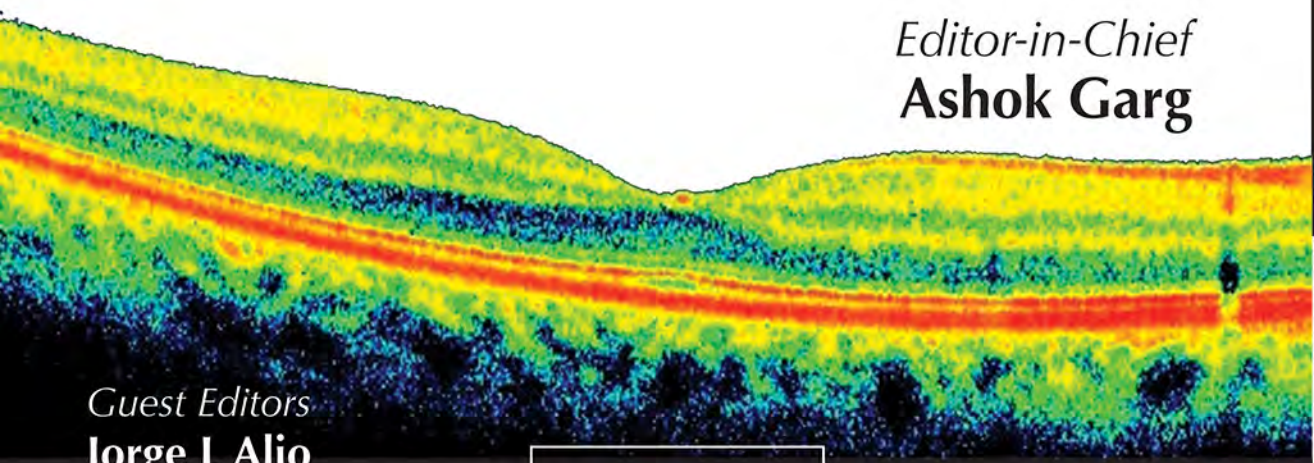
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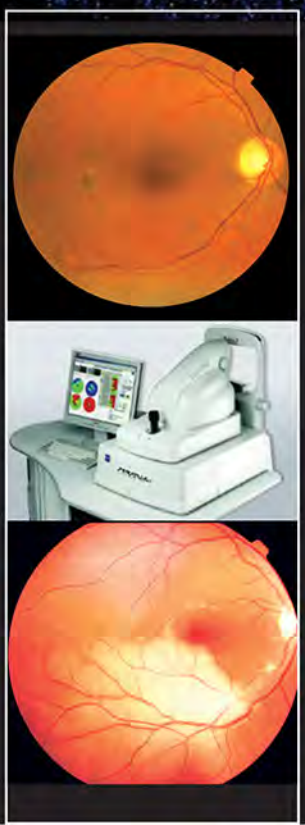
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CHAPTER

4

Analyze of the Cut Quality of the Newest Ziemers High Frequency FEMTO LDV Z6 PowerPlus for Femto-assisted Cataract Incisions

Bojan Pajic, Iraklis Vastardis, Brigitte Pajic-Eggspuehler, Mirko Resan, Farhad Hafezi, Slobodanka Latinovic, Miroslav Vukosavljevic (Switzerland)

INTRODUCTION

The femtosecond laser has been used clinically in a variety of anterior segment applications. These include creation of a corneal flap for laser *in situ* keratomileusis refractive surgery, arcuate incisions for modifying corneal astigmatism, and penetrating keratoplasty for corneal transplantation. In the past 3 years, femtosecond lasers have been used in cataract surgery for capsulotomy creation, lens fragmentation, and corneal incision creation. Cataract surgery is a frequently performed procedure that includes several steps, such as creating corneal incisions; opening the anterior lens capsule, also referred to as the capsulotomy; emulsifying and removing the opacified crystalline lens; and subsequently inserting the intraocular lens (IOL).

The capsulotomy provides the surgeon access to the capsular bag for fragmentation and removal of the natural lens and insertion of the IOL. The size of the remaining tissue should allow overlap between the capsule rim and the IOL haptic for correct IOL positioning. Intraocular lens alignment is particularly important with premium IOLs, such as accommodating, multifocal, and toric models. Hence, the size, shape, and centration of the capsulotomy influence the effective lens position and the refractive visual outcomes. The most critical steps are still manual procedures, most importantly and difficult maneuver to master is creating the continuous circular capsulorhexis (CCC) which is performed by freehand tearing of the capsule and is therefore highly dependent on surgical skills and complicating factors. The procedure is prone to consistence of size, shape and centration even in experienced hands. In the presence of many predisposing factors the level of difficulty and probability of creating a suboptimal CCC increases.[1] These challenges and limitations stimulated the development of the femtosecond laser for laser anterior capsulotomy (LAC).

