Intraoperative flap-related complications in FemtoLASIK surgeries performed with Visumax® femtosecond laser: A ten-year Romanian experience

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Abstract. Incidence and clinical results of intraoperative flap and interface-related complications were investigated after Femtosecond-LASIK surgery, where flap creation was performed with VisuMax® femtosecond laser. A retrospective 10-year cohort study was conducted including all eyes treated for all refractive errors by Femtosecond-LASIK technique. All the flaps were made by the same refractive surgeon with the VisuMax® (Carl Zeiss Meditec) femtosecond laser. We report the intraoperative flap and interface-related complications in these eyes, also describing their management. The study included 4,032 eyes. Flap and interface-related complications were: opaque bubble layer (OBL) 21.18%, suction loss 1.29%, difficult docking 0.69%, difficult dissection of the flap 0.59%, bleeding from limbal blood vessels 0.35%, de-epithelialization of the flap 0.12%, and interface debris 0.025%. These situations were appropriately addressed, with favorable outcomes. Flap creation is an important step in LASIK surgery. The predictability and safety have improved since the flap incision is assisted by a femtosecond laser, but complications of the flap and interface can still occur during the flap creation. Refractive surgeons should be aware and properly manage any unusual situation.

Introduction

Laser-assisted in situ keratomileusis (LASIK) is the default choice of refractive surgery procedures as it can be addressed to a wide spectrum of ametropias and can treat high order wavefront aberrations or topographic irregularities (1,2). Since some complications of the mechanical microkeratome (free caps, incomplete, irregular or displaced flaps) can be avoided using the femtosecond laser technology, many surgeons prefer using this new technology to perform the LASIK flaps (1,2). Comparing to mechanical microkeratome, femtosecond laser can create customized flaps - centration, diameter, thickness of the flap, position and length of the hinge and also the side cut angle can be set by the surgeon according to the characteristics of each patient (1-4).

However, the Femtosecond-LASIK (FemtoLASIK) technique is not risk-free (1,2). Performing the flap assisted by the femtosecond laser can produce specific cavitation bubble related complications: opaque bubble layer (OBL), buttonhole formation and presence of an air bubble in the anterior chamber (1,5). Complications of the classic LASIK technique can also be encountered (1).

Ten years after having started the Femtosecond-LASIK surgeries in Romania, we are reviewing our results, in order to assess the incidence of intraoperative flap and interface-related complications and their management.

Patients and methods

Data collection. A retrospective, non-comparative consecutive case series study was performed on eyes with different refractive errors that underwent FemtoLASIK surgeries. Patients were operated by the same refractive surgeon (H.T.S.) in two refractive centers: Europe Eye - Metropolitan Hospital in Bucharest and Timisoara Clinical Emergency Hospital, between June 2011 and April 2020. For the flap creation step all surgeries were performed using VisuMax® (Carl Zeiss Meditec) femtosecond laser.

A descriptive case series is reported of the intraoperative flap and interface-related complications encountered to the eyes included in the study.

Inclusion and exclusion criteria. Inclusion criteria for the surgery were as follows: patients ≥ 22 years of age with no refractive change for at least 2 years before surgery, central endothelial cell count ≥2,000 cells/mm², stable peripheral retina (normal or already treated by laser photocoagulation...
if at-risk peripheral lesions were present) and good compliance (1,6).

Eye-related exclusion criteria for the surgery were: evidence or suspected ectasia, thinnest point on pachymetry \( \leq 500 \, \mu m \), insufficient corneal thickness for laser ablation (estimated residual thickness of the stromal bed after treatment \( \leq 300 \, \mu m \)), severe dry eye syndrome, any sign of ocular inflammation or infection (1,6), any ocular disease that might interfere with visual acuity (e.g., cataract, congenital or acquired macular pathology, optic nerve pathology) (1,7,13), any previous ocular trauma, any previous ocular procedures (e.g., vitreoretinal surgery, glaucoma laser procedures or glaucoma surgery) (14-21), and patients taking medications with high risk of ocular side effects (e.g., amiodarone, isotretinoin) (1,22).

Orbital anatomy was assessed in order to permit the proper suction cup positioning. There were excluded patients with very deep-set eyes, patients with narrow palpebral fissures or periorcular tumors (23-25).

