Pachymetric Changes of the Cornea Amongst Patients Treated with LASIK

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ABSTRACT

Purpose: In this study, we have researched the possible parametrically changes before and after LASIK (laser-assisted in situ keratomileusis) and the influence of these changes in the cause of post LASIK ectasia. **Materials and methods:** In this study 204 eyes with different refractive anomalies were included. Candidates that underwent refractive surgery first have to undergo many ophthalmological examinations, firstly by evaluating their visual acuity, subjective and objective refraction with and without cycloplegia, slight lamp evaluation, computerized topography, pupillometry, retina examination and measurement of intraocular pressure. Pachymetric values were measured with Orbscan IIz (Bausch – Lomb). Refractive surgery was done with LASIK under local anesthesia. **Results:** In this study 102 patients were treated with LASIK who were with different refractive anomalies. According to the group age 44 or 43.1% were of the age 20 – 29, 46 or 45.1% were of the age 30 – 39, 11 or 10.8% were 40 – 49 years of age and 1 or 1% were above the age of 50 +. Pachymetric before surgery in right eye was approximately 565.4 μ m (DS+/- 39.4), from 507 μ m up to 678 μ m, but after surgery it was approximately 497.5 μ m (DS+/-61.7) from 346 μ m up to 644 μ m. Pachymetric on the left eye before surgery was approximately 564.8 μ m (DS+/-41.5) from 504 μ m up to 696 μ m but after surgery it was approximately 498.3 μ m (DS+/-62.2), from 329 μ m up to 646 μ m. Pachymetric in both eyes before surgery was approximately 549.1 μ m (DS+/-73.9), from 263 μ m up to 687 μ m. Pachymetric on both eyes after surgery was approximately 496.9 μ m (DS+/-60.1), from 337.5 μ m up to 645 μ m. With the “Paired T – test” we have reached a significant statistical change between the pachymetric values in both eyes before and after the surgery ($P<0.0001$). **Conclusion:** Corneal thickness is one of the main criteria in order to allow refractive surgeries, and as the main criteria it was evaluated at our patients treated with LASIK. **Keywords:** Pachymetric, Orbscan IIz, LASIK.

1. INTRODUCTION

Normal corneal thickness is about 540 microns. Laser in situ keratomileusis (LASIK) and photo refractive keratectomy (PRK) remain popular surgical procedures for the correction of myopia. Correcting vision by LASIK involves removal of corneal tissue. Therefore, the cornea is thinner after the procedure than before corneal thickness changes after LASIK.

Keratorefractive methods have to do with the evaluation of the radius of the curvature of the anterior surface of the cornea and from this most evaluate the central part of the optical zone and they determine the report between the anterior and the posterior surface of the cornea. Also we do have the evaluation of the corneal thickness (pachymetric). The cornea has an average value of

the radius curvature which is approximately 7.8 mm. The cornea is not completely transparent, it bends around 10 % of the light rays mainly because of the dispersion from the stroma (1).

The light which in a certain angle falls in an optical medium partially goes through it, partially is absorbed and partial is reflected from the edges of the surface. Depending on the optical density of the two environments and the surface that divides them the report between these three light characteristics will be different. During the crossing of the light in a homogeneous environment it's dispersed straight, but when crossing from one environment into another environment it will change its path, concretely the angle of direction will depend from the density of the optical medium. When crossing

from a less dense optical environment into a more dense optical environment the light rays will bend normally meaning the angle of fall is higher than the angle of refraction. The report of the sinus angle of the fall angle and the refraction angle is called the refractive index (2).

When the laser beams initially meet with any surface four phenomena's will happen: absorption, transmission, dispersion and reflection (3). Absorption and transmission are important for the cornea which depends on the wavelength of the laser beams. The action of the excimer laser can be used to remove small parts of the corneal tissue and do an effective remodeling of the cornea in order to achieve exact refractive changes. Excimer laser does its action under the control of a computer. Refractive surgery is a group of surgical procedures designed to reduce or eliminate the need for the use of glasses or contact lenses (4). The most frequent refractive procedure of the cornea is LASIK (5).

LASIK is a "lamellar" procedure in which photoablation and "excimer laser" are combined also intrastromal surgical technique by preserving the outer layer of the cornea. In its root "lamellar" refractive corneal surgery intends to displace to add or to modify the corneal stroma which changes the radius of the corneal curvature based on the given parameters. With LASIK a great deal of refractive anomalies can be changed, also it can be used with other refractive techniques in order to treat severe ametropias (6).

2. MATERIALS AND METHODS

In the study 102 patients are included or 204 eyes, the interventions are done in the German Eye Clinic in Prishtina. The possible candidates undergo many ophthalmic examinations by starting in evaluating the visual acuity, subjective and objective refraction with and without cycloplegia, slit lamp examinations, computerized topography, pupillometry, retina examinations, measuring the intraocular pressure. A detailed examination of all corneal layers is very important since any pathology in the cornea could be a contraindication for refractive surgery. The epithelium has to be intact, stroma has to be transparent also we have to be careful in examining the endothelium and the Descemet membrane.

