FEMTOLASIK VERSUS MICROKERATOME LASIK, A COMPARATIVE STUDY OF THE EFFECT ON TEAR FILM STABILITY BY USING ANT. SEGMENT OCT

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ABSTRACT

Femtosecond laser has a wavelength of 1053 nm. It is a type of infrared laser. It is similar to Nd: YAG laser in creating photo disruption of the transparent tissues like the cornea. Both of these laser systems generate an expanding cloud of ionized molecules and also free electrons that ultimately cause acoustic shock wave to disrupt the tissue.

There are several types of microkeratomes, which allow satisfactory reproducibility in an ever more secure surgical context. Technical and practical knowledge of the microkeratome used is therefore a necessary and essential prerequisite before all LASIK.

The cornea is one of the most sensitive tissues of the body, as it is densely innervated with sensory nerve fibers via the ophthalmic division of the trigeminal nerve by way of 70–80 long ciliary nerves. Research suggests the density of pain receptors in the cornea is 300-600 times greater than skin and 20-40 times greater than dental pulp, making any injury to the structure excruciatingly painful.

Optical coherence tomography is an imaging modality that uses a high-resolution cross-sectional image to capture retina and posterior segment. It uses near-infrared light of 830nm wavelength for this target.

In this study we compare between Lasik and FemtoLasik effect on tear film stability. The two groups show comparable results. Anterior segment OCT can give a reproducible and quantitative data by measuring the tear meniscus height.

Keywords: Femto-Lasik and Conventional Lasik, Anterior segment OCT,Dry eye Diseases

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INTRODUCTION

Femtosecond lasers and laser assisted in situ keratomileusis (LASIK)

The collateral damage produced by Femtosecond LASIK is much lesser than that produced by YAG laser, hence Femtosecond laser can be used in corneal surgeries. Early in 1990 was the first ophthalmic Femtosecond laser system to be designed. Many Femtosecond laser systems are available nowadays. They differ in pulse energy and frequency. Also, available applications are different. Some of them have a flat applanation surface, while others have a curved one. (1)

The laser firing system has a frequency that increased from 10 Khz to 150 kHz in new generations. It is to be considered that Femtolaser system works in mHz firing rate, rather than kHz. So, these higher frequencies reduce time needed for flap creation. Also, it lowers the energy per pulse. All these factors allow for a smoother corneal stromal bed. Hence, the corneal flap and stroma have a smooth surface. (2)

The pioneer of contemporary corneal refractive surgery is Doctor Jose Ignacio Barraquer who, in 1949, proposed modifying the anterior corneal curvature in order to correct certain spherical ametropias. (3)

In 1958, he used the first microkeratome that he himself had developed, in order to develop keratophakia techniques (compensation for aphakia by corneal surgery). The concept of the Barraquer microkeratome will evolve in the 60s (motorization, etc.).

In 1996, the company Moria started marketing the rotary microkeratome (called "Carriazo-Barraquer". Since then, this company has developed a system of disposable heads and rings that can be used on conventional engines and consoles.

In 1997 the Chiron Company has developed a microkeratome (Hansatome) allowing automated cutting by rail, arcuate and creating a superior hinge. (4)

The basic principles of the microkeratome and the role of the suction ring and cutting head are illustrated in Figure 5-3. The suction ring has 2 functions: to adhere to the globe, providing a stable platform for the microkeratome cutting head; and to raise the IOP to a high level, which stabilizes the cornea. (5)

Corneal nerves of the subepithelial layer terminate near the superficial epithelial layer of the cornea in a logarithmic spiral pattern. The density of epithelial nerves decreases with age, especially after the seventh decade. (6)

In comparison to UBM, AS-OCT is a non-contact procedure with a more friendly use. Spectral Domain and Time Domain have different capabilities. Time Domain faces a major restriction of moving mirror limiting speed and resolution. However, Spectral Domain utilizes a stable mirror enabling higher resolution along with faster image. (7)

Anterior Segment OCT can give a quantitative data of tear meniscus height and area that can reflect tear film stability. In that way OCT can be a useful technique for monitoring postoperative dryness and therapy. (8)

Patients & Methods

Inclusion criteria constitute:

- Stable refractive errors.
- Patient's age from 20 to 40 years old.
- Refractive errors from -1.00 to – 8.00 diopters.