Nagy et al.[2] conducted initial research on LAC in porcine eyes compared to standard manual CCC. Scanning electron microscopy revealed capsule buttons to have smooth edges regardless of method of cutting. Tackman et al.[3] conducted a nonrandomized trial, 49 LAC compared to 24 manual CCC, LAC mean deviation of capsule diameter was significantly less than with CCC. These findings suggest that laser-cut anterior capsulotomy exhibit improved precision, consistency, accuracy and strength compared with manual capsules. Nagy et al.[4] demonstrated in series of eyes that postoperative laser-cut capsulotomy exhibited significant improved capsular overlap over the IOL optic. Uy et al. showed that it significantly reduces horizontal decentration over time a femtosecond laser.

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Further studies have shown that the reduction in the amount of ultrasound energy from the phacoemulsification probe can diminish the risk for capsule complications and corneal endothelial injury. Phaco time and average phaco power are known to have a positive correlation with the nuclear opalescence/nuclear color grading results of nuclear cataract on the Lens Opacities Classification System III (LOCS III) scale. The publication by Conrad Hengerer et al. reports the reduction in the ultrasound energy required to break up and remove the cataractous lens after pretreatment using 2 grid sizes. The found that the use of the femtosecond laser-assisted system in cataract surgery led to a lower EPT compared to the standard procedure.[5] Femtosecond lasers can be used to segment the nucleus, allowing the surgeon to skip the difficult sculping and chopping steps that most frequently lead to complications. Patterns of cuts can be placed on the nucleus to soften harder cataracts. Maybe safety benefits in reducing the number of instruments used. The use of femtosecond laser in cataract surgery may lead to less intraocular movements and less manipulations of the lens. Furthermore it has been found that a liquid interface reduces the rise in IOP.[6]

METHODS AND PATIENTS

Femtosecond laser devices like the high frequency FEMTO LDV Z6 PowerPlus (Ziemer Ophthalmic Systems AG, Port, Switzerland) have been successfully used in modern corneal, refractive surgery and recent in the cataract surgery. These devices offer advantages of size, mobility, and safety while operating independently from environmental conditions. The Femto LDV operates at a high laser pulse rate of more than 5 MHz, approximately 1000 times faster than comparable femtosecond laser technologies. This results in ultrashort laser pulses (200–300 femtoseconds) of low energy density, which reduces undesirable side effects and results in a smooth corneal stromal bed.[7] The newest device allows for higher and adjustable pulse energy.

The clear corneal incision (CCI) has 100% customizable architecture, it is said 1 main incision and up to 2 side ports where 1 to 3 segments are possible at any diameter, position and arc length. In the study one shape is used with 3 segments with an arc of 70°, in depth of 300 µm a horizontal length of up to 1.24 mm **(Fig. 1)**. The other shape had 2 shapes with an initial arc of 30° which changes at a depth of 300 µm into 60° **(Fig. 2)**. The cut can be performed customize as seen in the laser monitor **(Fig. 3)**.

A prospective study was done with 12 patients with 12 eyes. The mean age of patients was 73.4 ± 7.4 years.



Fig. 1: Three segment cutting shape of the femtosecond laser



Fig. 2: Two segment cutting shape of the femtosecond laser

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Fig. 3: Monitor view of high frequency FEMTO LDV Z6 PowerPlus

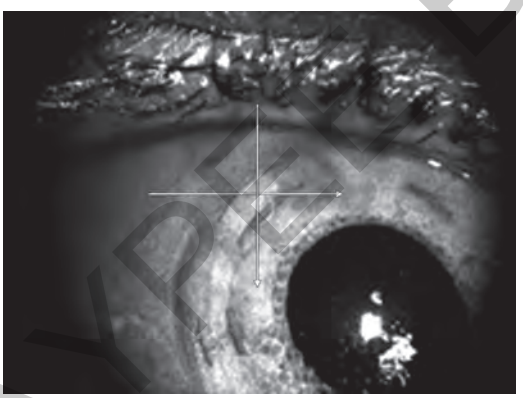


Fig. 4A: Overview of the OCT records, where the main incision of 2.4 mm and 3 segment shape were done

