Comparison of the efficiency of femtoLASIK and ReLEx SMILE in terms of dioptric error reduction

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Background and Aims. Refractive eye surgery is a rapidly expanding field of ophthalmology and corneal surgery is undergoing constant development leading to less invasive technologies. The goal of this study was to compare the most common femtoLASIK surgery with the newer ReLEx SMILE surgery which is gentler to the cornea. The comparison was made in terms of dioptric error reduction.

Methods. The studied cohort of patients consisted of two major groups: 30 patients who underwent femtoLASIK surgery and 30 who underwent ReLEx SMILE surgery. -30 patients, 60 eyes. All patients were aged 18–45 years with moderate myopia or astigmatism ranging from -3.25 to -6.0 spherical diopters and from 0 to -1.0 cylindrical diopters. In all, the best corrected visual acuity measured prior to surgery was 1.0. Pachymetry was not comparable because each surgical method was performed at a different time point and the introduction of an innovative method into practice led to a change in selection criteria.

Results. During postsurgical check-ups, the ReLEx SMILE method (0.74) led to lower values of non-corrected visual acuity compared to the femtoLASIK method (0.88), ($P<0.001$). However, the results changed at the one-year post-surgery check-up, when ReLEx SMILE patients achieved non-corrected visual acuity of 0.97 compared to femtoLASIK patients, who scored 0.83, ($P=0.007$). Based on data analysis from the automatic refractometer, the average spherical diopters of the femtoLASIK (-0.32 D) were higher than those of the ReLEx SMILE (-0.07 D), ($P<0.001$). The results for the cylindrical diopters were also significant, ($P=0.021$). When we compared the spherical equivalent one year after surgery, the difference between methods was significant. The FemtoLASIK method resulted in an average SE -0.55 D compared to -0.09 D for the ReLEx SMILE method, ($P<0.001$).

Conclusion. This study showed that there was a significant difference in results between the two surgical methods of treatment of moderate myopia and astigmatism, in terms of regression of dioptric error, as well as in achievement and maintenance of visual acuity during the observed period. The ReLEx SMILE had better results.

Key words: femtoLASIK, ReLEx SMILE, corneal stroma, flap, regression

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INTRODUCTION

Refractive eye surgery is a rapidly expanding field in ophthalmology. Corneal surgery is undergoing constant development, leading to less invasive technologies which give more stable results. Corneal refractive surgeries correct the dioptric error by altering the curvature of the cornea. The major difference between the two methods is the depth at which we perform the surgery and consequently the structures which are affected for a short or longer period of time post-surgery. Another difference between the two methods is the manner in which the corneal tissue is removed during surgery.

The ReLEx SMILE method is used to treat refractive errors ranging from -0.75 to -10.00 spherical diopters and -5.0 cylindrical diopters. FemtoLASIK is used to treat hyperopia, myopia and astigmatism based on a safe residual corneal stroma thickness (RST) value. The pachymetry value is no longer a conclusive parameter, because it is not advisable to perform femtoLASIK surgery on thinner corneas. However, it is possible to consider ReLEx

SMILE surgery or implant phakic intraocular lenses for patients with thinner corneas.

The goal of this study is to compare the efficiency of the two laser methods, femtoLASIK and ReLEx SMILE, in patients suffering from moderate myopia and astigmatism, focusing on the regression of dioptric error one year after surgery. In this study, we compare results of the surgery using femtoLASIK, currently the most common method, and ReLEx SMILE representing an innovative method which is gentler to the corneal structure.

Principle of dioptric error regression

Decrease in visual acuity caused by decline in dioptric error after corneal surgery generally requires additional surgery. Therefore, it is advisable to inform the patient about the possibility of additional surgeries before performing the primary surgery. The results of additional surgeries are more difficult to predict than in the case of primary surgery. Patients frequently expect more than what the surgery may realistically offer.