The evaluation of corneal morphology is the moment when it's decided whether a patient can undergo refractive surgery. The exact evaluation of central corneal thickness in order to set the limits up to which point stromal ablation, can be done in order to have a safe outcome of the eye. Here we are focused in three main elements which need to be evaluated: Flap thickness, depth of ablation and the residual stroma after ablation.

Pachymetric measurements were done with Orbscan IIz (Bausch – Lomb). In Orbscan we have a combined system of "slit – scanning" and the "Placido disc" (40 circles) to evaluate the "elevation" the anterior curvature and the "elevation" the posterior curvature of the cornea. With this we have the complete scheme of corneal pachymetric with the measurement "white to white". We have to scan "slit lamps" at a 45 degree angle in the right and in the left side of the axis. 40 images are done from the system, 20 from each projector and all this in 0.7 sec. Also we do have a "tracking" system for involuntary patient movement. Keratometric values can be measured (3 and 5 mm from the center of the cornea) and

the lowest pachymetric value. It can measure 9000 points in 1.5 sec (1). A photo of an Orbscan with a normal eye contains four parts: In the upper part it shows the anterior part of the cornea, upright the posterior surface of the cornea, left down the keratometric model and downright the pachymetric.

After dropping the eye with local anesthesia the eye is marked in the angles 0 and 180 degrees. The patient lies down in a horizontal position and a lid speculum is placed, the surface of the cornea and of the conjunctiva is cleaned, and the marking is done with a surgical sterile marker (gentian violet) in four points which serve for orientation once the repositioning of the flap is done. A successive, pneumatic LASIK ring is placed whose task is to hold the head of the Amadeus microkeratome (AMO – Irvine, CA, USA). After the vacuum is activated in the ring and before the cut with the microkeratome we have to verify that the intraocular pressure is raised (>65 mm/Hg), which is measured with the applanative tonometer of Barraquer, then the microkeratome is activated, the creation of the flap is 140 microns thick.

Choosing the right size of the ring depends from the length values "white to white" and the keratometric values by using the preoperative values measured with the Orbscan IIz and the ablations zone applied is 6.0 mm. The ring 8.5 mm is used when the length of "white to white" was 11.5 or smaller otherwise the ring of 9.5 mm was used. After the vacuum is stopped and the ring is removed the positioning of the flap is done in the opposite way and the drying of the stromal bed is done (7). Once we have verified once more that the refractive values and the laser calibration is correct that the positioning of the head is proper, the positioning of the cornea is perpendicular with the opening of the laser tube, the covering of the flap is done with the mask which is integrated in the computer system of the device then tracking of the system is activated. We can start the stromal ablation with the laser rays. After the effect of the laser rays the repositioning of the flap is done and the stromal bed is irrigated with BSS (balanced salt solution) with a syringe and a cannula where the flap is attached best possibly in its previous position. Finally the cornea is dried as best as possibly, we wait for 2 minutes and then we check once more to see whether the flap is placed correctly in its position. The eye is dropped with antibiotics and cortisone (monodose preservative free) and the lid speculum is removed. Every patient 15 minute after surgery is checked under the slit lamp for a possible flap decentration or complication. The presentation of data is done through tables. The processing of data is done with the statistical package InStat 3. From the statistical parameters there are calculated the index of the structure, the minimal and maximal value.

3. RESULTS

During the 3 year period 102 patients were analyzed (204 eyes) with different refractive anomalies (myopia, myopia with astigmatism, hyperopia, hyperopia with astigmatism, astigmatism).

In the study 102 patients are included who were treated with LASIK out of whom 56 or 54.9% were of female gender and 46 or 45.1% of male gender. With the "X2 - test" we did not gain a significant important statistical change with patients according to gender (X^2 - test=0.98, $P=0.322$). According to the group age, 44 or 43.1% were of the age 20 -

29 years of age, 46 or 45.1% were 30 - 39 years of age, 11 or 10.8% were 40 - 49 years of age and 1 or 1.0% were 50 + years. According to the group age we noticed that women more often were of the age above 40 compared to men but men were more often of the age 20 - 29 years (Table 1).

Age	F		M		Total	
	No	%	No	%	No	%
20-29	22	39.3	22	47.8	44	43.1
30-39	26	46.4	20	43.5	46	45.1
40-49	8	14.3	3	6.5	11	10.8
50+	-	-	1	2.2	1	1.0
Total	56	100.0	46	100.0	102	100.0

Table 1. Study according to the group age and gender

In 102 patients included in this study 83 or 81.4% had myopia with astigmatism in the right eye, 11 or 10.8% had hyperopia with astigmatism, 6 or 5.9% had myopia and 2 or 2.0% had hyperopia. In 102 patients included in this study 79 or 77.5% had myopia with astigmatism in the left eye, 15 or 14.7% had hyperopia with astigmatism and 8 or 7.8% had myopia (Table 2).