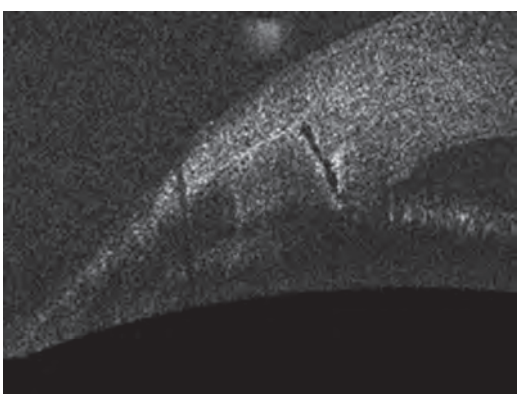


Fig. 4B: OCT record in horizontal direction through the main incision

The main corneal cataract incision was done with a diameter of 2.4 mm and with a 3 segment shape. The cut quality was very smooth and tight from the beginning. In **Figures 4A to C** the OCT record can be seen with a very précis cut shape and cut quality which is not only customizable but also can lead to better clinical outcome. Side ports were done in 4 cases with a diameter of 1 mm and 2 segment shape **(Figs 5A to C)**, in 4 cases with a diameter of 1 mm but with a 3 segment shape **(Figs 6A to C)** and finally 4 cases with a straight 1 segment shape with also a diameter of 1 mm **(Figs 7A to C)**.

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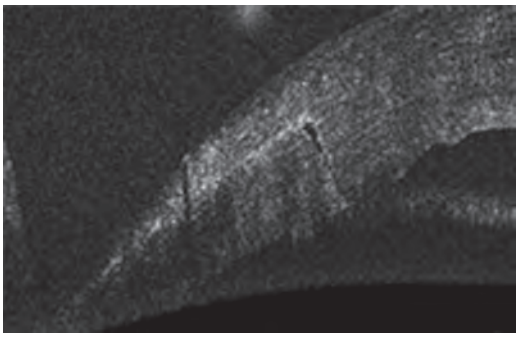


Fig. 4C: OCT record in vertical direction through the main incision



Fig. 5C: OCT record in vertical direction through the side port incision

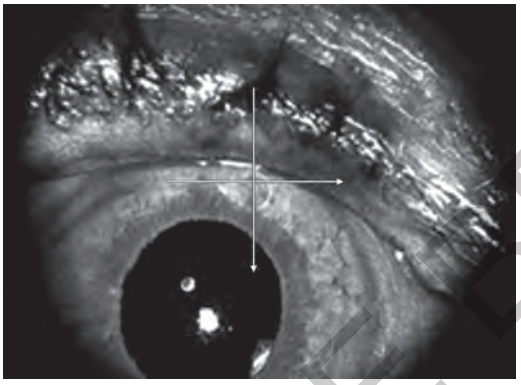


Fig. 5A: Overview of the OCT records, where the side port incision of 1.0 mm and 2 segment shape were done

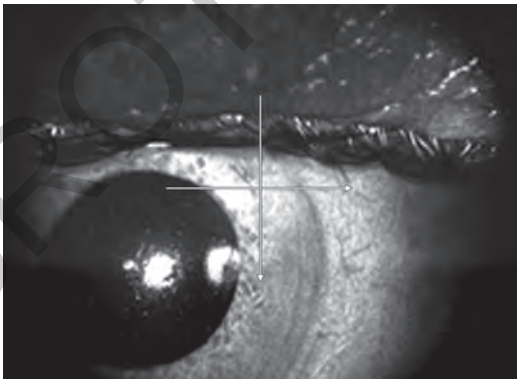


Fig. 6A: Overview of the OCT records, where the side port incision of 1.0 mm and 3 segment shape were done