Pregnancy or lactation were exclusion criteria for the surgery (1,6). Also excluded were patients with systemic diseases that could interfere with the wound-healing process (e.g., diabetes mellitus, autoimmune disorders) (1,6,26,27) or with risk of postoperative low visual acuity due to possible vascular complications including ischemic optic neuropathy or vascular occlusion (e.g., severe systemic hypertension, severe dyslipidemia and cardiovascular diseases) (7,9,28-30).

The psychological profile was also considered and patients with unreasonable expectations or unable to understand the perioperative conditions were excluded.

Preoperative assessment. Patients underwent preoperative ocular examination that included: uncorrected and corrected distance visual acuity, manifest and cycloplegic refractions, fogging refraction (in hyperopic and mixed astigmatic patients), non-contact tonometry, keratometry, ultrasound corneal pachymetry, white-to-white corneal diameter, corneal topography and tomography (Scheimpflug), pachymetry, corneal endothelial cell count, anterior segment slit-lamp examination and mydriatic fundus examination.

Soft contact lens wearing should have been discontinued 2 weeks prior to preoperative investigations and then 2 weeks prior to surgery.

The study was approved by the Ethics Committee of ‘Carol Davila’ University of Medicine and Pharmacy (Bucharest, Romania). After being fully informed about the benefits and risks of the procedure, all patients signed an informed consent in accordance with the Declaration of Helsinki.

Surgical technique. All surgeries were performed using the same protocol and technique, by a single refractive surgeon (HTS) with the same femtosecond laser (VisuMax®, Carl Zeiss Meditec).

Topical anesthesia with oxybuprocaine 0.4% was used before surgery. The eyelids were sterilized with 10% povidone-iodine solution, then a sterile surgical drape was applied and a lid speculum was inserted. The eye to be treated was positioned under the femtosecond laser integrated surgical microscope. The patient was asked to fix the target flashing light. The size of the docking cup was chosen according to the white-to-white corneal diameter. While the patient was asked not to move the head, after an appropriate centration, the surgeon initiated the automatic suction. When the suction was complete, the surgeon initiated the femtosecond laser procedure, settled at 1,043 nm wavelength and 500 kHz pulse frequency. For the corneal flap cutting, the parameters were 7.9-8.9 mm diameter, 100-130 \( \mu m \) depth, 3.45-3.84 mm hinge width (50˚ angle) in superior position and 90˚ side cut angle. In patients operated in both eyes, the procedure started with the right eye, and then the fellow eye was treated identically.

The dissection of the flap was performed using a double-ended flap lifter. After drying the corneal bed with special sponges, the underlying stroma was treated for refractive correction using an excimer laser. According to situation, when both eyes needed to be treated, the right eye was treated first. At the end of the surgery, a disposable bandage contact lens was applied and antibiotic (moxifloxacin 0.5%) and artificial tear drops were instilled in the treated eye/eyes.

Patients were examined at the slit lamp thirty minutes after the surgery, in order to assess the flap position, the flap regularity and the interface clarity.

Postoperative care. Postoperative treatment started after the surgery and consisted in topical eye drops: antibiotic q.d.s. for one week (moxifloxacin 0.5%), non-steroid anti-inflammatory t.d.s. for 2 weeks (pranoprofen 0.1% or indomethacin 0.1%), artificial tears q.d.s. for 12 months and steroids (fluorometholone 0.2%), recommended to be applied q.d.s. for 2 weeks, then gradually tapered (t.d.s., b.d.s. and q.d. 2 weeks each).

The bandage contact lens was removed at the first day postoperative visit when the evaluation consisted in measurement of the manifest refraction, uncorrected distance visual acuity and slit-lamp examination of the cornea.

The following postoperative visits were carried out at one, three, six and twelve months. At every of these examinations a slit-lamp examination of the anterior segment and several investigations were performed: manifest refraction, uncorrected distance visual acuity, non-contact tonometry, corneal topography and tomography (Scheimpflug). For the eyes where a residual refraction was determined or the visual acuity was uncorrelated with the manifest refraction, we also tested the corrected distance visual acuity and the cycloplegic refraction.