Exclusion criteria constitute:

- Absolute conditions: like Keratoconus
- Relative conditions: like;
  - Autoimmune disease and Immunological abnormalities.
  - Glaucoma and antiglaucoma medications.
  - Thin cornea.

Anterior segment OCT allows for accurate imaging of anterior segment structure. Spectral domain gives highly sensitive results. Those data correlate well with Schirmer's test and break up time test

Examinations:

- Chart visual acuity.
- Refraction,
- Slit-lamp Examination.
- posterior segment evaluation,
- Tear Break-up time test.
- Schirmer’s test
- Anterior segment OCT.

Surgical methods:

The microkeratomes still used today derive from the Barraquer concept, from which they retain a number of common constituent elements.

-a suction ring,
-a head (which carries the blade),
-a motor,
-cables (suction, electric motorization),
-a pedal (connected to the console to trigger the vacuum and cutting)
-a source of energy,
-a vacuum system
-accessories

Femtosecond Lasik exceeds the standard Lasik in the following parameters:

- Improves flap safety and predictability.
- Control of flap diameter and thickness.
- Accommodation of thin cornea and high refractive errors.
- Decreased incidence of epithelial ingrowth.
- Less elevation in IOP needed. (9)

Postoperative management:

AS-OCT cannot give image beyond the pigmented iris epithelium as it absorbs its light. However, it allows imaging the cornea, lens and anterior chamber. It is valuable to assess the cornea in case of LASIK patient that may go for enhancement.

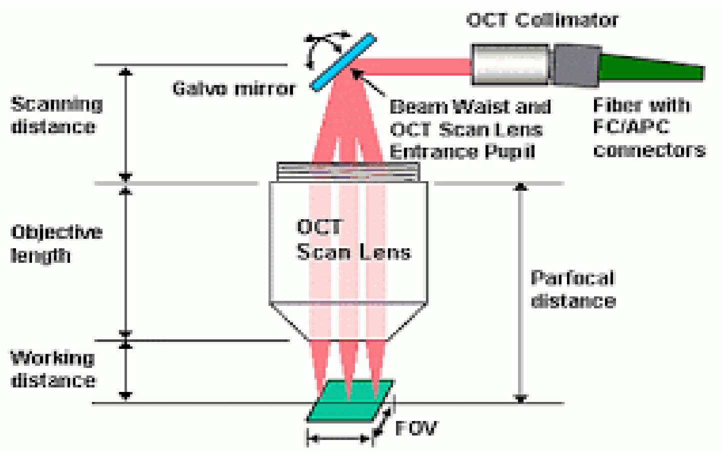

Fig. 1: Principles of OCT

To exclude postoperative ectasia, it is important to evaluate the flap thickness along with residual stromal thickness. In application to assess tear film stability, OCT can be used for measurement of tear meniscus. (10)

Measurement of the lower tear meniscus parameters was performed by AS- OCT. Application of the anterior segment line at 90 degrees at junction of lower cornea with lower lid margin. The lower tear meniscus is being imaged. In the software of the OCT system there is a caliber. This caliber allows measurement of the lower meniscus height.

