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RK incisions appeared to be well aligned. The iron deposits around the radial incision at the central cornea spared the optic axis. There was no haze or epithelial in-growth.

Conclusions: This case showed that Intralase® does not have unique benefit as opposed to the mechanical keratome for post-RK eyes. We recommend that femtosecond laser flap formation should be regarded with great caution in post-RK eyes. The suction performance of the device should be checked before the procedure and flap lifting maneuvers should be very cautious.
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Responses to comments of Reviewer #1:

1) The title of the manuscript has been changed to “COMPLICATED FLAP CREATION WITH FEMTOSECOND LASER AFTER RADIAL KERATOTOMY”.

2) The abstract has been revised, as recommended.

3) In the Introduction part, the sentence relating to improved safety and better predictability with the femtosecond laser was justified by appropriate citations (7,8).

4) The Case Report has been shortened by condensing the patient’s preoperative information in Table 1.

5) In the Discussion, the first three paragraphs were removed, as they are out of the scope of the paper. The improved safety profile for PRK in post-RK eyes, especially with the use of Mitomycin C was also addressed using recent publications (12,13,18). The paragraphs discussing the biological response of the cornea and ectasia were removed as they were outside the scope of this report. The sentences that discuss the mechanical microkeratome complications and femtosecond lasers were corrected and were justified by appropriate citations (23,24).

6) The treatment options after RK, including PRK, LASIK with mechanical microkeratome and LASIK with femtosecond flap were discussed, using current citations as references.
Responses to comments of Reviewer #3:

The Conclusion was corrected based on the problems encountered in the present case, in order to reflect that the Intralase does not have unique benefit as opposed to the mechanical keratome for post-RK eyes and that femtosecond laser flap formation should be regarded with caution in post-RK eyes.

The topographies were removed from the manuscript.

The case presentation, discussion and reference list were shortened.
Responses to comments of Reviewer #4:

1) The case presentation and discussion were significantly shortened, by condensing the necessary information and removing the parts that do not deal specifically with the case report presented herein.

2) The weakness of only one case report has been remarked in the text. Other possible complications were noted. Also, the previous report on RK opening after femtosecond laser for LASIK is cited in the text.

3) The reference by Binder about lack of impact of preoperative corneal curvature on flap dimensions created by femtosecond laser was cited in the text.

4) It has been stated in the text that the real thickness of the flap may not be 100 microns, since intraoperative pachymetry was not done.

5) The figures were eliminated from the manuscript.
Dear Sir,

We are sending you the revised form of the manuscript Cornea-D-06-00395, entitled “COMPLICATED FLAP CREATION WITH FEMTOSECOND LASER AFTER RADIAL KERATOTOMY”. Each reviewer comment was carefully evaluated and the following corrections in the manuscript were made.

We would be honored to make further improvements in the guidance of reviewers and editors.

We would be grateful if you could inform us with the assessment, as soon as possible.

With kind regards,

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None of the authors have any proprietary or financial interest in any of the devices mentioned in this manuscript.
ABSTRACT

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Conclusions: This case showed that Intralase® does not have unique benefit as opposed to the mechanical keratome for post-RK eyes. We recommend that femtosecond laser flap formation should be regarded with great caution in post-RK eyes. The suction performance of the device should be checked before the procedure and flap lifting maneuvers should be very cautious.

Key words: Femtosecond laser, Intralase, LASIK, Radial keratotomy
Introduction

Photorefractive keratectomy (PRK) and Laser in situ Keratomileusis (LASIK) with mechanical or femtosecond laser keratomes have been used for the correction of refractive errors following radial keratotomy (RK); such as hypermetropia due to overcorrection or hyperopic shift, and myopia due to undercorrection or myopic progression (1-11).

Femtosecond lasers are deemed to create corneal flaps for LASIK, with better predictability and reduced risks of button-holing, free or partial flap formation, compared with the mechanical microkeratomes (7,8). In corneas with radial incisions, precise and accurate determination of the flap thickness has critical importance in improving optical and refractive outcome.

In this report, a patient who underwent LASIK with femtosecond laser (Intralase®) because of residual myopic astigmatism is presented. The advantages and disadvantages of using femtosecond laser for flap creation in corneas with RK incisions are discussed.