The main cause which results in a decrease of visual

acuity after surgery is pre-surgical refractive mistakes. There are two possible mistakes, either overcorrection or undercorrection of the dioptric error. The majority of surgeons accept the fact that the worse the presurgical visual acuity, the higher the probability of regression. The disorder regresses more often in patients suffering from hyperopia, higher astigmatism or high myopia. In the case of hyperopia, the regression develops due to a change in latent and manifest accommodation. However, the cause for regression in high myopia is the slightly raised length of the eye axis, rather than the change of the shape of the cornea itself. Induced irregular astigmatism emerges most frequently during decentration of photoablation or when the surface layers of the cornea do not heal properly^{1,2}.

Potential mechanisms of regression after refractive surgery include sclerosis of cell nuclei, stromal synthesis of collagen during healing of the corneal wound, compensatory epithelial hyperplasia and iatrogenous keratectasia. Necrosis of stromal cells occurs to the largest extent until 24 hours after the procedure and we observe higher numbers of fibroblasts, neutrophils and monocytes at the site of injury for about 1 week after surgery. Another property of regression is the apoptosis of keratinocytes and their subsequent proliferation and transformation into myofibroblasts^{2,4}.

Regression of dioptric error after surgery of the cornea correlates with the increasing thickness of the cornea, its central steepness and particularly with the healing process. The healing process is more intense in tissue which absorbs more energy. Despite the fact that the transmission of radiation into the surrounding tissue is minimal during femtoLASIK surgery, considering the principle of tissue removal, the energy level is manifold higher than in ReLEx SMILE surgery. Therefore, stimulation of the healing process is significantly higher^{5,6}. A change in corneal curvature may also occur during pregnancy and lactation. Water metabolism changes under the influence of hormones, both in the cornea and intraocular lens. The thickness of the cornea increases by 1 to 16 μm . The reason for such thickening is water retention and a decrease in intraocular pressure. Significant increase in corneal steepness and a consequent change in curvature were observed in the second half of pregnancy. We observe change in the corneal curvature, which influences refraction. This may lead to a temporary loss of corneal accommodation during and after pregnancy, as well as to accommodation insufficiency during nursing. The tissue tends to return to the pre-pregnancy state after these changes subside. Nonetheless, in a minority of patients changes may remain⁷⁻⁹.

The width of the ablation zone may also influence the regression of dioptric error. If the width of the ablation zone is below 6 mm, it leads to development of the halo phenomenon (round phosphine around lights), glare effect and a higher probability of regression due to larger epithelial hyperplasia. The wider ablation zone includes a larger optical zone, which leads to improved quality of vision and offers a more stable basis for refraction^{5,10}.

MATERIALS AND METHODS

Characteristics of the cohort

The cohort consisted of two groups. Patients who underwent femtoLASIK surgery were assigned to the first group. The second group consisted of patients who underwent ReLEx SMILE. There was a comparable number of patients in each group: 30 patients and 60 treated eyes. All patients were between 18 and 45 years old. Patients included in the study suffered from moderate myopia and astigmatism ranging from -3.25 to -6.0 spherical diopters and from 0 to -1.0 cylindrical diopters. Pachymetry was not comparable, because each surgical method was performed at a different time point and the introduction of innovative methods into practice led to a change in selection criteria.

Patients under the age of 18 were excluded from the study, because refraction tends to be less stable and the risk of regression is higher due to the expected growth of the eye. Patients over the age of 45 years were excluded, because the dioptric error was not always fully corrected due to beginning presbyopia and persisting monovision.

In the femtoLASIK group, patients were 31-43 years old with an average age of 31.72 years. The surgeries were performed in 2014 and 2015. Initial best corrected visual acuity (BCVA) for both eyes was 1.0. In the ReLEx SMILE group, patients were 31-43 years old, with the average age of 32 years. Surgeries were performed in 2015 and 2016. Initial BCVA for both eyes was 1.0.

Patients underwent surgery with femtosecond laser VisuMAX and excimer laser MEL 80. Laser surgeries were performed by three surgeons. The first surgeries were performed using the femtoLASIK method, because ReLEx SMILE technology was introduced later into clinical practice. Both methods have been used since 2015 for different indications. If patients fulfilled the criteria for both, they were given the opportunity to choose. If there were no contraindications for either method, patients' main consideration was the financial aspect. Selection criteria were based on dioptric error of the patient, fulfilment of indication criteria and accessibility of the surgical method.

