USE OF A FEMTOSECOND LASER IN CATARACT SURGERY

Králik M.[1], Halička J.[1,2], Vida R.[1], Gajdoš M.[1], Javorka M.[3], Žiak P.[1,2]

[1]UVEA Mediklinik, Martin-Priekopa, Slovakia
[2]Eye clinic, Jessenius medical facutly in Martin, Commenius University in Bratislava, Slovakia
[3]Department of physiology, Jessenius medical facutly in Martin, Commenius University in Bratislava, Slovakia

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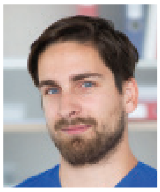

First author:
Michal Králik, MD

Correspondence author:
Peter Žiak, MD, PhD
Očná klinika JLF UK a UNM
Kollárova 2
036 59 Martin
E-mail: ocnesekr@unm.sk

SUMMARY

Aims: Cataracts continue to be the leading cause of blindness worldwide. Phacoemulsification is the gold standard in the treatment of cataracts. The aim of the study was to compare the postoperative results of the phacoemulsification technique in comparison with femtosecond laser-assisted cataract surgery (FLACS).

Material and Methods: Our work retrospectively evaluates the results of patients after implantation of an artificial intraocular lens for cataract from May 2017 to March 2019. The study evaluated a total of 80 implanted lenses in 47 patients operated on by two surgeons. Of the 47 patients, 28 were women. The mean age in the group at the time of surgery was 63.7 years, ranging from 34–79 years. Patients could choose FLACS (n = 45) surgery or standard phacoemulsification procedure (n = 35).

Results: Upon a comparison of the group regarding uncorrected distal visual acuity (UCDVA) up to 12 months after surgery, the group FAKO CATARACTS recorded 0.85 ±0.18 vs. 0.93 ±0.12 in the FEMTO CATARACTS group (p = 0.021), comparably uncorrected near visual acuity (UCNVA) was 0.77 ±0.18 vs. 0.84 ±0.17 (p = 0.034) respectively. A difference in the use of phacoemulsification energy (OZIL) was measured in patients with phacoemulsification 3.5 ±3.1 and in the use of femtosecond laser 2.2 ±3.1, (p = 0.005). In all cases, an AT LISA 839 trifocal lens (Carl Zeiss Meditec, Germany) was implanted.

Conclusion: The femtosecond platform assists the surgeon in cataract surgery with capsulorhexis and pre-fragmentation of the lens nucleus, which can be advantageous especially for complicated cataracts. We recorded significantly higher uncorrected distance and near visual acuity in the FLACS group, and also a significantly lower value of the phacoemulsification energy used.

Key words: femtosecond laser, cataract, photodisruption, femtosecond laser-assisted cataract surgery, capsulorhexis

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INTRODUCTION

Cataracts are opacities of the lens which cause a reduction in the transparency of the lens tissue, with a subsequent reduction in the amount of light reaching the retina. The pathogenesis of lens opacity is a multifactorial process, which increases in intensity with advancing age. Senile degeneration of the lens tissue is characterised by chemical changes in proteins (crystallines), with the formation of pigmentation, a lower concentration of potassium and glutathione, a higher concentration of sodium and calcium and increased hydration of the lens [1].

At present surgical treatment is the only possibility for ridding patients of cataracts. Causal therapy is not currently capable of preventing the onset of cataract. The preferred surgical method at present is phacoemulsification. This concerns a method of removing turbid lens matter with the aid of an ultrasonic tip, in which the solid lens matter is converted into a mass with properties similar to liquid. The emulsified matter is then drained off with a phaco probe. At the turn of the millennium, femtosecond technology was introduced in the field of ophthalmology. This technology was soon applied in refractive surgery performed for the formation of corneal folds, known as the LASIK method (Laser in situ keratomileusis) [2]. The treatment was then introduced into cataract surgery a decade later. The essence of femtosecond technology is the use of ultra-short impulses in order to induce the formation of plasma and acoustic shock waves in the target tissue. This process is also referred to as photodisruption. In photodisruption there is a release of a large quantity of energy concentrated in a small area, causing a microburst without minimally affecting the tissue in close proximity to the incision. Through the sum of these microbursts, in combination with adequate software, we are able to create various incision rasters which have wide possibilities for application in cataract surgery [3]. At present the assistance of a femtosecond laser consists in the possibility of creating corneal incisions, capsulorhexis, pre-fragmentation of the lens nucleus and arcuate corneal incisions.