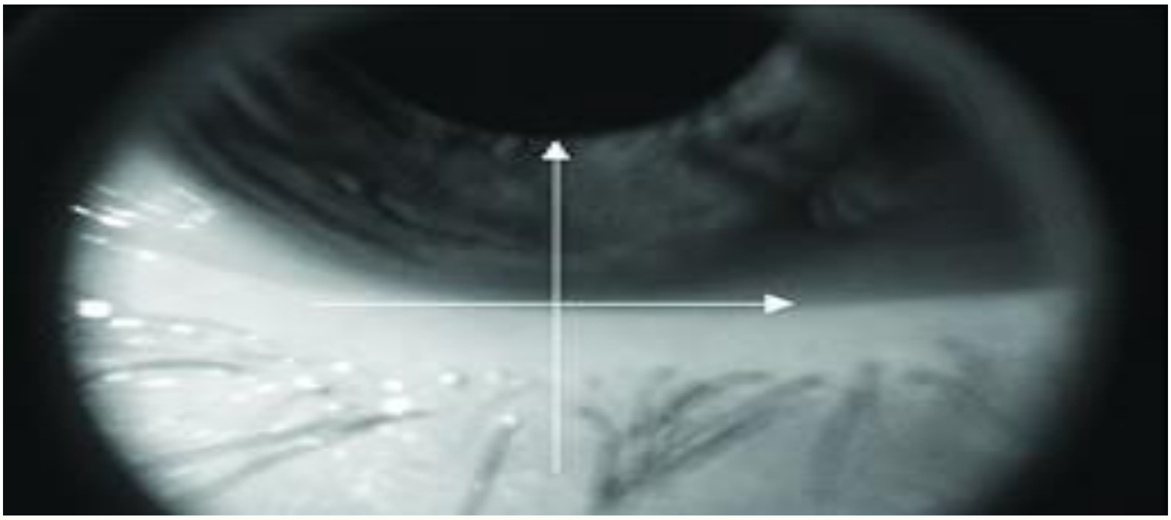

Fig. 2: A CL-cross line on with horizontal line on lower lid margin and vertical line on inferior cornea at 6'0 clock hour.

Anterior segment OCT allows for accurate imaging of anterior segment structure. Spectral domain gives highly sensitive results. Those data correlate well with Schirmer's test and break up time test.

Statistical analysis:

Paired sample t-test of significance are used when comparing between related samples.

- Independent-samples t-test of significance was used when comparing between two means.
- Chi-square (x^2) test of significance are used to compare proportions between qualitative parameters.
- Probability (P-value)
  - P-value ≤0.05 was considered significant.
  - P-value ≤0.001 was considered as highly significant.
  - P-value >0.05 was considered insignificant

Results

Table (1): Comparison between group A: Femtosecond LASIK and group B: Microkeratome LASIK according to Ref. Error, Un. V/A and BCVA.

	Group A: Femtosecond LASIK *(n=40)*	Group B: Microkeratome LASIK *(n=40)*	t-test	p-value
Ref. Error				
Mean±SD	-2.95±2.65	-3.36±2.61	0.492	0.485
Range	-6_4	-6_4		
Un. V/A				
Mean±SD	0.15±0.08	0.13±0.05	2.910	0.092
Range	0.1_0.3	0.1_0.3		
BCVA				
Mean±SD	0.88±0.11	0.85±0.11	1.114	0.294
Range	0.7_1	0.7_1		

t-Independent Sample t-test; p-value >0.05 NS;

