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Femtosecond laser offers surgical precision and versatility, but at a higher price

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in Nürnberg

FEMTOSECOND lasers are likely to replace mechanical microkeratomers for refractive surgical procedures, despite the markedly higher price associated with femtosecond-laser treatments that some believe is unethical for patients to pay, according to a panel of specialists who spoke at the annual Congress of the DOC (German Ophthalmic Surgeons).

"Femtosecond lasers will replace microkeratomers wherever the surgeon has a free choice, much like the way better, newer generation microkeratomers took the place of the first developed microkeratomers. They are more exact, reproducible, and safer than conventional microkeratomers, with a broader spectrum of application. They also appeal more to patients than microkeratomers – a factor that is quite important," said Thomas Neuhann MD of the ALZ Surgical Centre in München, Germany.

Femtosecond LASIK flaps have thickness homogeneity throughout the flap thickness, high reproducibility/predictability, placement exactness, improved safety (e.g. suction loss), and can optimise the edge profile, Dr Neuhann maintained.

Thickness homogeneity introduces less aberration caused by flap cut. In fact, one recent study confirmed that early postoperative visual acuity was better in femtosecond than microkeratome patients who had refractive surgery. Microkeratome flaps cut for instance by the Zyoptix SP, a newer generation microkeratome, although much better than their predecessors, still cut deeper at the periphery and flatter at the centre, while the IntraLase 60 Hz was homogeneous throughout the extent of the flap, Dr Neuhann noted.

Dr Neuhann cut flaps using the FS60 Hz femtosecond laser in a first group of 331 patients achieving a narrow flap thickness range of only 120-165 μm (SD 10 μm). By comparison, thickness reproducibility that was analysed in a study with OCPonline (Heidelberg) in 1859 consecutive patients revealed much wider flap thickness ranges using different microkeratomers and 30 kHz IntraLase. The Hansatome microkeratome (160 μm head) cut a mean of 121 μm (SD 20 μm) with a very wide spread of 64 to 184 μm (40 μm underneath the epithelium), the Zyoptix microkeratome (120 μm head) cut between 74 – 167 μm , and the 30 kHz IntraLase cut flaps with a spread of 84-164 μm .

The femtosecond laser uses a suction ring for gross flap placement and specialised software for placement adjustments, which is as simple as a mouse click, Dr Neuhann said. Cut failures, regularly associated with potentially vision threatening complications

and prolonged waiting times for reoperation (microkeratomers), rarely occur with the femtosecond laser. If a cut failure occurs, e.g. by loss of suction during the cut, the surgeon using femtosecond laser, can re-cut immediately without having to wait.

He noted that the flap edge profile/angle of margin was freely selectable, allowing flatter angles in higher ablations for better edge apposition and steep angles for better protection against slippage.

Dr Neuhann observed that further technical refinement, such as reduced energy output, increased speed, improvement / refinement of coupling, and automatic individual parameter optimisation are areas of improvement for femtosecond lasers. Some disadvantages of using femtosecond lasers include the duration of elevated pressure, temperature sensitivity (air conditioning required), and high costs, he noted.

Worth an extra €1000?

Considering the added expense of €600-€1000 more for femtosecond LASIK than conventional LASIK, however, there is evidence suggesting that the patient does not necessarily profit from better visual results. Femtosecond lasers offer patients no substantial advantage over the improved results obtained with new generation microkeratomers for safety and precision, according to Theo Seiler MD, IROC, Zürich, Switzerland, who described the disadvantages of femtosecond lasers as the *advocatus diaboli* in this discussion.

"Actually the femtosecond laser is medically indicated in a minority of our patients, probably less than five per cent. Seducing patients to get femtosecond LASIK as a standard procedure is at least an overkill, if not unethical, according to some," he said.

Recent studies seem to concur. A 100-patient investigation by Lim in 2006 showed that the femtosecond laser had failed to have significant superiority in clinical outcomes like contrast sensitivity and low contrast visual acuity, while in 2007, Patel revealed in over 100 patients that the method of flap creation did not affect the visual outcome.

Although flap thickness regularity is one of the main reasons surgeons choose femtosecond laser, an investigation by Talamo revealed that femtosecond-laser flaps were an average of $119 \pm 12 \mu\text{m}$ while mechanical microkeratome flaps measured $130 \pm 19 \mu\text{m}$ on average, which reduces variance only slightly, Dr Seiler said.

The virtual absence of cutting errors using femtosecond laser is strongly attractive to surgeons to reduce the error potential on the surgical end. The incidence of microkeratomers cutting errors, however, is far below one per cent in primary eyes with normal Ks as it is, he observed.

