Corneal Incisions with the Femtosecond Laser

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The main incision and paracenteses using the femtosecond laser

Corneal incisions made as part of cataract surgery can have an impact on postoperative outcome and image quality, although the type of surgical technique used with the different incision positions and sizes plays an important role [1]. Due to the high precision and reproducibility of the laser, one might assume that the predictability of the surgically induced astigmatism produced would be more accurate compared to manual incisions. However, reports in the literature are inconsistent and comparisons are difficult due to the data collection on different laser platforms and different laser settings. The influence and quality of limbal detection of the different devices in particular was not considered in all publications.

Due to the high precision and the digital incision planning, it is also not possible to inadvertently make a too short clear cornea incision, which also results in fewer intraoperative difficulties (e.g. unstable anterior chamber or iris prolapse) or a lower rate of postoperative problems (hypotension or endophthalmitis), and thus could potentially lead to a greater safety for the patient (though this has not been verified).

Another advantage of femtosecond laser-assisted corneal incisions was found by Grewal and colleagues using anterior segment OCT [2]. They were able to demonstrate smoother inner wound edges than manual incisions, which leads to less lift-off or defects of the Descemet at the inner wound edges. The explanation for these results is that the femto-cavitation spots cause disruption of the tissue and as

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the manual blade is advanced through the tissue, it pushes the Descemet membrane slightly away from the stroma, forming a small gap before it penetrates it.

Author's recommendation

An Arcus lipoides has a much smaller influence on the patency of the incisions than vascularization does. An increase in the incision energy in the preoperative setting should be taken earlier with vascularization in the incision area than is the case with an arcus lipoides.

An advanced vessel edge loop on the limbus can produce inadequate cut qualities even at lower levels. This is most likely due to the vessels filled with haemoglobin which shows a higher absorption of the laser, compared to the arcus lipoides. Due to the media turbidity of the arcus lipoid, there is only a slight scattering of the laser light, which has less influence on the effect of the laser than absorption of the laser beam.

The lower prevalence of an arcus lipoid and prominent vessels in the temporal quadrant and the lower surgically induced astigmatism to be expected suggest that the main incision should also be made in the temporal quadrant. This is also consistent with the general findings from other FLACS studies and manual cataract surgery.

Keypoint

As with manual cataract surgery, the main incision should be created with the smallest possible cut width with a temporal access is the preferred technique for femtosecond cataract surgery.

Anti-astigmatic keratotomies as part of cataract surgery.

In the treatment of cataract, we cannot only take a curative approach, but should also consider the refractive needs of patients. In the vast majority of patients, however, we can detect an astigmatism below 1.5 dpt preoperatively, which, if left untreated, can lead to insufficient uncorrected visual acuity. In these cases, arcuate shaped keratotomies or limbal relaxing incisions are an effective treatment option in cataract surgery (Fig. 1).

Keypoint

The anti-astigmatic keratotomies are an effective treatment option for astigmatism up to 1.5 dpt. For higher values of astigmatism (>1.5 dpt) toric intraocular lenses are clearly superior to keratotomies.

Anti-astigmatic keratotomies have the advantage that the preoperative operation logistics do not have to be changed. After a detailed diagnosis, in theory, an immediate operation can be performed without having to order a special intraocular lens. The treatment is also possible with all forms of anaesthesia, however, before general anaesthesia when using laser platforms without automatic alignment, the axial position should be marked preoperatively in a sitting position. In these cases it is important to make sure that the markings lie outside the treatment zone, as some coloured marks can block the application of the laser, resulting in incomplete cuts.

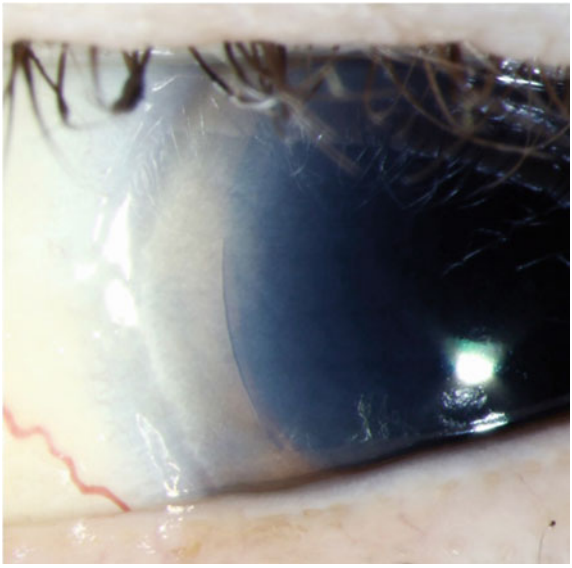

Fig. 1 Postoperative aspect of an arcuate corneal incision 4 weeks postoperative

Author's recommendation

If manual marking of the axis is required, it should be ensured that the marking is placed outside of the treatment zone, otherwise the laser may be blocked by the colour pigments.