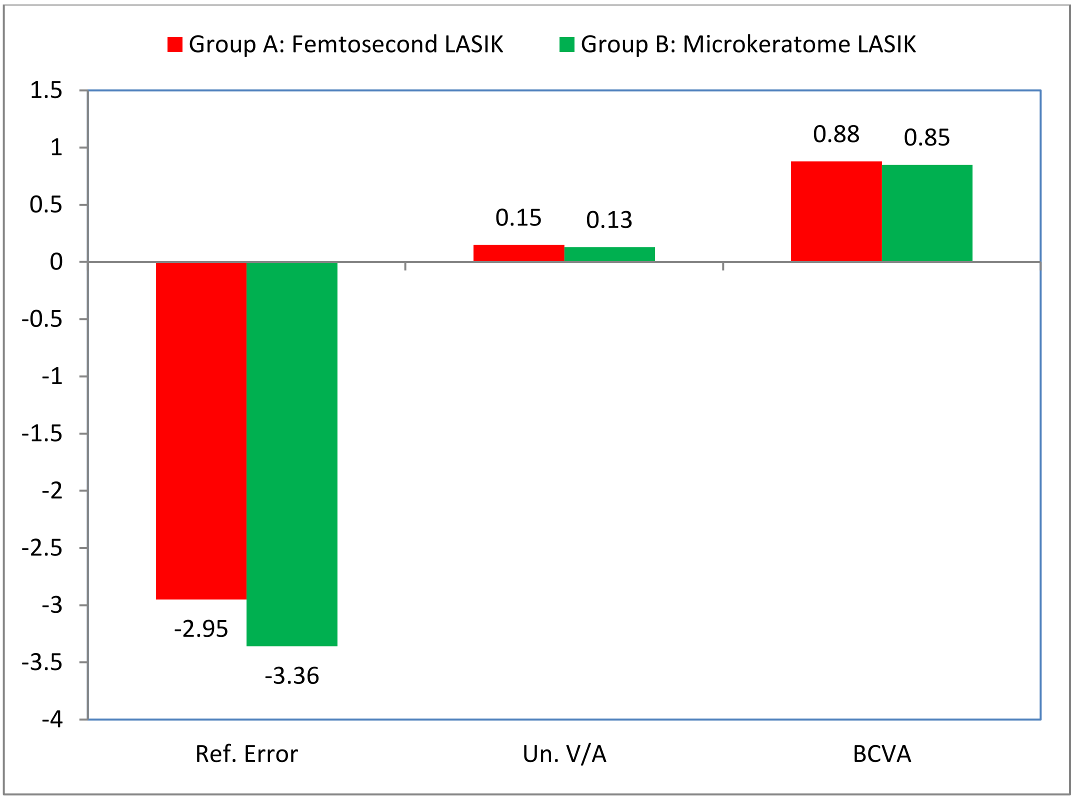

Fig. (1): Bar chart between group A: Femtosecond LASIK and group B: Microkeratome LASIK according to ref. error, Un. V/A and BCVA.

This table shows the refractive errors in our study. Mean range of refractive error was -2.95 in the first group with a standard deviation 2.65. Mean range was -3.36 in the second group with a standard deviation 2.61.
Unaided Visual acuity was comparable in the two groups. Also, best corrected visual acuity was in a close range between the two groups.
This table shows no statistically significant difference between groups according to Ref. error, Un. V/A and BCVA.

Table (2): Comparison between pre and after 1m according to tear break up time, schirmer's tests and tear meniscus height in group A: Femtosecond LASIK.

Group A: Femtosecond LASIK (n=40)	Pre	After 1m	Diff.	Paired t-test	p-value
Tear Break up Time (TBUT)	13.25±1.30	11.95±0.88	-1.30±0.88	4.313	0.021*
Schirmer's tests (ST)	13.30±1.36	11.08±1.31	-2.23±0.80	7.585	0.011*
Tear Meniscus height (TMH)	298.98±18.43	287.93±17.06	-11.05±6.45	10.837	<0.001**

