Femtosecond LASIK is fast becoming the standard of care for correcting mild to moderate refractive error. Since the time it was first available commercially in 2001, the technology of femtosecond for flap making in LASIK is progressively advancing allowing short time, better customization of flaps in terms of size, shape, side cut angle and additional procedures like creation of channels for Intra Corneal Ring Segments (ICRS) and keratoplasty.

**Physics of Femtosecond laser**

The femtosecond laser works based on the principle of light induced optical breakdown (photo ionization). It is a solid state Nd Glass laser similar to Nd YAG laser in the infrared range of 1000-1053nm, and the pulses produced are for very short duration of femtoseconds (10⁻¹⁵ seconds). It is because of this very short pulse duration that the collateral damage produced to the surrounding tissue is nearly absent. When the high number of photons concentrated in each laser pulse interact with electrons in the stromal tissue, vapourisation of the tissue occurs producing a microplasma / cavitation bubble. Each cavitation bubble contains CO₂ and water and the gas within the microplasma expands and coalesce with the adjoining ones with only thin tissue bridges separating them which are easily broken using spatula during a flap lift. This process of application of short duration pulses at a specific depth in the stromal tissue produces a cleavage plane for flap lift. Slower lasers (nanoseconds or picoseconds) have shown to produce larger cavitation bubbles, greater shock waves to the surrounding tissue and more collateral damage, hence not developed for photodisruption².

**Various machines and hardware differences**

Since the time this femtosecond technology was introduced, gradual technological advancements have taken place to increase the firing frequency from the initial 6 KHz to 500 KHz³.⁴. Currently five femtosecond laser platforms are available across the world (Table 1) and they differ primarily in pulse energy and frequency, applanation surface (flat or curved), laser delivery (raster or spiral pattern), available applications and mobility (Table 2)⁵. Apart from the LASIK flap creation, there is a wide range of procedures that can be performed with the femtosecond laser which includes laser assisted capsulotomy, incision placement and nucleotomy in cataract surgery, Astigmatic Keratotomy (AK), Channel creation for placement of Intra Corneal Ring Segments (ICRS), intrastromal lamellar pocket creation for the insertion of corneal inlays for presbyopia, femtosecond lenticule extraction (FLEX), Small Incision Lenticule Extraction (SMILE), Intrastromal Presbyopia Correction (INTRACOR), crafting a precise, interlocking graft host junction for penetrating keratoplasty and for creating donor lamellar buttons for both anterior and posterior lamellar keratoplasty⁶.

**Table 1: Currently available femtosecond laser platforms**

<table>
<thead>
<tr>
<th>Currently available femtosecond laser platforms</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Intralase (Abbott Medical Optics Inc, Santa Ana, California)</td>
</tr>
<tr>
<td>• Femtec (20/10 Perfect Vision, Heidelberg, Germany)</td>
</tr>
<tr>
<td>• Femto LDV (Zeimer Ophthalmic Systems, Port, Switzerland)</td>
</tr>
<tr>
<td>• VisuMax (Carl Zeiss Meditec AG, Jena, Germany)</td>
</tr>
<tr>
<td>• Wavelight FS 200 (Alcon Laboratories Inc, Ft Worth, Texas)</td>
</tr>
</tbody>
</table>
Wavelight Refractive suite

Wavelight FS 200 (Figure 1) produced by the Alcon Laboratories Inc (Fortworth, Texas) is FDA approved and commercially available since 2010 and has the following features:

- The world’s fastest platform, combining a 500 Hz excimer laser and a 200 kHz femtosecond laser
- Customized, patient-specific treatments - Wavefront Optimized, Wavefront - Guided, Topography-Guided, Custom - QTM and PTK treatments available (Table 3)
- Technology - leading ablation times of just 1.4 seconds per diopter
- Has WaveNet, an integrated network which allows seamless data transfer.

1050 Hz multi-dimensional eye tracker with a latency of 2 milliseconds.

Wavefront Optimized treatments result in a large true aspheric optical zone and a functional transition zone. This results in better mesopic and scotopic vision.

FS 200 kHz laser creates a 9.0 mm flap in 6 sec., total procedure time, “suction on” to “suction off” ~30 sec, allows flap centration adjustment after docking.

Other treatment options available include: Sub-Bowman Keratomileusis, Intracorneal ring segments, Lamellar and penetrating keratoplasty.

iFS – Intralase Femtosecond LASIK

This was the first machine commercially available for femtosecond flap making. Since then, the machine has advanced in the speed of femtosecond laser and ablation profiles and currently the fifth generation machine is available. Following are the features:

- The iFS laser (Figure 2) has two major innovations in flap architecture: the inverted bevel – in side cuts upto 150 degree for better biomechanical stability and elliptical shaped flaps for maximal stromal bed exposure.
- This laser also allows the creation of intrastromal channels for ring segments and keratoplasty.