The anti-astigmatic keratotomies are positioned in the steep meridian of corneal astigmatism. Ideally, a regular astigmatism is treated. In special cases—in case of irregular astigmatism with e.g. an asymmetrical bowtie or a symmetrical bowtie with axial tilt—a treatment with a toric IOL will not achieve a satisfactory result. Planning the femtosecond laser with different cut positioning and cut lengths offers a good option to perform an individual and customizable treatment.

It is recommended that the surgeon be flexible with regard to the main access, as the anti-astigmatic keratotomies should not overlap with the corneal incisions. Overlapping of these incisions must be avoided, as otherwise the incision architecture and the self-closing effect of the main access cannot be guaranteed.

Keypoint

Overlapping of the anti-astigmatic keratotomies with the corneal incisions should be avoided at the planning stage. The surgeon should therefore be flexible with regard to the main access in order to be able to treat these forms of astigmatism safely.

It should also be noted that a very large source of error can lie in the cyclorotation of the eye, which is not insignificant between the upright and supine positions of the patient. According to studies, this can be up to 17°. On average, however, a cyclorotation of 4–5° can be assumed. Even docking with the patient interface can increase a rotation error. Some providers recommend manual colour marking and

automatic correction of the rotation by the laser. When we consider the demands made on an automated procedure with the femtosecond laser, a reliance on manual marking is ultimately not satisfactory and therefore does not meet the qualitative requirements of an automated surgical procedure. The connection of preoperative diagnostics to the laser platform and the resulting loss-free transfer of information into the operative setting is essential to exploit the full potential and speed of the femtosecond laser. Individual providers already offer the integration of preoperative diagnostics with the femtosecond laser, which may also lead to better postoperative results. The combination of diagnostics and application ultimately allows the same level of automation and quality that we know from corneal refractive surgery to be applied in cataract surgery.

Another benefit of the femtosecond laser system is that it enables purely intrastromal incisions. Here, the laser cuts the intrastromal collagen fasciae without the involvement of the epithelial layers. This has the advantage that no epithelial ingrowth can occur in the wound gap and there is also a lower risk of bacterial keratitis. The current disadvantage, however, is that the predictability of the postoperative effect is currently not as high as in the case of penetrating keratotomies.

There is a lively discussion in specialist circles as to whether a manual, blunt opening of the keratotomies on the following day postoperatively can have a further effect if the result is insufficient. The author cannot recommend this, as it must be assumed that there is a high risk of epithelial invasion into the wound gap. Furthermore, the effect and the deviation from the calculations of the nomograms cannot be calculated (Video 1).

Video 1 The video shows how correct and complete the incision of the arcuate incisions is. A routine check of the incisions is not necessary or not recommended
(▶ https://doi.org/10.1007/000-8f7)

A further component in future treatments will also be the consideration of individual tissue specifications. In this case, the individual data are entered preoperatively into a web-based application and various corneal incisions are calculated using a complex algorithm, and thus the individually optimal incision is recommended based on the calculation [3].

Nomograms

On the basis of a nomogram, values are read off which give the desired postoperative effect. The variables that influence the treatment are comparable to those of manual astigmatic keratotomy. Influenceable and non-influenceable variables include the incision length and depth, distance of the incisions from the centre of the cornea and the age of the patient. The experience and rule regarding the effect of these incisions say that the longer, deeper and the more central the incisions are, the higher the effect. Older patients respond better to anti-astigmatic keratotomies than younger patients. For incision lengths between 30° and 90°, a coupling ratio of 1 can be assumed. In case of a coupling effect, the incisions have no influence on the spherical equivalent. Larger incisions however can have an influence on the spherical equivalent.

Most nomograms recommend an incision depth between 80 and 90% of the corneal thickness and an incision position that varies with an optical zone of between 8 and 9 mm. Depending on the laser platform, the incisions are checked by means of OCT or Scheimpflug technique. The incisions themselves are usually performed perpendicularly. Some nomograms distinguish the position of the preoperative astigmatism. In general, an astigmatism "with the rule" is treated with shorter incisions than an astigmatism "against the rule". Oblique astigmatism is treated with a mean of the two values with a tendency towards the values of the "with the rule" astigmatism. The most commonly used nomogram in the literature is the modified Lindstrom nomogram in cataract surgery. However, the author uses the "Castrop" nomogram developed by Hoffmann for anti-astigmatic keratotomies in femtosecond laser-assisted cataract surgery.

Keypoint record

Astigmatism "with the rule" is treated with shorter cuts than "against the rule".

Conclusion

In summary, femtosecond laser is an ideal instrument to perform both corneal incisions and anti-astigmatic keratotomies in cataract surgery with high precision and reproducibility. Anti-astigmatic keratotomies are an effective and safe treatment option, especially for astigmatisms up to 1.5 dpt in cataract surgery, but can also be considered for higher astigmatisms after penetrating keratoplasty.

The sources of error in the treatment with anti-astigmatic keratotomies should be known and avoided. Intrastromal anti-astigmatic keratotomies may be less effective than penetrating but they show a lower complication rate. An appropriate adapted nomogram should be selected for intrastromal or penetrating keratotomies.

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