Case Report

Thirty-nine years-old male patient had undergone bilateral RK operation for myopic correction, in Beyoglu Eye Research and Training Hospital in June 1991, with 12 radial incisions at 100% thickness of the thinnest pachymetric reading. After RK redeepening, bilateral scleral reinforcing with dura mater was performed in April 1992, to slow down the progression of axial myopia, since the globe axial lengths were 25.08mm OD, 25.51mm OS.

The patient was admitted to Turkiye Hospital Eye Clinic on August 2005, for correction of the residual refractive error in his left eye. Since the patient was lost to follow-up from the previous clinic, it was assumed that the refractive error remained stable in this period of time depending on spectacle prescriptions and his subjective comments. The Orbscan measurements were repeated until well-focused and aligned images were obtained; which displayed central flattening of the cornea due to RK incisions. The scotopic pupil
diameter was 4.5 mm. LASIK operation with femtosecond laser flap formation was planned for the left eye.

The pre-RK, post-RK and pre-LASIK findings are shown in Table 1.

The patient was given detailed information about LASIK procedure, possible complications and outcomes of the planned surgery because of his previous operations. Signed informed consent was obtained from the patient, according to the Tenets of Helsinki.

**Surgical Intervention**

Superior hinged corneal flap formation was intended with Intralase® femtosecond laser (30 Hz); with 8.7mm diameter, 100µm thickness and 50º hinge angle. During flap formation, the femtosecond laser lost suction and stopped when intrastromal incision finished at approximately 1/4th of the whole corneal area. The Intralase® device was controlled and flap formation procedure was repeated at the same intrastromal plane and could be finished without any problem. The patient waited still for 10 minutes, for the absorption of gas bubbles under the flap. Then, the flap-stroma interface was separated with a blunt spatula. The flap was lifted very slowly and carefully, in order not to separate the radial incisions. However, the radial incision at one o’clock meridian broke down and the spatula at the interface passed through the incision to the corneal surface; and the incision progressed centripetally until the central cornea. During lifting the rest of the flap from the stromal bed, the edges of the radial incisions separated from each other peripherally for 2-3 mm. No sectoral piece separated completely from the flap. The obtained stromal bed was clean and dry.

Laser treatment was done with VISX S4® excimer laser device, with 160 mJ/cm² laser fluence, 10.0Hz pulse frequency; and refractive correction of -1.25(-1.25@180º)D was performed. After the laser, flap edges and the RK incisions were settled into their correct places on the stromal bed. There was no loss of tissue from the corneal flap.
Postoperatively, topical antibiotic (Exocin® 6x1) and corticosteroid (Predforte® 8x1) medication was started.

**Postoperative Control**

At the postoperative 5th month control visit, his UCVA was 20/20. Orbscan examination revealed centralized ablation pattern; central and thinnest corneal thicknesses of 487µ and 476µ, respectively. On slit-lamp examination, the flap was found to be properly placed on the stromal bed and all RK incisions seemed to be well aligned. There were iron deposits around the radial incision at the central cornea, but the optic axis was preserved. There was no haze or epithelial in-growth.

**Discussion**

Especially in post-RK high myopic eyes, there has been concerns about the PRK (9), which could lead to separation of the incisions during epithelial abrasion, keratocyte activation and 5–10 times more risk of subepithelial haze development with 20% less refractive predictability (9,12). Loss of BCVA after PRK has been known to be related with corneal subepithelial scar formation and surface irregularity (2). On the other hand, successful uses of mitomycin C were reported recently, to treat subepithelial fibrosis after previous refractive surgery including RK, as well as to prevent and treat haze after PRK (13,14).

LASIK has been considered after RK and PRK (2); since it does not necessitate epithelial separation, preserves Bowman’s layer, and leads to less tissue reaction and minimal disorganization in stromal collagen fibers (15,16). Successful outcomes were reported in the management of both post-RK myopia and hyperopia, by LASIK (2,17). However, this treatment has also some limitations. It should not be performed in corneas in which epithelial inclusion cysts are present in the RK incisions. Following LASIK, these epithelial cells could migrate in the flap-stroma interface and lead to irregular astigmatism, loss of BCVA and even flap melting and amputation (5,18). Thus, in order to prevent severe and persistent epithelial
ingrowth after LASIK in these eyes, surface ablation with prophylactic mitomycin C has been recommended (19). Also, in relatively destabilized corneas with 16 or 32 RK incisions, LASIK procedure with suction could cause over-correction and should be avoided (20). In the present patient, there were a total of 12 RK incisions.