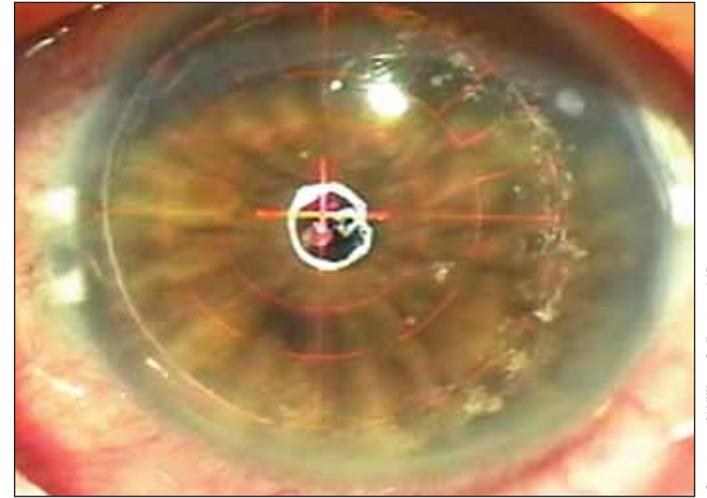
Meanwhile, other complications seem to have increased in femtosecond LASIK patients. Javaloy showed a 10 per cent increased incidence of diffuse lamellar keratitis with femtosecond-laser interventions versus less than one per cent with microkeratomers, and transient light sensitivity syndrome was 1.3 per cent in femtosecond laser patients (zero per cent with microkeratomers) according to Munoz.

Another increased complication in femtosecond LASIK patients who had no previous choroidal neovascularisation included macular haemorrhage, according to a study by Principe. Also, Chung noted mycobacteria infections in femtosecond LASIK patients, explained by the fact that surgeons must use instruments to lift the flap and irrigate the interface.

Contrary to Dr Neuhann's experience with high patient appeal for femtosecond LASIK, recent evidence from Patel suggested that patient satisfaction showed no significant difference between the two methods. In fact, the investigation predicted a trend moving away from femtosecond laser due to falling patient enthusiasm. Dr Seiler corroborated low patient enthusiasm from his own experience.

He said that based on the evidence available so far, femtosecond lasers were indicated for two case scenarios in particular that required the most precise instrument available. This includes eyes with no allowance for cutting errors (high/low Ks, or previous surgery) or eyes in which flap thickness was an issue (thin corneas, high corrections). The latter cases, however, were more likely to be treated with phakic IOLs, he observed.

Two medical indications for femtosecond laser treatments seemed like a short list to William Culbertson MD from the Bascom Palmer Eye Institute in Miami, US. He told DOC listeners that femtosecond lasers represented the future of refractive surgery to perform procedures that included minimally invasive keratomileusis (MIKE) for thin, small diameter, custom shaped flaps; incisional keratotomy like astigmatic- and sub-surface astigmatic keratotomy (for instance to create corneal pockets for refractive inlays); limbal relaxing incisions; and presbyopia treatment (lens softening).



Descemetorhexis created with femtosecond laser prior to Descemet stripping endothelial keratoplasty (DSEK)

"Small flaps cut fewer sensory nerves, spare more collagen fibres and nerves than mechanical microkeratomers, and are thinner and planar. In addition, customised flaps are possible such as oval-shaped instead of round flaps, which preserve the peripheral vital lamellar fibres," Dr Culbertson pointed out.

Furthermore, Dr Culbertson sees a place for femtosecond lasers in therapeutic surgery, as well. For instance the laser can be used for cataract surgery (cataract incision, capsulorhexis, lens softening, LRI) and keratoplasty (penetrating and lamellar). The laser can create various special end-shapes that facilitate postoperative healing, such as top-hat shaped PK, mushroom-shaped or zigzag PK, which may reduce the incidence of astigmatism and wound rupture as well as allow for earlier visual rehabilitation he said. When the side cut has been created by the femtosecond laser, the incision appears to have exhibited greater fibrosis and heal faster than incisions made with a metal trephine.

Dr Culbertson uses femtosecond laser regularly for the descemetorhexis in Descemet stripping endothelial keratoplasty (DSEK) and for precisely localising and creating small diameter (3-5mm) corneal biopsies in patients with undiagnosed keratitis.

The femtosecond laser is so versatile because it uses spot and line spacing to create vertical and horizontal incisions in the cornea. Variables that are controlled through the specialised software include spot size (energy), spot separation, spot timing, depth of cut, diameter (length) of cut and direction (angulation) of the cut, Dr Culbertson said.

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