Major selection criteria for the right method in the observed cohort were pachymetry and RST. FemtoLASIK surgery was not recommended for patients who had pachymetry of 500 μm and below, and planned RST lower than 300 μm . ReLEx SMILE was recommended for patients who had lower pachymetry (lower than 250-260 μm), in order to maintain the architecture of the front corneal stroma. The indication is to perform the surgery in patients older than 18 years with stable refractive error, which means that the state of the eye had not changed in the last 6 to 12 months prior to surgery by more than 0.25-0.5D and the patient did not suffer from any other eye pathology^{11,12}. It is currently possible to use ReLEx SMILE technology to correct a refractive error from -0.75 to -10 D and to -5.0 cylindrical D. FemtoLASIK surgery is indicated to correct hyperopia, myopia and astigmatism based on a safe RST value¹¹.

Both procedures are contraindicated for selected eye pathologies. Anamnesis including herpetic keratitis, unstable refractive error and acute or chronic illnesses anywhere in the eye are contraindications for laser refractive surgery. Post-injury eye, especially with subsequent irregular corneal astigmatism and ectasia, are among other contraindications. It is also necessary to understand the overall health status of the patient which may negatively affect the healing process.

Surgery is also contraindicated during pregnancy and 6 months of lactation, because the hormonal imbalance may lead to changes in water metabolism. We may observe temporary changes in refraction during this period¹¹⁻¹⁴.

Presurgical examination of patient

Patients must undergo eye examination during admission before each surgery. It is recommended that patients not wear contact lenses for at least 3 days before the examination and the surgery itself. During the examination, we measure objective refraction values and intraocular pressure on an automatic keratorefractometer. Furthermore, we use data including pachymetry from a Pentacam corneal topograph. We watch for potential higher-order aberration, using wavefront analysis, pupil width, shape and number of corneal endothelial cells under the endothelial microscope. The findings on the eye background are documented, using a nonmydriatic fundus camera. After the initial examination, we determine subjective refraction, using Snellen's optotypes on the LCD display. We perform the basic ophthalmological examination of the front and rear eye segment, examination of motility and eye position and, in indicated cases, elementary control of binocular function and strabismus. If needed, we examine the periphery of fundus in artificial mydriasis and measure cycloplegic refraction. We perform Schirmer's test to establish the quantity of tear film. At the end of the initial examination, the patient is informed about the suggested surgical method, surgical procedure, possible complications and postsurgical regime^{11,12,15}.

Surgeries were performed by the standard procedure.

Statistical analysis

To compare the surgical methods, we assumed a normal distribution of variables. However, there were two measurements for each patient (left and right eye). Age was another factor. These reasons led us to use analysis of variance, repeated measures. To compare the effect of time, we used a repeated measures ANOVA one day, one week, one month and one year post-surgery. We used the SPSS program, version 22. and MS Excel 2010 to analyse the data and graphs.

RESULTS

Data analysis

The average value of spherical diopters was $-4.64 \text{ D} \pm 0.62$ (-3.25 to -5.75), the average value of cylindrical diopters was $-0.39 \text{ D} \pm 0.25$ (-1.0 to 0) and the average spherical equivalent was $-4.83 \text{ D} \pm 0.81$ (-3.5 to -6.0) in the femtoLASIK group. Patients had their eye medical findings within the norm. The uncorrected visual acuity (UCVA) was checked during subsequent controls. The average visus on the first day was 0.88, 0.88 after one week, 0.86 after one month and 0.83 after one year. The findings were evaluated on an automatic refractometer one year post-surgery, taking into account the possible improvement of visual acuity. The average value measured for spherical diopters was $-0.32 \text{ D} \pm 0.38$ (-1.75 to $+1.0$), for cylindrical diopters $-0.47 \text{ D} \pm 0.24$ (-2.5 to $+0.5$) and the average of spherical equivalent was $-0.55 \text{ D} \pm 0.40$ (-2.25 to $+0.63$).