Pathology	Right eye		Left eye	
	No	%	No	%
Myopia	6	5.9	8	7.8
Hyperopia	2	2.0	-	-
Myopia with astigmatismus	83	81.4	79	77.5
Hyperopia with astigmatismus	11	10.8	15	14.7
Total	102	100.0	102	100.0

Table 2. Pathologies in the study according to the eyes

Pachymetric in right eye before surgery in average was 565.4 μm (DS+39.4), from 507 μm up to 678 μm . Pachymetric in right eye after surgery in average was 497.5 μm (DS+61.7), from 346 μm up to 644 μm . With the "paired T-test" we have gained a significant important statistical change between the values of pachymetric in the right eye before and after the surgery ($P < 0.0001$), (Table 3).

Pachymetry in right eye	Before surgery	After surgery
No	102	102
Average	565.4	497.5
SD	39.4	61.7
Min	507	346
Max	678	644
Paired T-test	$P < 0.0001$	

Table 3. Pachymetry in the right eye before and after surgery

Pachymetric in the left eye before surgery in average was 564.8 μm (DS+41.5), from 504 μm up to 696 μm . Pachymetric in the left eye after surgery in average was 498.3 μm (DS+62.2), from 329 μm up to 646 μm . With the "paired T-test" we gained a significant statistical change between the

Pachymetry in left eye	Before surgery	After surgery
N	102	102
Average	564.8	498.3
DS	41.5	62.2
Min	504	329
Max	696	646
Paired T-test	$P < 0.0001$	

Table 4. Pachymetry in the left eye before and after surgery

values of pachymetric in the left eye before and after the surgery ($P < 0.0001$), (Table 4).

Pachymetric in both eyes before surgery in average was 549.1 μm (DS+73.9), from 263 μm up to 687 μm . Pachymetric in both eyes after surgery was in average 496.9 μm (DS+60.1), from 337.5 μm up to 645 μm . With "paired T-test" we gained a significant statistical change between the pachymetric values in both eyes before and after the surgery ($P < 0.0001$), (Table 5).

Pachymetry	Before surgery	After surgery
Number of patients	102	102
Number of eyes	204	204
Average	549.1	496.9
SD	73.9	60.1
Min	263.0	337.5
Max	687.0	645.0
Paired T-test	$P < 0.0001$	

Table 5. Pachymetry in both eyes before and after the surgery

4. DISCUSSION

In our study we found out that mean pachymetric was 549.1 milimicrons (DS+73.9), which does not correlate with gender. Similar results had Prasad et al (8) and Cho and Lam (9). They came to a conclusion that gender does play a role in corneal thickness.

In the aspect of refractive anomalies we noticed that the most common refractive anomaly was myopia with astigmatism (81.4% right eye and 77.5% left eye), then hyperopia with astigmatism and last myopia, hyperopia. We did not have any patient only with astigmatism.

Almost every day we come across new applications in the technology of refractive surgery especially in preoperative measurements, in the creation of the flap and in the action of laser rays itself. As a main goal we try to have accuracy in the results through a high energy with very short pulses (10).

Refractive interventions with thin cornea are considered as a possible cause in keratectasia post - LASIK. But in literature we notice that we do not have an increase of incidence with keratectasia post - LASIK amongst patients with a corneal pachymetric under 500 milimicrons but with a normal topography. Caster et al. (11) did not find any case with keratectasia at 109 eyes which preoperatively had a corneal thickness under 500 milimicrons. Also Tomita et al. (12) in a very long study of about 5 years postoperatively came to a conclusion that there is not much of a significant change in the pachymetric of the patients with a thin cornea even after a long period postoperatively just as with small postoperative refractive changes which check out with our study. With "Paired T-test" we got a significant statistical change in the pachymetric values of both eyes before and after surgery ($P < 0.0001$).

The corneal film creates the smooth outer layer of the corneal surface, which itself is almost rough. This smooth layer in the optical sense has a very important essential role in the refractive system of the eye. Also we do know that the corneal film is not constant all the time, after blinking the corneal film needs a few seconds to create the smooth layer in the surface of the cornea (13). In our study we had this consideration so we suggested the removal of contact lenses and the use of artificial eye drops before surgery in order not to have

a break in the corneal film so this would not have any affect in the preoperative and postoperative results. Also we tried to notice every detail in this aspect and eventually we did not include any of these patients in our study who had a disorder in their corneal film.

In our study the topographic measurements are done with the Orbscan IIz and we now that the topographical measurements of the anterior and the posterior cornea are in the function of change. So a mistake in the measurement of the anterior corneal elevation will give us wrong results of corneal thickness. The measurement of the anterior corneal thickness is easier to measure therefore the mistakes happen more often in the measurement of the posterior corneal thickness. Topographically, a falsely thin CCT measurement can appear as a forward protrusion of the posterior corneal surface. This artifact generated by the Orbscan in post-LASIK eyes may be responsible for the finding in earlier studies that all corneas develop subclinical ectatic changes after LASIK (7).

5. CONCLUSION

Corneal thickness is one of the main reasons in order to allow refractive surgical intervention and as the main criteria it was evaluated at our patients treated with LASIK. The contraindication for LASIK are also the patients with corneal pachymetric under 500 milimicrons or a abnormal topography, where at this point its important to avoid ectasia pos LASIK.

CONFLICT OF INTEREST: NONE DECLARED.

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