It is known that the RK incisions never heal completely. In LASIK procedure, the lamellar cut perpendicular to these incisions could cause separation of the incisions and division of the flap into triangular sectoral pieces (20,21), even if LASIK is done 5-15 years after RK and clinically there are no epithelial cysts in the incisions (22). In order to avoid this, it is intended to create as thick a flap as possible. The mechanical keratomes have some limitations in adjusting the flap dimensions. The creation of a flap with more predictable thickness by femtosecond laser, which works by focusing the laser pulses next to each other precisely at desired depths and creating an intracorneal resection plane by photodisruption mechanism, was thought to be useful in preventing both the RK incision-related flap complications and post-LASIK keratectasia (23). The femtosecond laser holds the advantages of homogenous flap formation at desired depth and having the risk of mechanical microkeratome related complications less (24). Additionally, Binder et al reported on his 1,000 consecutive cases that the impact of preoperative corneal curvature had no impact on flap dimensions created by the Intralase®, besides eliminating physical complications associated with mechanical flap creation (25).

In the present patient, since 14 years had been passed after the RK operation, we considered that the wound healing mechanism was complete and the biomechanical balance of the incisions had been settled down; and we offered LASIK operation for the residual refractive error. We examined thoroughly the cornea and ensured that there were no epithelial inclusion cysts in RK incisions. Since the keratometry readings were less than 40.00D, it was expected that problems could occur with maintenance of the microkeratome vacuum, beside
risks of small flap, incomplete flap or buttonholing. For the above mentioned reasons, LASIK with Intralase® flap formation was planned. However in our case, the femtosecond laser device lost suction during laser pulsation, which could be due to the biomechanical instability of the globe even after 14 years following RK. After device control, flap could be formed at the same intracorneal plane. Formation of a 100 µm thick flap was intended by Intralase®, but intraoperative pachymetry was not performed; so it is possible that the real flap thickness of the flap may not be 100µm.

Careful manipulation of the corneal flap is essential to avoid serious complications (26). Since lifting the flap by routine ways would cause separation of the radial incisions or progressive tears by pulling forces, special flap holding techniques have been developed (22). During holding and lifting the flap edge by forceps, corneal epithelium should be treated cautiously, since keratocyte activation leads to corneal haze formation and epithelial ingrowth. Since the lamellar cut by femtosecond lasers are not created by cutting all the stromal fibers, but only by separation of the corneal lamellae with microplasma induced by intrastromal focused laser pulses; all of the stromal fibers at the flap interface are not readily cut. The flap should be lifted carefully from the stromal bed, by inserting a blunt spatula into the interface. In our case, even though the flap interface manipulations were very carefully made, RK incisions were separated and one of them progressed to the corneal center, with the force applied by the spatula. In such a case, avoiding flap tissue loss and alignment of the flap edges and incision places to their stromal markings are critically important in order to provide good postoperative optical quality to the patient; as well as to prevent epithelial ingrowth and related irregular astigmatism and flap melting. Munoz et al have also reported that in their case series of 11 post-RK eyes which had surgery with Intralase® femtosecond laser, the separation of at least 1 radial incision was seen in all eyes at flap lifting (23). However
postoperatively in all of their cases, all RK incisions appeared to be well aligned with no signs of fibrosis different from the preoperative appearance, as it was in our case.

In conclusion, this case showed that the Intralase® does not have unique benefit as opposed to the mechanical keratome for post-RK eyes. Experience in only one case has certain weakness in reaching conclusion. However it should be kept in mind that beside the 2 complications encountered in this case; central corneal haze, epithelial ingrowth or irregular astigmatism together with loss of BCVA could be possibly seen. Therefore, we recommend that femtosecond laser flap formation should be regarded with great caution in post-RK eyes. The suction performance of the device should be checked before the procedure and the flap lifting maneuvers should be very cautious.
REFERENCES


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**Table 1.** Pre-RK, post-RK and pre-LASIK findings of the patient (Pre-RK and post-RK data were obtained from the previous clinic)

UCVA: Uncorrected visual acuity  
BCVA: Best corrected visual acuity  
RK: Radial keratotomy  
UNK: Unknown