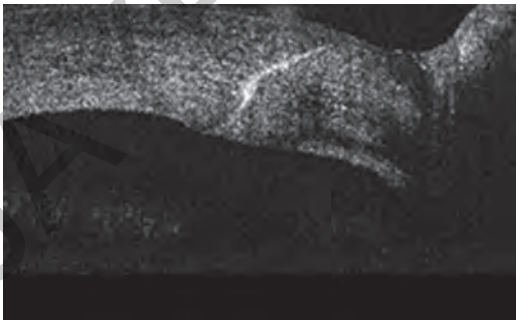


Fig. 5B: OCT record in horizontal direction through the side port incision

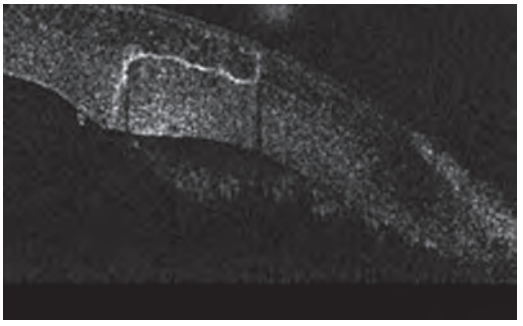


Fig. 6B: OCT record in horizontal direction through the side port incision

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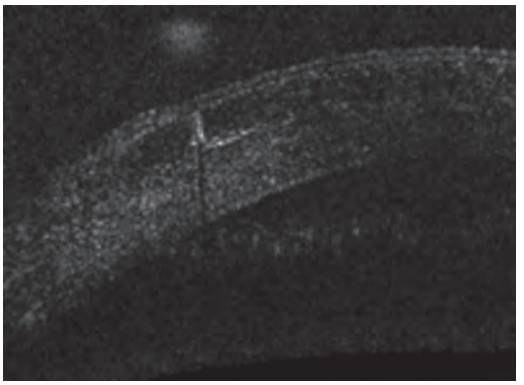


Fig. 6C: OCT record in vertical direction through the side port incision

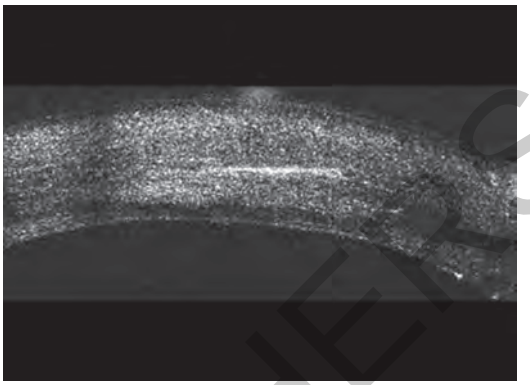


Fig. 7C: OCT record in vertical direction through the side port incision

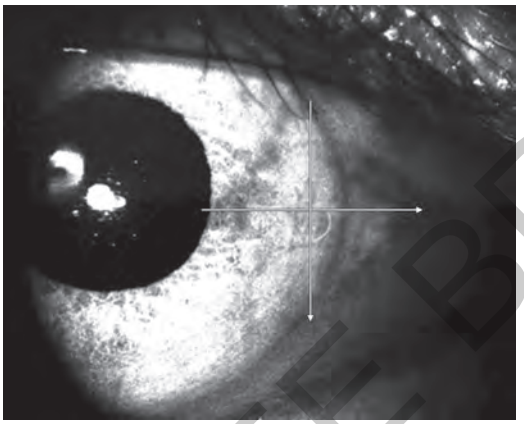


Fig. 7A: Overview of the OCT records, where the side port incision of 1.0 mm and 1 segment shape (straights) were done

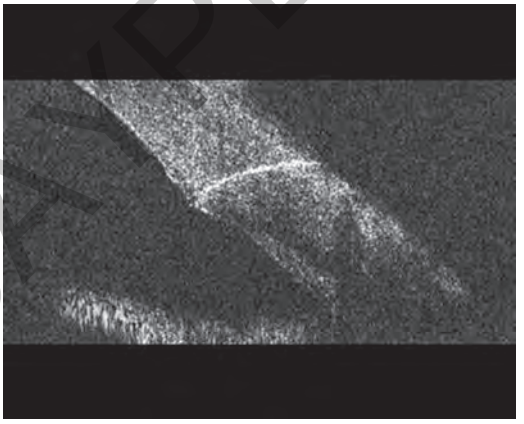


Fig. 7B: OCT record in horizontal direction through the side port incision

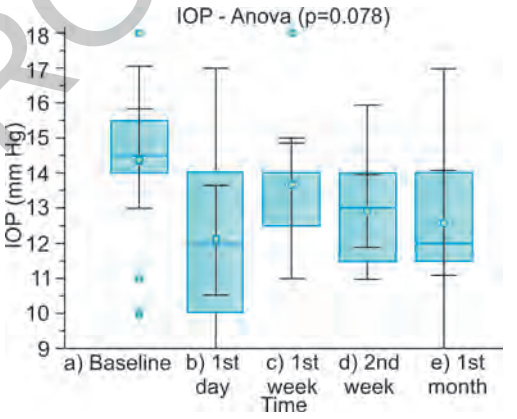


Fig. 8: IOP over time (day 1, week 1 and 2, months 1)

The wound were postoperatively tight and any time. Thus there were no hypotonia. The IOP ranges between 9 and 17 mm Hg from the first postoperative day with a small fluctuation of IOP after one, two weeks and also after one month **(Fig. 8)**. The visual acuity increases significantly from in mean 0.5 preoperatively to postoperative 0.9 postoperatively **(Fig. 9)**. The astigmatism decrease significantly from preoperative in mean 1.8 D (range 0.4–3.0) to one month postoperatively in mean 0.68 (range 0.25–1.4) **(Fig. 10)**.