FLACS, an abbreviation of femtosecond laserassisted cataract surgery, refers to the use of a femtosecond laser (FSL) in cataract surgery. Its advantage consists in acceleration, increased safety and greater predictability of the refractive result following cataract surgery. One of the main advantages of FLACS is the reduction of the phacoemulsification time, which in its end result to a smaller depletion of endothelial cells and postoperative corneal edema [4]. Another advantage is the higher quality of the diameter, shape and centration of capsulorhexis performed with the aid of the FSL. FLACS capsulorhexis has a positive influence on the positional stability of the IOL (intraocular lens), with a subsequent impact on visual quality and refractive results [5]. Nevertheless, a meta-analysis covering 14 567 eyes did not find statistically significant differences between FLACS and standard cataract surgery with the implantation of a monofocal intraocular lens with regard to important visual and refractive results, and overall complications [6].

MATERIAL AND METHOD

The study retrospectively evaluates the results of patients following a replacement of an artificial intraocular lens for a cataract in the period from May 2017 to March 2019, during which a total of 101 eyes were operated on, with subsequent implantation of an At Lisa 839 (Zeiss, Germany) trifocal artificial intraocular lens. After the exclusion of patients according to the exclusion criteria (see below), a total of 80 implanted lenses in 48 patients were evaluated, operated on by 2 surgeons. The mean age in the group at the time of surgery was 62.2 ±11 years, within the range of 34–79 years. In the FLACS group the mean age was 60.75 ±7.71 years, and in the standard phacoemulsification group 63.68 ±13.98 ($p = 0.26$). Out of 47 patients, 28 were women. The patients had a choice of a lens operation by FLACS (n = 45, of which 9 unilaterally and 18 bilaterally) or standard phacoemulsification (n = 35, of which 7 unilaterally and 14 bilaterally), in both cases with subsequent implantation of an intraocular lens – for a detailed description see Table 1. The patients paid for the trifocal lens themselves, and also paid the difference in price between femtosecond laser assisted cataract surgery and phacoemulsification. All the patients provided their informed consent. The exclusion criteria from observation were a medical history of glaucoma or retinal detachment (RD), corneal pathology, previous corneal surgery, inflammatory ocular pathologies, macular degeneration or other central retinopathy.

The procedures were performed at the UVEA Mediklinik surgical centre. Phacoemulsification was performed using the Constellation (Alcon, Switzerland) system, FLACS was performed on the VICTUS (Bausch&Lomb, Canada) platform. The assistance of a phemtosecond laser consisted in anterior capsulorhexis (diameter 5.2 mm; height of edge 700 µm; energy 7.3 µJ) and fragmentation of the nucleus (3 circular incisions with a diameter of 4.0 mm; 4 radial incisions with a diameter of 6.0 mm; energy 7.5 µJ). In both groups the corneal incisions were located in the place of the corneal steep meridian. In all cases an AT LISA 839 (Carl Zeiss Meditec, Germany) trifocal lens was implanted with the aid of an applied injector via an incision with a width of 2.2–2.75 mm. The choice of size of corneal incision depended on the preoperative corneal astigmatism, upon DCyl < 0.5 the size of the incision was 2.2 and upon DCyl > 0.5 it was 2.75. The mean value of the implanted lens in the group of standard phacoemulsification was +22.1 ±2.9, and +22.5 ±1.9 in the FLACS