Results

Patient demographics and operative data. Four thousand and thirty-two eyes (2,086 right eyes and 1,946 left eyes) from 2,310 patients (1,344 females and 966 males) were reviewed in our retrospective interventional consecutive case series study. Mean patient age at the time of surgery was 31.28±6.72 years (range, 22-49 years). One thousand seven hundred and forty-two patients were operated in both eyes, the procedure started with the right eye, and then the fellow eye was treated identically.

Eight hundred and ninety-six eyes (22.22%) had myopic astigmatism and 196 eyes (4.87%) underwent for hyperopic astigmatism and 196 eyes (4.87%) underwent FemtoLASIK surgery for hyperopia.
Intraoperative flap and interface-related complications.

| Intraoperative complications | No of cases (%) |
|------------------------------|-----------------|
| Difficult docking            | 28 (0.69)       |
| Suction loss                 | 52 (1.29)       |
| Cavitation gas bubble related complications | 854 (21.18) |
| Opaque bubble layer (OBL)    | 854 (21.18)     |
| Vertical gas breakthrough with buttonhole formation | 0 (0) |
| Air bubbles in the anterior chamber | 0 (0) |
| Bleeding from limbal blood vessels | 14 (0.35) |
| Difficult dissection of the flap | 24 (0.59) |
| Free flap                    | 0 (0)           |
| De-epithelialization of the flap | 5 (0.12) |
| Interface debris             | 1 (0.025)       |

Intraoperative suction loss.

| Time of suction loss | No of cases (%) |
|----------------------|-----------------|
| During building-up the vacuum | 31 (1.02) |
| During the flap creation | 1 (0.025) |
| After the flap was created but before the side cutting began | 4 (0.1) |
| During the side cutting | 16 (0.15) |

Intraoperative suction loss. Intraoperative flap and interface complications included difficult docking (n=28; 0.69%), suction loss (n=52; 1.29), cavitation gas bubble related complications (n=854; 21.18%), bleeding from limbal blood vessels (n=14; 0.35%), difficult dissection of the flap (n=24; 0.59%), de-epithelialization of the flap (n=5; 0.12%) and interface debris (n=1; 0.025%) (Table I).

Difficult docking was encountered in 28 cases (0.69%) due to unfavorable orbital anatomy or to inappropriate patient cooperation. All cases required multiple repeated maneuvers of repositioning of the docking cup.

Suction loss occurred in 52 eyes (1.29%). The causes for suction loss were: excessive eyelid squeezing (19 eyes, 0.47%), inappropriate docking (16 eyes, 0.39%), patient head movement (12 eyes, 0.29%), conjunctiva penetrating under the suction cup (2 eyes, 0.05%), flat corneas (keratometric power - 38.50D, respectively, 38.75D for the same patient, 0.05%) and interruption of the power supply of the femtosecond laser machine (1 eye, 0.025%). There were different situations of losing suction (Table II). In most cases (31 eyes, 1.02%) suction break occurred during building up the vacuum, requiring another placement of the suction cup. The challenging situations were losing suction after the femtosecond laser treatment began. If the suction loss occurs after flap creation has started, managing the case may be quite complicated. In one patient, in the left eye, the second to be treated, the suction loss occurred during the flap creation. In this one case (0.025%), we dissected the flap in the right eye where the femtosecond laser treatment was already performed, but without excimer laser treatment, then the procedure was aborted and rescheduled after three months for both eyes. At retreatment time, the femtosecond laser treatment for the left eye was set and performed 20 µm deeper, followed by excimer laser treatment and for the right eye, the already cut flap was only lifted and the excimer laser was applied. In all the other cases, the suction loss occurred either after the flap cut was done but before side cut creation (4 eyes, 0.1%) (Fig. 1) or during the side cut time (16 eyes, 0.15%) (Fig. 2). In all these cases the surgeon could recenter the suction cup, the eyes could be re-docked and the femtosecond procedure could be continued from the moment when the suction was lost.

In order to assess the impact of the OBL on the laser procedure we divided the OBL according to its extension and position, as follows: minimal (OBL located at the periphery of the flap and/or width <2 mm), moderate (OBL located near the pupillary area and/or width between 2-4 mm) and severe (OBL located centrally and/or width >4 mm). Mild OBL was encountered (Fig. 3) in 742 cases (18.40%), moderate OBL (Fig. 4) in 112 cases (2.77%) and not severe OBL (Table III). In none of the OBL cases were difficulties or incidents encountered in
dissecting or lifting the flap or in the subsequent excimer laser treatment. No other cavitation bubble complication such as buttonhole formation or presence of air bubbles in the anterior chamber were encountered.