In the ReLEx SMILE group, the average value of spherical diopters was $-4.32 \text{ D} \pm 0.78$ (-3.25 to -6.0), the average value of cylindrical diopters was $-0.42 \text{ D} \pm 0.25$ (-1.0 to 0) and the average spherical equivalent was $-4.52 \text{ D} \pm 0.60$ (-3.5 to -5.88). One patient had a congenital glaucoma before surgery, the other patients presented normal medical findings. The UCVA was observed at the subsequent examinations. Average visus was 0.74 on the first day, 0.84 after one week, 0.94 after one month and

Fig. 1. Average of the presurgical and one-year postsurgical spherical equivalent of both eyes using femtoLASIK and ReLEx SMILE. X axis: representation of individual dioptric range. Y axis: number of eyes¹.

0.97 after one year. The findings were evaluated on an automatic refractometer one year post-surgery, taking into account the possible improvement of visual acuity. The average measured value of spherical diopters was $-0.07 \text{ D} \pm 0.38$ (-1.25 to $+0.75$), the average value of cylindrical diopters was $-0.32 \text{ D} \pm 0.29$ (-1.0 to $+1.75$) and the average value of spherical equivalent was $-0.09 \text{ D} \pm 0.55$ (-1.5 to $+0.63$), (Fig. 1).

Based on the data analysis conducted at specific times (one day, one week, one month, one year), the values for uncorrected visual acuity were unambiguously lower from the beginning for the ReLEx SMILE method (0.74) than for the femtoLASIK method (0.88), ($P < 0.001$). Nonetheless after one year, the values changed: ReLEx SMILE showed better uncorrected visual acuity (0.97)

than femtoLASIK (0.83), ($P = 0.007$). The overall analysis proved the results and the time trend ($P < 0.001$). Analysis proved that femtoLASIK achieved higher values of uncorrected visus after surgery in the short-term perspective, but the long-term values were higher using the ReLEx SMILE method (Fig. 2).

Based on the data analysis from automatic refractometer examination performed one year after the surgery, we found that the average values of spherical diopters were higher for patients who underwent femtoLASIK surgery (-0.32 D) than for patients who underwent ReLEx SMILE (-0.07 D) surgery, ($P < 0.001$). The differences for cylindrical diopters were not as significant. The average of cylindrical diopters was -0.47 D for the femtoLASIK group and -0.32 D for ReLEx SMILE, ($P = 0.021$). When

Fig. 2. The average postsurgical visus of both eyes after femtoLASIK and ReLEx SMILE. X axis: time horizon observation. Y axis: UCVA values².

Fig. 3. The average values collected from automatic refractometer before and after surgery using femtoLASIK and ReLEx SMILE.

X axis: representation of diopters before and after surgery. Y axis: dioptric value³.

we compared spherical equivalents one year after surgery, the resulting values varied significantly, as well as the resulting uncorrected visual acuity. The average SE for the femtoLASIK group was -0.55D and -0.09 for the ReLEx SMILE group, ($P < 0.001$), (Fig. 3).

DISCUSSION

Patients selected for this study suffered from mild short-sightedness and astigmatism, because we treated an evaluable number of patients in both groups and both surgeries were indicated by these disorders. The selection of patients for the individual methods was based on different corneal thickness, different preoperative refractive values, as shown in Figure 1, and patients' personal preference, which may lead to a slight bias in the results. There were not sufficient patients with lower spherical diopters who underwent ReLEx SMILE surgery, because the indication for the surgery was -2.0 diopters at the time. There were not sufficient patients with high myopia who underwent femtoLASIK surgery, because they have a thinner cornea and the surgery was contraindicated. There were also not sufficient patients with high astigmatism included, because ReLEx SMILE technology is not recommended due to a lack of iris registration and precise centration. The size of pachymetry was not conclusive, because it is not recommended that femtoLASIK surgery be performed on thinner cornea, but it is possible to consider ReLEx SMILE or implantation of a phakic intraocular lens.