Table 1. Patient group description

Operation type / Group characteristic	PHACO, n = 35	FLACS, n = 45	p-value
AGE (years)	63.68 ±13.98	60.75 ±7.71	0.25
SEX	14 woman, 12 man	14 woman, 7 man	0.32
SUBJ. REFRACTION BEFORE OPERATION (SE)	+0.38 ±2.89	+1.23 ±2.31	**0.009**
ASTIGMATISM BEFORE OPERATION (DCyl)	0.48 ±0.52	0.64 ±0.58	0.11
IMPLANTED IOL (D)	+22.1 ±2.9	+22.5 ±1.9	0.87
K1 BEFORE OPERATION (D)	42.95 ±1.64	43.33 ±1.5	0.49
K2 BEFORE OPERATION (D)	43.73 ±1.81	44.08 ±1.55	0.66
PHOTOPIC PUPILLA DIAMETER (mm)	2.76 ±0.48	3.07 ±0.58	**0.048**
SCOTOPIC PUPILLA DIAMETER (mm)	4.49 ±0.77	4.94 ±0.94	0.12

D – diopters, SE –spherical equivalent, DCyl – diopter cylinder, mm – millimeters, p-value – probability value group. Cases in which a toric lens was used are not included in this study. Surgery on the second eye was usually performed at an interval of one week later. After the operation the patients were instructed to apply 1 drop of 0.5% levofloxacin (Oftaquix) 5 times per day for a period of 1 week and 1 drop of 0.1% dexamethasone (Unidexa) 5 times per day for a period of 1 month, reducing the dose by 1 drop each week.

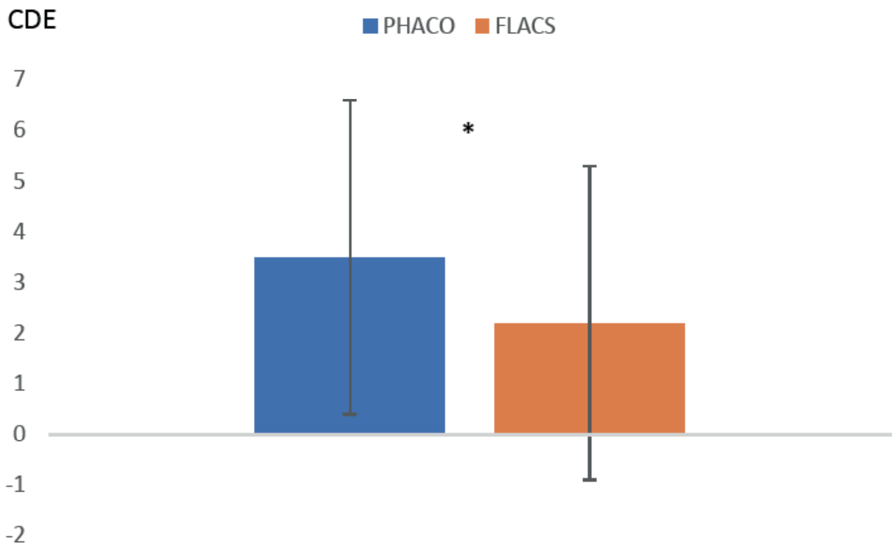
Preoperative biometry was performed using the optic biometric system IOL master 700 (Carl Zeiss Meditech, Oberkochen, Germany). In the calculation of dioptric power of the intraocular lens, the Hoffer-Q formula was used at an axial length of the eye of ≤ 24.0 mm, and the Holladay formula at an axial length of the eye of > 24.0 mm. Planned postoperative refraction was selected at a small, first plus dioptre. A postoperative follow-up examination was conducted 1 and 12 months after surgery. During the ophthalmological examination we measured refraction (Nidek, Japan), uncorrected and corrected near and distance visual acuity (Snellen diagrams, LCD optotype CX-1000, Topcon, Japan), and we examined the anterior and posterior segment on a slit lamp (LS 220, Zeiss, Germany). We measured pupil size at the preoperative examination with the aid of a Sirius Scheimpflug camera (Schwind, Germany).

A statistical analysis of the data was performed with the aid of the software SPSS for Windows (version 19.0, SPSS, Inc.). The normality of the sample was tested with the aid of a Kolmogorov-Smirnov test, and homoscedasticity with the aid of a Levene test. If a parametric statistical analysis was possible, a paired Student T-test was used to assess the significance of the differences between the preoperative and postoperative data; a non-parametric Friedman test with subsequent post hoc tests (Conover test) was used when a parametric statistical analysis was not possible. Upon a comparison of OZIL Femto vs. Phaco we used a Mann-Whitney test. The level of statistical significance was always the same ($p < 0.05$). To evaluate the correlation between the variables we used correlation coefficients (Pearson or Spearman, depending on whether it was possible to expect normality of the tested sample).

