28% at the two postoperative examinations. Values ranging between ±1.00 -> ±2.00 diopters have increased at the rate of 5,64% preoperative to 15,50% and respectively to 19,72% in the two postoperative examinations. There was no case of astigmatism greater than 2.00 diopters preoperatively or postoperatively. There was no case of astigmatism greater than 2,00 diopters, preoperative and postoperative.

Surgically induced astigmatism in the supero-nazal location and 1,8 mm incision, was of:

=> At 6 weeks postoperative: 33,75 - 33 = 0,75

=> At 6 months postoperative: 36,5 - 33 = 3,5

Supero-nazal incision of 2,2 mm

The number of astigmatisms of small values ranging between 0,00 -> ±0.75 diopters, decreased from 49 cases before surgery, to 34 and 35 cases at six weeks and six months after surgery. The number of astigmatisms ranging between ±1.00 -> ±2.00 diopters raised from 9 cases preoperative to 25 and 24 cases ar the two postoperative examinations. The number of astigmatisms greater than 2.00 diopters has decreased from 2 cases preoperative to one case at each of the postoperative examinations.

Surgically induced astigmatism in supero-nazal location and incision of 2,2 mm was of:

=> At 6 weeks postoperative: 44,5 - 46 = -1,5

=> At 6 months postoperative: 44,5 – 46 = -1,5

Supero-nazal incision of 2,2 mm

Astigmatisms with values ranging from 0.00 -> ±0.75 diopters decreased from 94,20% preoperative to 59,42% and 56,52% at the two postoperative examinations. Astigmatism values ranging between ±1.00 -> ±2.00 diopters increased from 5,80% preoperatively to 40,58% and 43,48% at the two postoperative examinations. Both preoperatively and postoperatively there was no amount of astigmatism greater than 2.00 diopters.

Surgically induced astigmatism in supero-nazal location and incision of 2,75 mm was of:

=> At 6 weeks postoperative: 41,5 - 34,5 = 7

=> At 6 months postoperative: 44,5 - 34,5 = 10

Temporal location

Temporal incision of 1,8 mm

Astigmatisms ranged between ±1.00 -> ±2.00 diopters decreased from 100% preoperative to 61,53% and respectively 53,84% at the two post surgery examinations. While there was no pre-operative astigmatism value ranged between 0,00 -> 0.75 diopters, postoperative, these values were 38,47% at six weeks post surgery and 46,16% at six months post surgery.

Surgically induced astigmatism in temporal location and incision of 1,8 mm was of:

=> At 6 weeks postoperative: 8,25 - 15 = - 6,75

=> At 6 months postoperative: 7,5 - 15 = -7,5

Temporal incision of 2,2 mm

If preoperative the astigmatism with values between ±1.00 -> ±2.00 diopters represented 100% of cases, postoperative, in both evaluations, these values were present in a ratio of 66,66%. Values ranging between 0.00 -> - ±0.75 diopters increased from 0,00% to 23,81% at the teo postoperative examinations. However, the values greater than 2 diopters have increased from 0.00 preoperative to 9.53% in the postoperative controls.
Surgically induced astigmatism in temporal location and incision of 2,2 mm was of:

=> At 6 weeks postoperative: 27,25 - 22,75 = 4,5

=> At 6 months postoperative: 26,75 - 22,75 = 4

Temporal incision of 2,75 mm

Preoperative astigmatism values ranging between 0.00 -> ±0.75 diopters represented 0.00%, while at the two postoperative examinations to be present in an amount of 22,72% and respectively 18, 18% of the total. Values ranging between ±1.00 -> ±2.00 diopters decreased from 86,36% preoperative to 63,63% and 68,17% at the two postoperative controls. There was the same proportion of astigmatism with values greater than 2 diopters, both preoperative and postoperative, at both exmination (13,65%).
Surgically induced astigmatism in temporal location and incision of 2,75 mm was of:

=> At 6 weeks postoperative: 32,25 - 25,75 = 6,5

=> At 6 months postoperative: 32 - 25,75 = 6,25

Superior location

Superior 1,8 mm incision

Preoperative all of the astigmatism cases in this subgroup had values ranging between ±1.00 -> ±2.00 diopters. At the six weeks postoperative examination, the astigmatisms ranging between these values represented only 46,66% of the total, the rest were between 0.00 -> ±0.75 diopters.