Patients from the femtoLASIK group usually reached the maximal visual acuity on the first day after surgery and retained the same values until the next scheduled examination. For patients' subjective perception of the procedure, fast healing and restitution of visual acuity were an advantage. The decrease in visual acuity one year after surgery was explained by the partial regression of dioptric error, which was confirmed by the measured values of objective refraction. Lower visual acuity after ReLEx SMILE surgery is related to slower stabilisation of the tissue after stromal lenticule extraction. The visual acuity improved and remained stable until the next scheduled examination one year post-surgery.

We determined that the resulting visual acuity shortly after surgery was better in patients who underwent femtoLASIK surgery. However, the long-term visual acuity was better in patients after ReLEx SMILE surgery, based on measurements one year after surgery. The same was true for the measured values of spherical diopters on automatic refractometer one year after surgery: the ReLEx SMILE method led to a lower value of spherical diopters. Measured values of cylindrical diopters were also lower in ReLEx SMILE patients, but not as significantly. The entire spherical equivalent one year after surgery was also significantly lower for patients treated with ReLEx SMILE technology.

The main advantages of the ReLEx SMILE method compared to flap technologies are the small incision

site, which heals faster, and the minimal ingrowth of the epithelium which minimises patient discomfort after the procedure. Moreover, ReLEx SMILE prevents complications related to the flap creation, such as dislocation, microfolded, tearing or complete dissociation of the flap due to trauma etc. (ref.¹⁶). In addition, there is minimal intervention into the innervation of the cornea and minimal risk of dry eye syndrome development after surgery¹⁷⁻²². It is essential to maintain the biomechanical stability of the cornea and decrease the risk of the development of postsurgical corneal ectasia due to preserving continuous frontal stroma across the cornea²³⁻²⁶. ReLEx SMILE influences the development of higher-grade aberrations, changes in contrast sensitivity and corneal sensitivity to a minimal extent^{17,18,27-29}.

The economic, clinical and health benefits of using femtosecond laser are clear. Economic benefits stem from decreased costs since we do not use excimer laser. However, the clinical benefits are key. Excimer laser uses the photoablation principle and vaporisation to correct dioptric error. ReLEx SMILE removes the lenticule through photodisruption and subsequent extraction of the entire structure. Ablation is dependent on hydration of the cornea, the moisture and temperature of the surrounding tissue and depth of the stroma at which it is performed. The range of ablation is large, especially in cases of a greater depth of ablation, which explains the larger range during treatment of higher dioptric errors. The principle of femtosecond laser is not dependent on any of the previously mentioned factors, so the range of lenticule thickness is minimal and does not depend on the level of dioptric error²³.

The peripheral treatment zone is not influenced by excimer laser, which may induce spherical aberrations. The majority of modern excimer lasers have systems balancing out the energetic loss, which further increase the ablation depth. Using femtosecond laser prevents peripheral energetic loss and therefore eliminates the need for a balancing action. The amount of tissue to be eliminated in order to correct the refractive error is smaller than when using excimer laser. The overall amount of used energy is significantly lower when using femtosecond laser than with excimer laser. The heat generated by fast excimer laser has an adverse effect on the healing properties of the cornea after femtoLASIK surgery. The ReLEx SMILE method leads to a release of energy only during creation of the refractive lenticule and sidecut. In contrast, femtoLASIK surgery has manifold higher energy requirements needed for photoablation of the entire mass of removed stromal surface³⁰. Last but not least, ReLEx SMILE saves time, because it is not necessary to transport the patient to another laser during surgery. Thanks to new software introduced in 2014, the time of femtosecond laser use was rapidly decreased from 36s to 28s. The shorter time needed to perform the surgery decreases the risk of removal of the eye from the suction ring in the case of the patient moving.

CONCLUSION

This study has proved that there is a difference between the two methods in stability and regression of dioptric error, as well as in maintenance of resulting visual acuity in the observed time frame. When we compared the two methods on comparable cohorts of patients, it was found that the femtoLASIK group reached the maximal visual acuity faster. However, from the long-term perspective, the ReLEx SMILE method seems more convenient, especially considering more stable visual acuity and lower probability of regression of the dioptric error^{28,31}.