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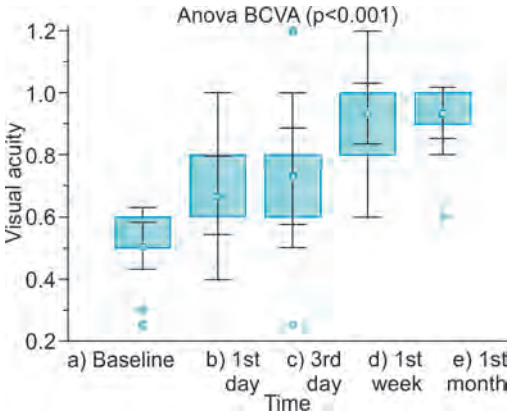


Fig. 9: Best visual acuity over time (day 1, week 1 and 2, months 1)

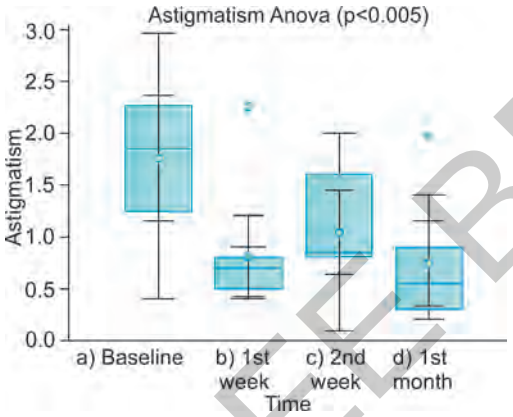


Fig. 10: Astigmatism over time (day 1, week 1 and 2, months 1)

DISCUSSION AND CONCLUSION

There is a high precision cutting with a high frequency FEMTO LDV Z6 PowerPlus femtosecond laser. The advantage is a great reproducibility and the possibility for a customize cutting. Regarding the clinical outcome the femtosecond laser procedure in cataract surgery is a safe application with a high impact for astigmatism control and decrease. The wounds are tight thus a IOP hypotonia was not seen. On the basis of the cutting shape we suppose that even a cut diameter of 5.8 mm, i.e. implanting an Artisan IOL is possible without suture. The high frequency FEMTO LDV Z6 PowerPlus femtosecond laser has overlapping spots which leads to a very smooth cutting surface without tissue bridges. One of the big advantages is that with the mobile LDV femtosecond laser there is no need to move the patient during the cataract surgery. Thus that leads for a single working position for the doctor.

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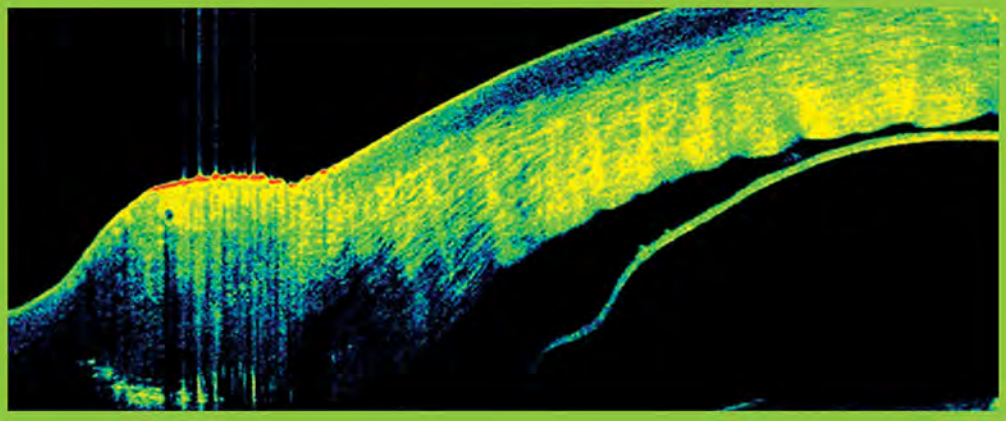
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