Surgically induced astigmatism in superior location and incision of 1,8 mm was of:

=> At 6 weeks postoperative: 3,5 - 17,75 = -14,25

=> At 6 months postoperative: 8 - 17,75 = - 9,75

Superior de 2,2 mm incision

For this subgroup, astigmatisms ranging between 0.00 -> ±0.75 diopters increased from 0.00% preoperative to 44,44% and 50,00% at the two postoperative examinations. Astigmatisms ranging between ±1.00 -> ±2.00 diopters decreased from 88,88% preoperative to 55,56% and 50,00% at postoperative examinations. Values greater than 2.00 diopters decreased from 11,12% preoperative to 0.00% at postoperative examinations.

Surgically induced astigmatism in superior location and incision of 2,2 mm was of:

=> At 6 weeks postoperative: 14,5 - 24,25 = - 9,75

=> At 6 months postoperative: 15 - 24,25 = - 9,25

Superior 2,75 mm incision

In terms of percentage, astigmatism values ranged between ±1.00 -> ±2.00 diopters decreased from 92,85% preoperative to 42,85% and 57,14% at the two postoperative examinations. If there was no preoperative value between 0.00 -> ±0.75 diopters, postoperative, such values were found in the proportion of 42,85% and 35,71%. Values greater than 2.00 diopters have been at a rate of 7,15% before surgery and after six weeks post surgery rose to 14,30%, while at six months after the surgery, to return to the same number as preoperative (7.15 %).

Surgically induced astigmatism in superior location and incision of 2,75 mm was of:

=> At 6 weeks postoperative: 16 - 18,5 = - 2,5

=> At 6 months postoperative: 15,5 - 18,5 = - 3

II.7. DISCUSSIONS

⇨ *DISCUSSION OVER DISTRIBUTION OF CASES ACCORDING TO PREOPERATIVE ASTIGMATISM VALUE*

In our study group, low value astigmatism (0.00 -> ±0.75 diopters) was present in proportion of 70,78% of cases. Preoperative astigmatism values ranging between ±1.00 -> ±2.00 diopters represented 27,53% of the total. Astigmatism greater than 2.00 diopters was present only in 1,69% of the total. The presence in our study group of the preoperative astigmatism of low value (≤ ±0.75 diopters) is an aspect which corresponds to the literature data and which indicates that approximately 15% to 29% of the patients operated of cataract were more than 1.5 diopters, preexisting astigmatism [72].

⇨ *DISCUSSION OVER DISTRIBUTION OF CASES ACCORDING TO THE CLINCAL FORM OF PREOPERATIVE ASTIGMATISM*

Regarding the clinical form of preoperative astigmatism there was a slight predominance of with the rule clinical forms, which represented 54,77% of the total, over those who were against the rule, which were found in proportion of 42,31% of the total.

⇨ *DISCUSSIONS OVER THE REPARTITION OF CASES OF POSTOPERATIVE ASTIGMATISM AT THE SIX WEEKS EXAMINATION IN COMPARISON WITH THE PREOPERATIVE ONE*

The comparative analysis of postoperative astigmatism (at the six weeks examination) with the preoperative on, there were no significant differences in the distribution of cases of astigmatism on groups of values, most of them being the low values astigmatisms (0.00 -> ±0.75 diopters) which postoperative were 69,59% of the total, compared to 70,94% as found preoperatively. In

the group of values ranging between ±1.00 -> ±2.00 diopters there was a negligible increase of their proportion from 27,36% preoperative to 29,22% at the six weeks postoperative examination.