Carl Zeiss – Visumax

Visumax (Figure 3) is the only laser that allows the treatment by refractive lenticule extraction for SMILE (Small Incision Lenticule Extraction) procedure. It is the fastest femtosecond laser.
laser that is currently available (500 kHz). Specific features include:

- Curved applanating surface available in three different sizes (small, medium large) to ensure an optimal fit with the cornea
- Short treatment times with pulse frequency of 500 kHz

**Surgical technique**

Since the flap making and the excimer ablation are computer controlled, data regarding the desired flap diameter, depth, hinge location its angle and side cut angle, patient’s refractive error are entered first. After anaesthetizing the ocular surface with topical proparacaine eye drops, suction ring is placed to stabilize the eye and for the seating of applanation plate. Once the suction is achieved, the applanation cone (patient interface) is inserted and docking done. Depending on the type of the laser a flat or curved contact surface is used. A flat contact lens simplifies the creation of planar dissection however it requires a higher level of suction and greater increase in Intraocular Pressure (IOP) which can temporarily reduce the vision during flap making. Curved applanation surface provides a better approximation to the cornea with less suction required leaving the patients’ visualization unhindered during the process of flap making. However curved contact surface makes the creation of planar flaps more technologically challenging and suction loss may occur more readily with the eye movement. Currently available femtosecond platforms take 10 – 40 seconds to create a lamellar corneal flap and this does not include docking and undocking times as it varies widely with the surgeon’s experience. The sequence in which a FS flap is created includes the creation of a canal / pocket first followed by the hinge and then the bed cut and finally the side cut. Many systems allow the flap position to be changed even after docking to achieve centration. After flap creation, the flap is then lifted using a blunt spatula. Since the tissue bridges are inherently present in the femtosecond created flap, it takes little more time and effort to lift the flap compared with a microkeratome created flap. The excimer laser ablation and further steps are the same as for a standard LASIK procedure.

**Femtodynamics**

Femtodynamics refers to using various intraoperative clues and postoperative outcomes to modify the laser settings and techniques to optimize the outcomes. The pattern of OBL, the ease or difficulty of flap lift, the appearance of peripheral side cut and the presence or absence of DLK provide useful clues whether too much or too little energy is being delivered to the cornea. One parameter is changed at a time and atleast 2 successive treatments must be assessed before further modifying the laser parameter.

**Femtosecond Vs Mechanical microkeratome**

Femtosecond flaps are planar compared to the meniscus shape flaps created with microkeratome. The flap thickness

<table>
<thead>
<tr>
<th>ABLATION PROFILE</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavefront optimised</td>
<td>Aspheric ablation profile, maintains asphericity of the cornea</td>
</tr>
<tr>
<td>Wavefront Guided (A - CAT)</td>
<td>Ablation based on the wavefront map of the patient, indicated where RMS &gt; 0.3µ</td>
</tr>
<tr>
<td>Topo – guided (T – CAT) (Topolyser)</td>
<td>Topo guided LASIK specifically indicated for enhancement procedures, irregular corneas</td>
</tr>
<tr>
<td>Topo – guided (T – CAT) (OcuLink)</td>
<td>Same as Topolyser guided T – customized ablation treatment (CAT) except that the data used is from scheimpflug based topographer</td>
</tr>
<tr>
<td>Custom Q (F – CAT)</td>
<td>For fine correction of refractive errors to achieve a target Q value for the patient’s cornea</td>
</tr>
</tbody>
</table>
Refractive Surgery

Table 4: Comparison of Microkeratome and Femtosecond lasers for LASIK flap creation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Microkeratome</th>
<th>Femtosecond Laser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flap shape</td>
<td>Meniscus</td>
<td>Planar</td>
</tr>
<tr>
<td>Flap / hinge diameter</td>
<td>Keratometry dependent</td>
<td>Computer control</td>
</tr>
<tr>
<td>Flap thickness</td>
<td>Dependent of pachymetry, Keratometry, Intra Ocular pressure (IOP), blade quality and translational speed</td>
<td>Computer control</td>
</tr>
<tr>
<td>Thickness predictability</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>Side cut</td>
<td>Shallow angled</td>
<td>Computer control</td>
</tr>
<tr>
<td>Epithelial in growth</td>
<td>More than femtosecond laser flaps</td>
<td>Less</td>
</tr>
<tr>
<td>Unique complications</td>
<td>Flap buttonhole</td>
<td>Opaque bubble layer, vertical gas breakthrough, transient light sensitivity syndrome, rainbow glare</td>
</tr>
</tbody>
</table>

is consistently within 10 micron of intended thickness. The flap can be created over a wide range of thickness profile compared to only a few modifications possible with the microkeratome. The increased side cut angle in femtosecond flaps act as a barrier to epithelial cells preventing complications like flap displacement, epithelial ingrowth. No differences have been noted with regard to the final visual outcome in the various studies (Table 4).

References


The Agenda of General Body Meeting of Delhi Ophthalmological Society

The Agenda of the General Body Meeting shall be :
1. Confirmation of the minutes of the previous Annual General Body Meeting held on 25th August, 2013.
2. Adoption of the annual report of executive committee presented by Hony. Secretary.
3. Financial highlights by Treasurer.
5. Report of Editor DJO.
6. Report from Representative to AIOS.
7. Ratification of New Members.
8. Presentation of Awards and Momentoes.
10. Address of the outgoing President.
11. Installation of incoming President.
12. Address of incoming President.
14. Any other matter with the permission of the Chair.
15. Vote of thanks by Secretary.

held at 13th April, 2014 on 4:30 PM at Banquet Hall, Ashok Hotel, Chanakyapuri, New Delhi