Bleeding from limbal blood vessels immediately after the flap creation occurred in 14 cases (0.35%), all those patients being chronic contact lens wearers before the surgery. In all the cases, the haemorrhage was stopped before the excimer laser ablation and there were no visual consequences.

In 24 eyes (0.59%) the dissection of the flap was difficult to perform, due to the impossibility of opening of the side cut on its entire circumference. All cases were preceded by suction loss, leading to the presence of some adhesions at the side cut or incomplete side cut. Dissection of the areas of adhesion and flap lifting were possible using a spatula, a LASIK flap forceps and a crescent blade (Fig. 5).

Epithelial defects of the flap (Fig. 6) were encountered in 5 eyes (0.12%) and this situation was due to multiple surgical maneuvers in the context of inappropriate patient cooperation (3 eyes, 0.07%) or anterior basement membrane dystrophy (both eyes of the same patient, 0.05%). Surgical approach included de-epithelialization of the entire corneal surface, permanent removal of the epithelial debris avoiding contact with flap margins and continuous wear of the bandage contact lens until complete re-epithelialization occurred.

Immediately after the surgical procedure, when assessing the flap position and interface clarity at the slit-lamp, we found in one eye (0.025%) a textile debris at the flap interface (Fig. 7). Surgical solution was lifting the flap, removal of the textile debris by irrigating the interface with saline solution and proper repositioning of the flap.
Discussion

Laser refractive surgery techniques and technology have undergone continuous advancements in the last decades, being increasingly precise and highly predictable (1,2,31,32). Although small incision lenticule extraction (SMILE) is the newest and promising refractive technique with controversial advantages (31), LASIK is still currently the most popular refractive procedure worldwide, as it can be used to correct all types of ametropias, between large diopters limits (1,2,33-35). The essential step of LASIK is the corneal flap creation which is performed nowadays in the most modern way, assisted by a femtosecond laser (1,33). Compared with the mechanical microkeratome, the femtosecond laser-assisted flaps are more precise, more accurate, can be customized and have a high reproducibility (1,2,36). However, this step is not risk-free but fortunately, flap-related complications are quite rare in FemtoLASIK technique (1,33).

Docking is the step that connects the eye to the femtosecond laser system. The time required for proper docking reduces with the learning curve (37). Docking can be difficult in case of deep set orbits or tight palpebral aperture (38).

Suction loss is a femtosecond laser specific complication. The suction loss occurs more likely when the suction cup is not perfectly applied on the eye, allowing the fluid to pass between the eye and the suction cup (39). Other predisposing factors for suction loss are: flat corneas, excessive tearing reflex, narrow palpebral aperture, bad positioning of the patient, poor compliance of the patient due to anxiety or inability to follow instructions (40-42). Suction loss can occur in any step of flap creation. Managing the result of a suction break varies according with the moment of occurrence. If the suction loss occurs during the flap creation, the procedure should be aborted and rescheduled for up to 2 months (1,42). If the suction loss occurs either after the flap was fully created or during the creation of the side cut, the procedure can be resumed from the moment of interruption after proper re-docking (1,42).
Cavitation gas bubbles produced by the femtosecond laser can lead to specific complications (1,42). OBL occurs when these bubbles expand and become trapped in the anterior stroma, at the interface plane (1,42). The incidence of OBL ranges up to 48% (42,43), its formation being influenced by flap diameter under 8 mm (44), thick corneas (43,45), high hysteresis (43,45) and laser settings such as: spot spacing, pocket size and energy level (42). Severe OBL presence can interfere with interface dissection (42) and can disturb eye tracking of the excimer laser (46). In addition to the OBL, the cavitation gas bubbles can produce other complications: vertical gas breakthrough with buttonhole formation or presence of the bubbles in the anterior chamber (42).

Bleeding from limbal blood vessels in chronic contact lens wearers can be avoided using, if possible, smaller suction cups. If perilimbal haemorrhage lead to interface haze, according to severity it is possible either to medically treat with steroid drops or to lift the flap and to irrigate the interface with saline solution (47,48).