ReLEx SMILE ensures high precision, reproducibility and good visual acuity in the observed period of one year after surgery. ReLEx SMILE technology represents a great advance in corneal refractive surgery. Nonetheless, femtoLASIK remains the method of choice for patients with contraindications for ReLEx SMILE, especially those with hyperopia, higher astigmatism, mild myopia and in the case of significant occurrence of high-rate aberrations.

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REFERENCES

- Hersh PS, Fry KL, Bishop DS. Incidence and associations of retreatment after LASIK. *Ophthalmology* 2003;110(4):748-54.
- Nordan LT, Reoperation after LASIK and PRK. *CRST* 2003 17
- Lohmann CP, Güell JL. Regression after LASIK for the treatment of myopia: the role of the corneal epithelium. *Semin Ophthalmol* 1998;13(2):79-82.
- Mohan RR, Hutcheon AE, Choi R, Hong J, Lee J, Mohan RR, Ambrósio R Jr, Zieske JD, Wilson SE. Apoptosis, necrosis, proliferation, and myofibroblast generation in the stroma following LASIK and PRK. *Exp Eye Res* 2003;76(1):71-87.
- Gauthier CA, Holden BA, Epstein D, Tengroth B, Fagerholm P, Hamberg-Nyström H. Factors affecting epithelial hyperplasia after photorefractive keratectomy. *J Cataract Refract Surg* 1997;23(7):1042-50.
- Chayet AS, Assil KK, Montes M, Espinosa-Lagana M, Castellanos A, Tsioulis G. Regression and its mechanisms after laser in situ keratomileusis in moderate and high myopia. *Ophthalmology* 1998;105(7):1194-9.
- Dalton M. Pregnancy and refractive surgery. *ASCRS Eye world* 2012.
- Sharif K. Regression of myopia induced by pregnancy after photorefractive keratectomy. *J Refract Surg* 1997;13(5 Suppl):S445-6.
- Weinreb RN, Lu A, Beeson C. Maternal corneal thickness during pregnancy. *Am J Ophthalmol* 1988 15;105(3):258-60.
- Endl MJ, Martinez CE, Klyce SD, McDonald MB, Coopender SJ, Applegate RA, Howland HC. Effect of larger ablation zone and transition zone on corneal optical aberrations after photorefractive keratectomy. *Arch Ophthalmol*. 2001;119(8):1159-64.
- Buratto L, Slade S, Tavolato M, LASIK The evolution of refractive surgery, Thorofare 2012: 7-40,105-133
- Kuchynka P a kol, Oční lékařství, Praha Grada, 2007:71-209
- Feder R, Rapuano Ch, The LASIK handbook- a case-based approach, Philadelphia, Lippincott Williams&Wilkins, 2007:3-78
- Garg A, Alio J, Surgical techniques in ophthalmology-Corneal surgery, New Delhi, Jaypee-highlights medical publishers, 2010:323-333
- Sekundo W, Gertner J, Bertelmann T, Solomatin I. One-year refractive results, contrast sensitivity, high-order aberrations and complications after myopic small-incision lenticule extraction (ReLEx SMILE). *Graefes Arch Clin Exp Ophthalmol* 2014;252(5):837-43. doi: 10.1007/s00417-014-2608-4
- Ursea R, Feng MT. Traumatic flap striae 6 years after LASIK: case report and literature review. *J Refract Surg* 2010;26(11):899-905. doi: 10.3928/1081597X-20091209-02
- Ganesh S, Gupta R. Comparison of visual and refractive outcomes following femtosecond laser-assisted lasik with smile in patients with myopia or myopic astigmatism. *J Refract Surg* 2014;30(9):590-6.
- Li M, Niu L, Qin B, Zhou Z, Ni K, Le Q, Xiang J, Wei A, Ma W, Zhou X. Confocal comparison of corneal reinnervation after small incision lenticule extraction (SMILE) and femtosecond laser in situ keratomileusis (FS-LASIK). *PLoS One* 2013 9;8(12):e81435. doi: 10.1371/journal.pone.0081435. eCollection 2013