RESULTS

Upon an examination of corneal topography in the whole group before the implantation of an AT Lisa 839 lens, the mean preoperative value of astigmatism was measured at +0.57 ±0.55 DCyl, 1 month after surgery this was 0.61 ± 0.51 DCyl and 12 months after surgery +0.35 ±0.47 DCyl (p = 0,0007). Preoperative subjective refraction for distance vision was +0.38 ±2.89 DSE (dioptres of spherical equivalent) in the group of patients operated on with phacoemulsification, and upon the use of a femtosecond laser +1.23 ±2.31 DSE.

In the group with phacoemulsification of the cataract (FAKO CATARACTS), photopic pupil width was 2.76 ±0.48 mm and scotopic width 4.49 ±0.77. The correlation of pupil width and uncorrected distance visual acuity was not



Graph 1. Comparison of used energy during phacoemulsification (OZiL handpiece) in cataract surgery using phacoemulsification alone or femtosecond laser assisted cataract surgery (p = 0.005)

PHACO – phacoemulsification group,
FLACS – femtosecond assisted cataract surgery group,
CDE – cumulative dissipitated energy

significant 1M (month) after surgery (Spearman correlation parameter rho = -0.013, insignificant [ns]) and 12M after surgery with a tendency towards significance (rho = -0.092, ns). The correlation of pupil width and uncorrected near visual acuity was not significant 1M after surgery (rho = -0.11, ns) or 12M after surgery (rho = 0.011, ns).

In the FLACS group (FEMTO CATARACTS), photopic pupil width was 3.07 ±0.58 mm and scotopic pupil width was 4.94 ±0.94. In this group the correlation of pupil width and uncorrected distance visual acuity was shown to be significant 1M after surgery (rho = 0.394, p = 0.011) and 12M after surgery with a tendency toward significance (rho = 0.293, p = 0.060). The correlation of pupil width and uncorrected near visual acuity was not significant 1M after surgery (rho = -0.211, ns) or 12M after surgery (rho = -0.233, ns).

Preoperative uncorrected distance visual acuity (UCDVA) in the FAKO CATARACTS group was 0.31 ±0.26 and in the FEMTO CATARACTS 0.29 ±0.19, and preoperative uncorrected near visual acuity (UCNVA) was 0.23 ±0.20 vs. 0.22 ±0.21. Postoperative uncorrected distance visual acuity 1 month after surgery was 0.85 ±0.18 in the FAKO CATARACTS group and 0.93 ±0.12 in the FEMTO CATARACTS group, while uncorrected near visual acuity 12 months after surgery was 0.77 ±0.18 vs. 0.84 ±0.17. For detailed results see Table 2. Upon a comparison of the groups in terms of uncorrected distance visual acuity 12 months after surgery, the FAKO CATARACTS group recorded 0.84 ±0.18 vs. 0.94 ±0.1 in the FEMTO CATARACTS group (p = 0.021), while uncorrected near visual acuity was 0.79 ±0.19 vs. 0.86 ±0.16 respectively (p = 0.034).

Upon a comparison of postoperative refraction 1 year after surgery we recorded a significant difference in spherical dioptres, specifically 0.56 ±0.49 Dsf vs. 0.25 ±0.36 Dsf (p = 0.01) in the FAKO vs. FEMTO CATARACTS groups respectively, and also upon a comparison of spherical equi-

Table 2. Change in visual acuity (Snellen) in patients undergoing cataract surgery. Statistical significance was determined between the preoperative (Pre-OP) findings and the findings 12 months after the operation (Post-OP)