t-Paired Sample t-test; *p-value>0.05 NS; *p-value <0.05 S; **p-value <0.001 HS*

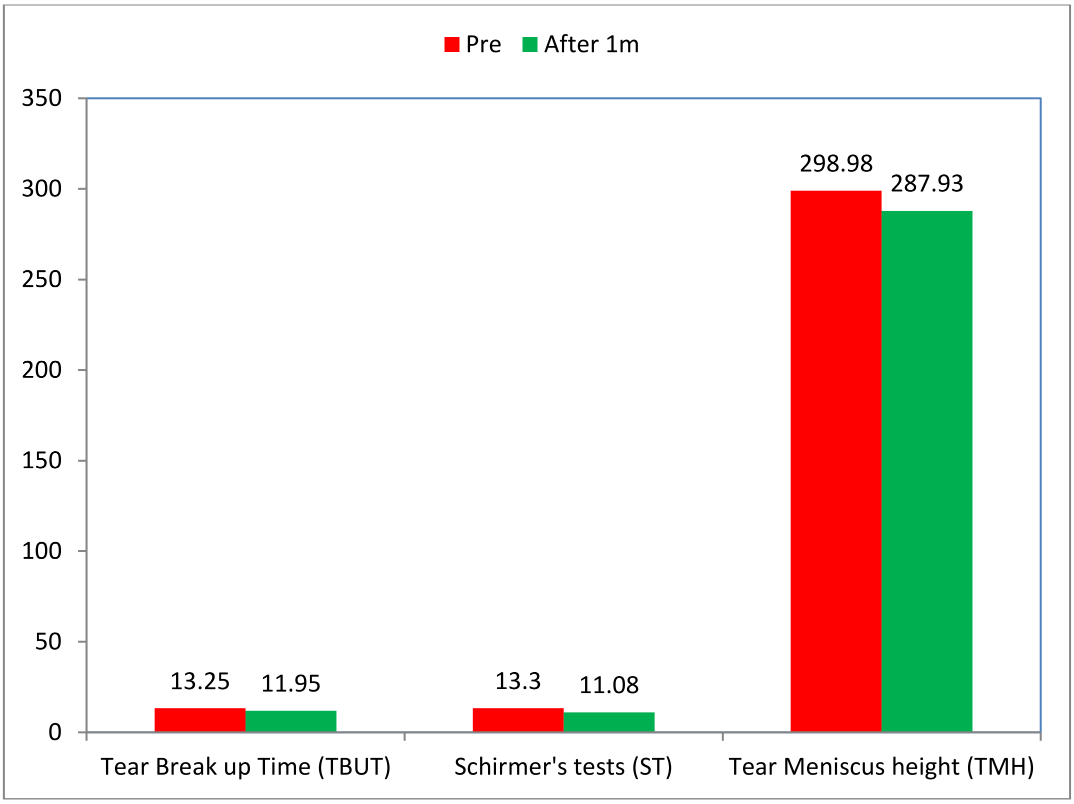

Fig. (2): Bar chart between pre and after 1m according to tear break up time, schirmer's tests and tear meniscus height in group A: Femtosecond LASIK.

In this table we can compare between pre and 1 month postoperative according to Tear Break up Time test, schirmer's tests and tear meniscus height in group A: Femtosecond LASIK.

Preoperative data shows TBUT 13.25 that decreases 1 month postoperative to 11.95 second. The difference equal -1.30 (p-value 0.021)

According to Schirmer's test, it shows a level of 13.30 preoperatively, that decreases to 11.08- 1 month postoperatively. The difference is -2.23 (P-value 0.011)

Tear Meniscus Height is compared to show a height of 298.98 preoperatively. This declines to 287.93 one month postoperatively. The difference equal -11.05.

This table shows statistically significant decrease mean of after 1m compared to pre-test according to tear break up time, schirmer's tests and tear meniscus height in group A: Femtosecond LASIK.

Table (3): Comparison between pre and after 1m according to tear break up time, schirmer's tests and tear meniscus height in group B: Microkeratome LASIK.

Group B: Microkeratome LASIK (n=40)	Pre	After 1m	Diff.	Paired t-test	p-value
Tear Break up Time (TBUT)	13.95±1.13	12.33±0.83	-1.63±0.93	5.110	0.022*
Schirmer's tests (ST)	13.43±1.03	11.30±1.14	-2.13±0.85	4.756	0.034*
Tear Meniscus height (TMH)	289.98±18.54	279.18±16.79	-10.80±6.06	9.279	0.003*