Compared with microkeratome-created flaps, dissecting and lifting the femtosecond laser-assisted flaps can be more difficult, the risk of flap tears being increased (42). If a small peripheral flap tear is present and the dissection is complete, the excimer ablation can be performed (42). In case of large or central flap tear, the procedure is recommended to be aborted, considering further a surface ablation (42).

Epithelial defects are uncommon in FemtoLASIK technique (42). Predisposing factors include: use of excessive topical anaesthetic, recurrent erosion syndrome and anterior basement membrane dystrophy (42). Manipulation of the spatula along the side cut edge can produce epithelial defects (42).

Interface debris can result due to Meibomian gland secretions, eyelashes, textile material from sponges or gloves (42). Despite prevention methods, debris is still reported to be noted at the postoperative visit (42). If it is not visually significant or it does not cause infection or inflammation, interface debris can be just observed. Otherwise, flap lifting and thoroughly irrigation of the interface is necessary (42).

FemtoLASIK technique has revolutionized refractive surgery since its introduction. Although the procedure is highly safe, complications can occur (49). Refractive surgeons should be aware of all the intraoperative flap-related complication in FemtoLASIK procedure. Fortunately, these complications are rare and with proper management, studies have shown no alteration of the visual function (33).

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Availability of data and materials

The data that support the findings of this study are available from the corresponding author (HTS) upon reasonable request.

Authors’ contributions

BT, HTS, SS, MZ and VM contributed to the conception and design of the study, the acquisition, analysis and interpretation of the data. BT, HTS, SS, MZ and VM also contributed to the drafting of the manuscript and its critical revision for important intellectual content. MM contributed to the analysis and interpretation of the data, the drafting of the manuscript and its critical revision for important intellectual content. All authors read and approved the final version of the manuscript and agreed to be accountable for all aspects of the study in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Ethics approval and consent to participate

The study was approved by the Ethics Committee of ‘Carol Davila’ University of Medicine and Pharmacy (Bucharest, Romania). All participants signed an informed consent.

Patient consent for publication

This manuscript does not contain case details, personal information or images that may enable an individual to be identified.

Competing interests

The authors have no financial or proprietary interest to declare in any device presented in this article.