- Mohamed-Noriega K, Riau AK, Lwin NC, Chaurasia SS, Tan DT, Mehta JS. Early corneal nerve damage and recovery following small incision lenticule extraction (SMILE) and laser in situ keratomileusis (LASIK). *Invest Ophthalmol Vis Sci* 2014 25;55(3):1823-34. doi: 10.1167/iov.13-13324
- Tuisku IS, Lindbohm N, Wilson SE, Tervo TM. Dry eye and corneal sensitivity after high myopic LASIK. *J Refract Surg* 2007;23(4):338-42.
- Vestergaard AH, Grønbech KT, Grauslund J, Ivarsen AR, Hjortdal JØ. Subbasal nerve morphology, corneal sensation, and tear film evaluation after refractive femtosecond laser lenticule extraction. *Graefes Arch Clin Exp Ophthalmol* 2013;251(11):2591-600. doi: 10.1007/s00417-013-2400-x
- Xu Y, Yang Y. Dry eye after small incision lenticule extraction and LASIK for myopia. *J Refract Surg* 2014;30(3):186-90. doi: 10.3928/1081597X-20140219-02
- Ang M, Tan D, Mehta JS. Small incision lenticule extraction (SMILE) versus laser in-situ keratomileusis (LASIK): study protocol for a randomized, non-inferiority trial. *Trials* 2012 31;13:75. doi: 10.1186/1745-6215-13-75
- Vestergaard AH. Past and present of corneal refractive surgery: a retrospective study of long-term results after photorefractive keratectomy and a prospective study of refractive lenticule extraction. *Acta Ophthalmol* 2014;92 Thesis 2:1-21. doi: 10.1111/aos.12385
- Wang D, Liu M, Chen Y, Zhang X, Xu Y, Wang J, To CH, Liu Q. Differences in the corneal biomechanical changes after SMILE and LASIK. *J Refract Surg* 2014;30(10):702-7. doi: 10.3928/1081597X-20140903-09
- Wu D, Wang Y, Zhang L, Wei S, Tang X. Corneal biomechanical effects: small-incision lenticule extraction versus femtosecond laser-assisted laser in situ keratomileusis. *J Cataract Refract Surg* 2014;40(6):954-62. doi: 10.1016/j.jcrs.2013.07.056
- Lin F, Xu Y, Yang Y. Comparison of the visual results after SMILE and femtosecond laser-assisted LASIK for myopia. *J Refract Surg* 2014;30(4):248-54. doi: 10.3928/1081597X-20140320-03 Erratum in: *J Refract Surg* 2014;30(9):582.
- Vestergaard A, Ivarsen A, Asp S, Hjortdal JØ. Femtosecond (FS) laser vision correction procedure for moderate to high myopia: a prospective study of ReLEx(®) flex and comparison with a retrospective study of FS-laser in situ keratomileusis. *Acta Ophthalmol* 2013;91(4):355-62. doi: 10.1111/j.1755-3768.2012.02406.x
- Wei S, Wang Y. Comparison of corneal sensitivity between FS-LASIK and femtosecond lenticule extraction (ReLEx flex) or small-incision lenticule extraction (ReLEx smile) for myopic eyes. *Graefes Arch Clin Exp Ophthalmol* 2013;251(6):1645-54. doi: 10.1007/s00417-013-2272-0 Erratum in: *Graefes Arch Clin Exp Ophthalmol* 2013;251(10):2495-7.
- Dong Z, Zhou X, Wu J, Zhang Z, Li T, Zhou Z, Zhang S, Li G. Small incision lenticule extraction (SMILE) and femtosecond laser LASIK: comparison of corneal wound healing and inflammation. *Br J Ophthalmol* 2014;98(2):263-9. doi: 10.1136/bjophthalmol-2013-303415. Epub 2013 13
- Ivarsen A, Asp S, Hjortdal J. Safety and complications of more than 1500 small-incision lenticule extraction procedures. *Ophthalmology* 2014;121(4):822-8. doi: 10.1016/j.optha.2013.11.006. Epub 2013 21