t-Paired Sample t-test;
*p-value>0.05 NS; *p-value <0.05 S*

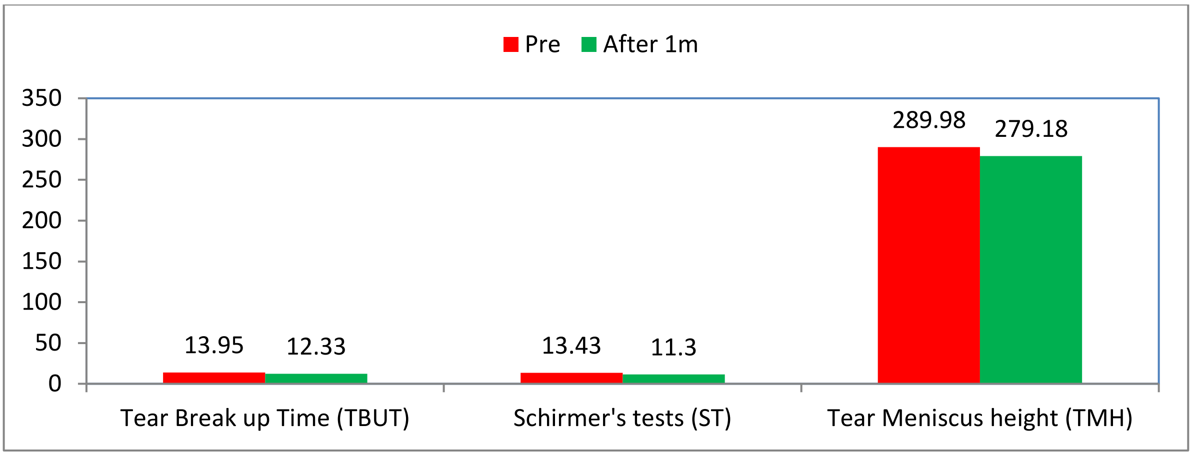

Fig. (3): Bar chart between pre and after 1m according to tear break up time, schirmer's tests and tear meniscus height in group B: Microkeratome LASIK.

In this table we can compare between preoperative and 1 month postoperative in the microkeratome group.
Tear break up time test was 13.95 then changed to 12.33 with p-value 0.022. The difference hence is –1.63. Shirmer's test was 13.43 then decreased to 11.30 with p-value 0.034.

In relation to Tear Meniscus Height, I showed a value of 289.98 preoperatively then declined to 279.18 by about 1 month postoperative. The difference hence is -10.80 with a P-value 0.003.
This table shows statistically significant decrease mean of after 1m compared to pre-test according to tear break up time, schirmer's tests and tear meniscus height in group B: Microkeratome LASIK.

DISCUSSION

Regarding to Tear Meniscus Height:
Group A:

Preoperative	After 1 m.	After 3 m.
298.98±18.43	287.93±17.06	292.73±17.86

Group B:

Preoperative	After 1 m.	After 3 m.
289.98±18.54	279.18±16.79	283.18±18.38

Table (4): Comparison between group A: Femtosecond LASIK and group B: Microkeratome LASIK according to tear meniscus height (CMH).

Tear Meniscus height (TMH)	**Group A: Femtosecond LASIK *(n=40)***	**Group B: Microkeratome LASIK *(n=40)***	**t-test**	**p-value**
Pre Mean±SD Range	298.98±18.43 270_320	289.98±18.54 270_320	1.742	0.097
After 1m Mean±SD Range	287.93±17.06 265_309	279.18±16.79 265_309	1.345	0.089
After 3m Mean±SD Range	292.73±17.86 266_311	283.18±18.38 264_311	1.055	0.060
Change (Pre and after 1m) Mean±SD Range	-11.05±6.45 -25_-1	-10.80±6.06 -25_-3	0.032	0.859
Change (Pre and after 3m) Mean±SD Range	-6.25±4.34 -13_0	-6.80±3.92 -13_-1	0.354	0.554
Change (After 1m and 3m) Mean±SD Range	4.80±6.57 1_22	4.00±5.74 -1_22	0.336	0.564