References

1. Tăbăcaru B: Femtosecond Laser - Excimer Laser Platform for ametropias surgery (unpublished PhD thesis) ‘Carol Davila’ University of Medicine and Pharmacy, no. TD 4697, 2019.
2. Shah R: History and results; Indications and contraindications of SMILE Compared With LASIK. Asia Pac J Ophthalmol (Phil) 8: 371-376, 2019.
3. Soong HK and Malta JB: Femtosecond lasers in ophthalmology. Am J Ophthalmol 147: 189-197.e2, 2009.
4. Sugar A: Ultrafast (femtosecond) laser refractive surgery. Curr Opin Ophthalmol 13: 246-249, 2002.
5. Stonecipher KG, Ignacio TS and Stonecipher KG: Complications and management with the femtosecond laser. In: Management of Complications in Refractive Surgery. Alio JL and Azar DT (eds). 1st edition. Springer-Verlag Berlin Heidelberg, pp169-177, 2008.
6. Stanca HT, Munteanu M, Jianu DC, Motoc AGM, Tăbăcaru B, Stanca S and Preda MA: Femtosecond-LASIK outcomes using the VisuMax®-MEL® 80 platform for mixed astigmatism refractive surgery. Rom J Morphol Embryol 59: 277-283, 2018.
7. Cameron BD, Saffra NA and Strominger MB: Laser in situ keratomileusis-induced optic neuropathy. Ophthalmology 108: 660-665, 2001.
8. Stanca HT, Suvac E, Munteanu M, Jianu DC, Motoc AGM, Rosca GC and Boruga O: Giant cell arteritis with arteritic anterior ischemic optic neuropathy. Rom J Morphol Embryol 58: 281-285, 2017.
9. Maden A, Yılmaz S and Yurdakul NS: Nonarteritic ischemic optic neuropathy after LASIK with femtosecond laser flap creation. J Neuroophthalmol 28: 242-243, 2008.
10. Munteanu M, Rosca C and Stanca H: Sub-inner limiting membrane hemorrhage in a patient with Terson syndrome. Int Ophthalmol 39: 461-464, 2019.
11. Vingolo EM, Grenga PL, Meduri A, Lupo S and Grenga R: Refractive surgery in patients with retinitis pigmentosa. Eur J Ophthalmol 20: 271-275, 2010.
12. Branisteancu DC, Munteanu M, Branisteancu DE, Stanca HT, Moraru A and Balta F: ‘Off-label’ drug use - ethical challenges-case study - AVASTIN®. Rev Rom Biot 13: 83-88, 2015.
13. Stanca HT, Stanca S, Tabacaru B, Boruga M and Balta F: Bevacizumab in Wet AMD treatment: A tribute to the thirteen years of experience from the beginning of the anti-VEGF era in Romania. Exp Ther Med 18: 4993-5000, 2019.
14. Panozzo G and Parolini B: Relationships between vitrectomy and refractive surgery. Ophthalmol 108: 1663-1668, discussion 1668-1669, 2001.
15. Osman E: Laser refractive surgery in glaucoma patients. Saudi J Ophthalmol 25: 169-173, 2011.
16. Kozobolis V, Konstantinidis A, Sideroudi H and Labiris G: The effect of corneal refractive surgery on glaucoma. J Ophthalmol 2017: 8914623, 2017.
17. Stanca HT, Munteanu M, Jianu DC, Motoc AG, Tăbăcaru B, Stanca S, Ungureanu E, Boruga VM and Preda MA: New perspectives in the use of laser diode transscleral cyclophotoagulation. A prospective single center observational cohort study. Rom J Morphol Embryol 59: 869-872, 2018.
18. Ahmad M, Chocron I and Shrivastava A: Considerations for refractive surgery in the glaucoma patient. Curr Opin Ophthalmol 28: 310-315, 2017.
19. Preda MA, Karancsi OL, Munteanu M and Stanca HT: Clinical outcomes of micropulse transscleral cyclophotocoagulation in refractory glaucoma - 18 months follow-up. Lasers Med Sci: Jan 14, 2020 (Epub ahead of print). doi: https://doi.org/10.1007/s10103-019-02934-x.
20. Shrivastava A, Madu A and Schultz J: Refractive surgery and the glaucoma patient. Curr Opin Ophthalmol 22: 215-221, 2011.
21. Bashford KP, Shafranov G, Tauber S and Shields MB: Considerations of glaucoma in patients undergoing corneal refractive surgery. Surv Ophthalmol 50: 245-251, 2005.
22. Bower KS and Woreta F: Update on contraindications for laser-assisted in situ keratomileusis flaps. Semin Ophthalmol 29: 363-375, 2014.
23. Abell RG, Kerr NM and Vote BJ: Femtosecond laser-assisted cataract surgery compared with conventional cataract surgery. Clin Exp Ophthalmol 41: 455-462, 2013.
24. Roberts TV, Lawless M, Bali SJ, Hodge C and Sutton G: Surgical outcomes and safety of femtosecond laser cataract surgery: A prospective study of 1500 consecutive cases. Ophthalmol 120: 227-233, 2013.
25. Boruga O, Bălășoiu AT, Giuri S, Munteanu M, Stanca HT, Iovănescu G and Preda MA: Caruncular late-onset junctional nevus: Apropos of an anatomic-clinical observation. Rom J Morphol Embryol 58: 1461-1464, 2017.