If preoperative prevailed the according to the rule astigmatisms (57.60%), at 6 weeks postoperative there was a net change in astigmatism axis orientation, consisting of a clear majority of those against the rule, which accounted for 70,10% of the total.

⇨ ***DISCUSSIONS OVER THE REPARTITION OF CASES OF POSTOPERATIVE ASTIGMATISM AT THE SIX MONTHS EXAMINATION IN COMPARISON WITH THE PREOPERATIVE ONE***

At the six months evaluation, it was concluded that in this case there were no significant changes regarding the magnitude of the values compared to the preoperative one. Thus, there was only a slight decrease in the percentage of astigmatism with values ranging from 0.00 -> ±0.75 diopters, from 70,94% preoperative to 69,76% postoperative. Values ranging between ±1,00 -> ±2,00 diopters rose slightly from a rate of 27,36% preoperative to 29,39% at six months postoperative.

At the six months postoperative examination there was a clear predominance of the against the rule astigmatisms, representing 71,29% of the total.

⇨ ***DISCUSSION OVER THE GLOBAL ANALYSIS OF ASTIGMATISM SIX WEEKS POST SURGERY IN COMPARISON WITH THE PREOPERATIVE ONE***

A global analysis of postoperative astigmatism at the six weeks examination compared with the preoperative, shows that although the share of low-grade astigmatisms (0.00 -> ±0.75 diopters) underwent a slight decline from 70,94% preoperative to 69,59% preoperative, the total sum of the astigmatisms values also showed a decrease from 412,502 preoperative to 356 postoperative. This decrease in the amount of postoperative astigmatism values at this range can be explained by the fact that the lowest average of astigmatisms values was recorded postoperative respectively 0,601 compared to 0,696 preoperative.

⇨ ***DISCUSSION OVER GLOBAL ANALYSIS OF ASTIGMATISM SIX MONTHS POST SURGERY IN COMPARISON WITH THE PREOPERATIVE ONE***

An analysis of postoperative astigmatism at six months compared with the preoperative one, shows the same issues, consisting in the decrease of the sum of values from 412,502 preoperative to 378,25 after surgery, although in this case there was a slight decrease in low-grade astigmatisms (between 0.00 -> ±0.75 diopters) from 70,94% preoperative to 69,76% postoperative. Values ranging between ±1.00 -> ±2.00 diopters have increased slightly from 27,36% preoperative to 29,39% after the operation, while values greater than 2.00 diopters decreased from 1,70% preoperative to 0,85% after surgery. Decreasing the amount of postoperative astigmatism values at six months compared with the amount of preoperative values, might be due, as in the case mentioned above, to the decrease of the average of the postoperative values (0,638) than the preoperative ones (0,696).

⇨ ***DISCUSSION OVER THE GLOBAL ANALYSIS OF THE SURGICAL INDUCED ASTIGMATISM***

At the six weeks postoperative examination, the overall amount of surgically induced astigmatism was negative (-56,502) this being the result of the difference between the sum of astigmatism values at six weeks postoperative (356) and the amount of preoperative values (412,502).

At the six months postoperative examination there was still a negative value (-34,252), but slightly higher than the one found at six weeks (-56,502), explained by a slight increase in the amount of astigmatism values in this assessment compared to the previous (378,25 at six months compared to 356 at six weeks postoperatively).

The negative value of surgically induced astigmatism in both postoperative examinations can be translated into a favorable refractive outcome, respectively the lack of this type of astigmatism at a global level. This aspect was due, as mentioned above, to the stability of the refractive cornea offered by these small corneal incisions.