t-Independent Sample t-test; p-value >0.05 NS

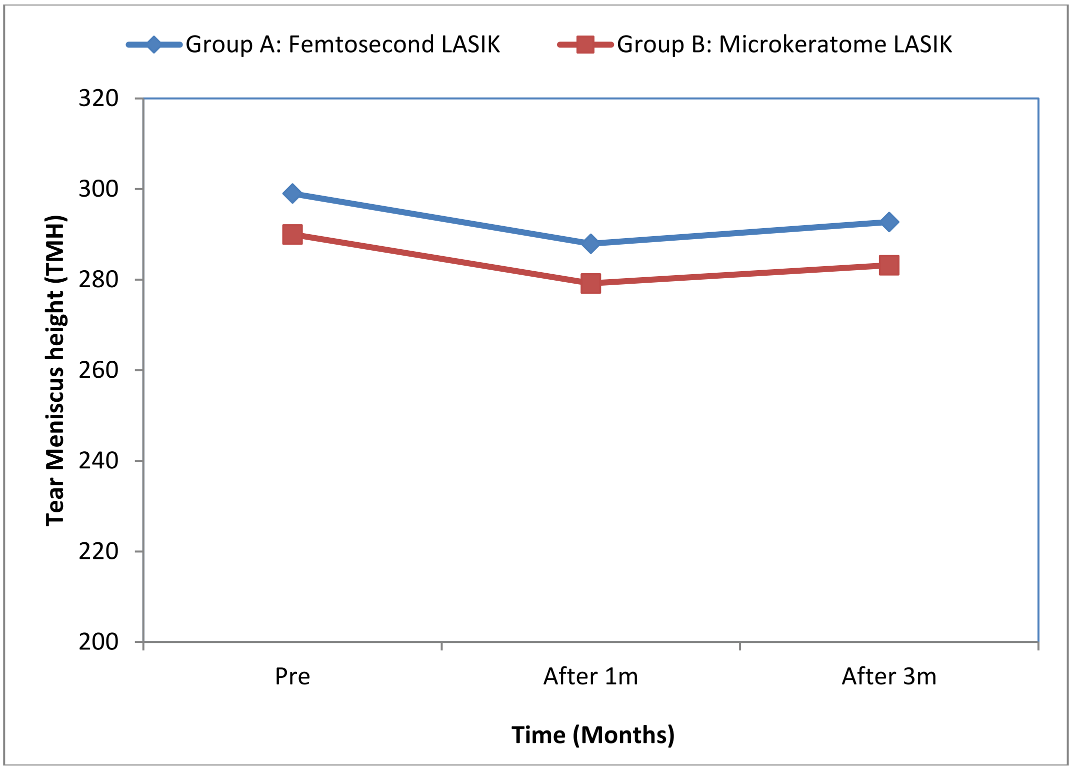

Fig. (5): Comparison between group A: Femtosecond LASIK and group B: Microkeratome LASIK according to tear meniscus height (TMH).

By using Anterior Segment OCT, the tear meniscus height could be assessed. The mean range was 298.98 micrometer with standard deviation 18.43 in the Femtosecond group.

Tear Meniscus Height showed mean range of 289.98 micrometer in the microkeratome group with standard deviation 18.54. That height was decreased 1 month postoperatively to reach 287.73 in the first group and 283.18 in the second group. By 3 months Tear Meniscus Height was reaching 292.73 and 279.18 with a standard deviation 17.86 and 18.38 in both groups respectively.

The microkeratome cutting head has several key components. The highly sharpened disposable cutting blade is discarded after each patient, either after a single eye or after bilateral treatment. The applanation head, or plate, flattens the cornea in advance of the cutting blade.

The length of the blade that extends beyond the applanation plate and the clearance between the blade and the applanation surface are the principal determinants of flap thickness. Smaller and thinner flap size and longer hinge cord length may be more important than hinge location in sparing the nerves and reducing the incidence and severity of dry eyes. Regardless of hinge type, patients generally recover corneal sensation to preoperative levels within 6–12 months after surgery.