26. Garcia-Gonzalez M, Gros-Otero J, Rodriguez-Perez I, Rodero A and Teus MA: Effect of age on visual and refractive results after LASIK: Mechanical microkeratome versus femtosecond laser. Int J Ophthalmol 12: 848-849, 2019.
27. Simpson RG, Moshirfar M, Edmonds JN, Christiansen SM and Behunin N: Laser in situ keratomileusis in patients with collagen vascular disease: A review of the literature. Clin Ophthalmol 6: 1827-1837, 2012.
28. Balint GS, Iovănescu G, Stanca H, Popoiu CM, Boia E, Popovicci RA and Bolintineanu SL: The protective effect of HDL-cholesterol in patients with essential hypertension. Rev Chim 68: 949-952, 2017.
29. Smith BT, Park CH and Fekrat S: Hemi-retinal vein occlusion following LASIK. Ann Ophthalmol (Skokie) 38: 139-140, 2006.
30. Stanca HT, Petrovic Z and Munteanu M: Transluminal Nd:YAG laser embolisation - a reasonable method to reperfuse occluded branch retinal arteries. Vojnosanit Pregl 71: 1072-1077, 2014.
31. Hamed AM, Abdelwahab SM and Soliman TF: Intraoperative complications of refractive small incision lenticule extraction in the early learning curve. Clin Ophthalmol 12: 665-668, 2018.
32. Alio J: Refractive surgery today: Is there innovation or stagnation? Eye Vis (Lond) 1: 4, 2014.
33. Espandar L and Meyer J: Intraoperative and postoperative complications of Laser in situ keratomileusis flap creation using Intralase Femtosecond Laser and mechanical microkeratomes. Middle East Afr J Ophthalmol 17: 56-59, 2010.
34. Tăbăcaru B and Stanca HT: One year refractive outcomes of Femtosecond-LASIK in mild, moderate and high myopia. Rom J Ophthalmol 61: 23-31, 2017.
35. Tăbăcaru B and Stanca HT: Scheimpflug topographical changes after Femtosecond LASIK for mixed astigmatism - theoretical aspects and case study. Rom J Ophthalmol 61: 69-75, 2017.
36. Perez-Straziota C and Randleman JB: Femtosecond-assisted LASIK: Complications and management. Int Ophthalmol Clin 56: 59-66, 2016.
37. Christy JS, Nath M, Mouttapa F and Venkatesh R: Learning curve of femtosecond laser-assisted cataract surgery: Experience of surgeons new to femtosecond laser platform. Indian J Ophthalmol 65: 683-689, 2017.
38. Moshirfar M, Churgin DS and Hsu M: Femtosecond laser-assisted cataract surgery: A current review. Middle East Afr J Ophthalmol 18: 285-291, 2011.
39. Hamed AM, Heikal MA, Soliman TT, Daifalla A and Said-Ahmed KE: SMILE intraoperative complications: Incidence and management. Int J Ophthalmol 12: 280-283, 2019.
40. Wong CW, Chan C, Tan D and Mehta JS: Incidence and management of suction loss in refractive lenticule extraction. J Cataract Refract Surg 40: 2002-2010, 2014.
41. Qu PJ and Yang YB: Analysis and management of intraoperative complications during small-incision lenticule extraction. Int J Ophthalmol 9: 1697-1700, 2016.
42. Tucker SH and Sood P: Flap complications from femtosecond laser-assisted in situ keratomileusis. US Ophthalmic Rev 12: 21-27, 2019.
43. Courtin K, Saad A, Guilbert E, Grise-Dulac A and Gatinel D: Opaque bubble layer risk factors in femtosecond laser-assisted LASIK. J Refract Surg 31: 608-612, 2015.
44. Mastropraqua L, Calienno R, Lanzimi M, Salgari N, De Vecchi S, Mastropraqua R and Nubile M: Opaque bubble layer incidence in Femtosecond laser-assisted LASIK: Comparison among different flap design parameters. Int Ophthalmol 37: 635-641, 2017.
45. Wu N, Christenbury JG, Dishler JG, Bozkurt T, Duel D, Zhang L and Hamilton DR: A technique to reduce incidence of opaque bubble layer formation during LASIK flap creation using the VisuMax femtosecond laser. J Refract Surg 33: 584-590, 2017.
46. Wei CH, Dai QY, Mei LX, Ge Y, Zhang PF and Song E: Paired eye-control study of unilateral opaque bubble layer in femtosecond laser assisted laser in situ keratomileusis. Int J Ophthalmol 12: 654-659, 2019.
47. Au J and Krueger RR: Interface blood as a new indication for flap lift after LASIK using the WaveLight FS200 femtosecond laser. J Refract Surg 30: 858-860, 2014.
48. Vajpayee RB, Balasubramany R, Rani A, Sharma N, Titijal JS and Pandey RM: Visual performance after interface haemorrhage during laser in situ keratomileusis. Br J Ophthalmol 87: 717-719, 2003.
49. Shah DN and Mekli S: Complications of femtosecond-assisted laser in situ keratomileusis flaps. Semin Ophthalmol 29: 363-375, 2014.