⇨ *SURGICALLY INDUCED ASTIGMATISM ACCORDING TO THE DIMENSION OF THE INCISION*

The analysis of surgically induced astigmatism in the three study groups, based on the corneal incision size, has shown that this type of astigmatism is present only in the 2.75 mm incision group, missing from the 1.8 mm and 2.2 mm incision groups. There were no major refractive differences between the 2.2 mm and that of 1.8 mm incisions groups. The magnitude of surgically induced astigmatism in the above case (incision of 2.75 mm) is small and has not shown significant changes at the six months examination compared to those found at six weeks post surgery. In this respect postoperative refractive change was 13.25 at six weeks postoperative and of 22 at six months postoperative.

⇨ *SURGICALLY INDUCED ASTIGMATISM ACCORDING TO THE LOCATION OF THE INCISION*

General analysis of surgically induced astigmatism according to the corneal incision location shows that this type of astigmatism was not revealed in the subgroup of supero-temporal and superior incisions, but was present in the subgroup of supero-nasal and temporal incisions . From the data presented above also results that although it was present in the two locations, the amplitude of surgically induced astigmatism was very low and there were no significant changes from at the six months examination from the one made at six weeks post surgery.

⇨ *SURGICALLY INDUCED ASTIGMATISM ACCORDING TO THE LOCATION AND SIZE OF THE INCISION*

Detailed analysis of surgically induced astigmatism depending on the location and size of peripheral corneal incision showed that the results were varied. Thus, if the case of supero-temporal location, the corneal incision size was not the main determinant in the development of surgically induced astigmatism, meaning that this type of astigmatism was absent in the case of 1.8 mm and 2.75 mm incisions, but was present in the case of 2.2 mm incisions, but of very low amplitude.

II.8. PROPHYLAXIS AND TREATMENT OF SURGICALLY INDUCED ASTIGMATISM AND OF POSTOPERATIVE ASTIGMATISM

- reducing the size of the corneal incision
- making the incision on the more refringent meridian
- making the incisions in clear cornea on opposite meridians
- relaxing limbic incisions technique
- relaxing peripheral corneal incisions, single or in pairs
- correction of intraocular lenses - toric implantation of artificial lens
- postoperative correction of refractive surgery techniques (PRK, LASIK).

II.9. EXAMINATION PROTOCOL AND SURGICAL TREATMENT OF THE PATIENT IN ORDER TO FIGHT THE SURGICALLY INDUCED ASTIGMATISM

a. Usual preoperative clinical examination:

- determining the distance visual acuity, corrected and uncorrected
- contrast sensibility
- biomicroscopy of the anterior segment
- measuring the number of endothelial cells
- anterior chamber depth measurement
- aplanotonometry
- direct and indirect oftalmoscopy

b. Determination of the patient's preoperative refractive status

- determination of ocular refraction with the help of the Humphrey autorefractometer in the cases where the evolutionary stage of the cataract is not so advanced and allows this examination
- keratometry
- corneal topography

c. Ocular biometry and calculation of artificial lens implant (IOL target)

d. The choice of surgical incision in terms of size, location in a particular anatomical area (scleral, corneal Language) and its configuration

e. Choice of type of artificial lens to be implanted in terms of its quality, material, implant design (spherical, aspherical, design of haptics), optical party size.

f. Preoperative astigmatism treatment

II.10. CONCLUSIONS

* The postoperative astigmatism magnitude map is very slightly different from that of the preoperative astigmatism, in both cases the most present ones being the ones ranging between 0.00 -> -0.75 diopters

* Regarding the clinical form, postoperative there was a shift of astigmatism axis, meaning that if preoperative there was a slight predominance of with the rules astigmatism, after surgery there was a clear predominance of against the rule astigmatisms.

* In the cataract surgery, the practice of small incisions in clear cornea minimizes corneal damage and postoperative complications that can compromise the functional outcome after surgery, leading to dissatisfaction of both the surgeon and the patient.

* Such incisions also reduce the time required for visual rehabilitation, restore patient independence, enabling faster resumption of their normal activity.

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