Femtosecond laser technology was first developed by Dr. Kurtz at the University of Michigan in the early 1990s and was rapidly adopted in the surgical field of ophthalmology. Femtosecond lasers emit light pulses of short duration (10^{-15} s) at 1053 nm wavelength that cause photodisruption of the tissue with minimum collateral damage. This enables bladeless incisions to be performed within the tissue at various patterns and depth with high precision.

The femtosecond laser has revolutionized corneal and refractive surgery with respect to its increased safety, precision, and predictability over traditional microkeratomes. Advantages of bladeless femtosecond assisted LASIK (FS-LASIK) over conventional microkeratome assisted LASIK (MK-LASIK) include reduced dry eye symptomatology, reduced risk of flap button hole or free cap formation.

It was postulated that patients in the IntraLase group incurred less goblet cell damage than in the Hansatome group. This could be attributed to the higher IOP required for microkeratome (Hansatome) flap creation. Additionally, they speculated that the thinner flaps created with the IntraLase were responsible for less afferent nerve damage in the anterior corneal stroma that may influence dry eye symptomatology.

The femtosecond laser was first popularized as an alternative to the mechanical microkeratome for the creation of LASIK flaps. The femtosecond laser is applied to the corneal stroma at a pre-calculated depth. Flap creation using the femtosecond laser has been compared with creation using the mechanical microkeratome. Reports have shown reduced higher-order aberrations and enhanced flap thickness predictability.[4] In addition, the femtosecond laser offers more options in terms of flap thickness, and side cut angle, hinge specifications, and firing patterns.

Dry eye remains a common and important post-LASIK complication with up to 90 % of LASIK patients experiencing dry eye symptoms. Some studies looked at dry eye symptoms, signs, and severity with the IntraLase femtosecond and Hansatome LASIK. They found that significantly less patients suffered dry eye symptoms and had less evidence of superficial punctate epithelial erosions in the IntraLase group 1-month post LASIK.

Tear break up time test correlates well with tear film stability. A fluorescein strip is applied and the patient is asked to stare ahead without any blinking. The distributed dye over the tear film is visualized by cobalt blue light. The time between last blink and appearance of the first hole or spot in the tear film is equal to break up time.

Schirmer test allows for a paper test to be put in the lateral third of the lower lid. After 5 minutes, the length of the moistened part of the strip is measured. It is f great value in patient with severe aqueous deficiency.

Tear Meniscus Height can be used for tear volume estimation. Height less than 0.25 mm is abnormal. This parameter will suggest dry eye condition.

OCT has influenced refractive surgery. The refractive patient can be scanned for corneal or flap abnormalities. For example; epithelial ingrowth can be regularly checked. OCT can differentiate between cases that need flap elevation or others that need a close monitoring.

Conclusion

Ocular surface disease index is an index that reflects the state of tear film stability over the ocular surface. Patients with dry eye can experience different symptoms; some of them may be frustrating or may preclude daily activities.

Irritation, stinging, burning or foreign body sensation can be annoying symptoms. Also, fluctuation in vision or light sensitivity can be problematic. Headache or ocular pain can be extremely distressing.

However, not all patients will have signs correlated with their symptoms. Examination for those patients should include complete evaluation of eyelid condition, eyelid margin and lashes diseases. A thorough examination of the conjunctiva and cornea should take place, together with assessment of tear film stability.

By using anterior segment OCT, we get a valuable assessment of the tear film. It has the advantage of being a non-invasive technique. OCT imaging also has a good repeatability of tear meniscus measurements. It gives a quantitative assessment of tear film and meniscus. No need for dye instillation needed during the procedure. Also, there is no contact with the ocular surface.

Recommendations

Refractive surgeries usually result in tear film instability. Although reversible effect, mechanical keratome, through cutting the corneal nerves will change tear film condition. Femto-Lasik gives fast recovery time with more satisfactory results.

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