Cataract surgery	**Pre-OP**	**Post-OP**		
Visual acuity		**1 mesiac**	**12 mesiacov**	**p**
AT LISA 839 MP (FAKO, n = 35)				
UCDVA (average ±SD) interval (min, max)	0.31 ±0.26 0.02; 0.9	0.85 ±0.18 0.4; 1.0	0.84 ±0.18 0.5; 1.0	p < 0.05
BCDVA (average ±SD) interval (min, max)	0.69 ±0.25 0.10; 1.0	0.98 ±0.05 0.8; 1.0	0.99 ±0.05 0.8; 1.0	p < 0.05
UCNVA (average ±SD) interval (min, max)	0.23 ±0.20 0.1; 0.8	0.77 ±0.18 0.3; 1.0	0.79 ±0.19 0.2; 1.0	p < 0.05
BCNVA (average ±SD) interval (min, max)	0.7 ±0.2 0.1; 1.0	0.92 ±0.13 0.5; 1.0	0.95 ±0.11 0.5; 1.0	p > 0.05
AT LISA 839 MP (FEMTO, n = 45)				
UCDVA (average ±SD) interval (min, max)	0.29 ±0.19 0.03; 0.7	0.93 ±0.12 0.5; 1.0	0.94 ±0.1 0.6; 1.0	p < 0.05
BCDVA (average ±SD) interval (min, max)	0.74 ±0.23 0.05; 1.0	0.99 ±0.4 0.8; 1.0	1.0 1.0	p < 0.05
UCNVA (average ±SD) interval (min, max)	0.22 ±0.21 0; 0.8	0.84 ±0.17 0.5; 1.0	0.86 ±0.16 0.5; 1.0	p < 0.05
BCNVA (average ±SD) interval (min, max)	0.74 ±0.2 0.4; 1.0	0.96 ±0.09 0.63; 1.0	0.99 ±0.05 0.8; 1.0	p > 0.05

UCDVA – uncorrected distal visual acuity,
BCDVA – best corrected distal visual acuity,
UCNVA – uncorrected near visual acuity,
BCNVA – best corrected near visual acuity, SD – standard deviation, min – minimum, max – maximum, p-value – probability value, Pre-OP – preoperatively, Post-OP – postoperatively

valent, specifically 0.23 ±0.41 SE vs. -0.04 ±0.37 SE (p = 0.014) in the FAKO vs. FEMTO CATARACTS groups respectively. The difference in postoperative cylindrical dioptre was not significant, specifically -0.71 ±0.44 Dcyl vs. -0.58 ±0.27 (p = 0.13).

A difference was recorded in the use of phacoemulsification energy with the use of an OZIL tip in patients with phacoemulsification, specifically 3.5 ±3.1 (%-s, or CDE - Cumulative dissipated energy), and upon the use of a femtosecond laser 2.2 ±3.1 CDE, (p = 0.005). See Graph 1.

DISCUSSION

Cataracts continue to be the leading cause of blindness worldwide. To date, surgery remains the sole effective treatment. In recent decades the gold standard for cataract surgery has been phacoemulsification, and today it is now a classic surgical procedure. With the arrival of femtosecond lasers and their increasing utility, with a significant contribution to improving the quality and predictability of procedures in refractive surgery and corneal surgery, it appeared that they could also have a similarly significant effect also in the field of cataract surgery, and that the now classic cataract procedure of phacoemulsification would recede into the background. However, with hindsight this prediction appears to have been unrealistic for a number of reasons. The first of these is the high initial investment when measured against the actually small contribution to improving quality in comparison with the classic manual surgical procedure. Another reason is that the market is dominated by FS platforms which are focused exclusively either on the cornea or alternatively on FLACS. In terms of utility, as well as from an economic point of view, the ideal solution is therefore a combined FS platform which provides the option of changing the modes, i.e. from corneal or therapeutic to FLACS and vice versa. A further reason in the case of some femtosecond lasers is the large demands placed in terms of the temperature stability in the room in which the instrument is placed. The temperature should fluctuate by a maximum of +/-1 °C, whether the instrument is switched off or in full operation. These are the primary reasons why FLACS, evidently in the near future, will not become a "game changer" in cataract surgery.

In our retrospective study, slightly better results were recorded in postoperative uncorrected visual acuity upon use of the FLACS method. Upon a comparison of the groups in terms of uncorrected distance visual acuity 12 months after surgery, the FAKO CATARACTS group recorded 0.84 ±0.18 vs. 0.94 ±0.1 in the FEMTO CATARACTS group (p = 0.021), while uncorrected near visual acuity was 0.79 ±0.19 vs. 0.86 ±0.16 respectively (p = 0.034).

In large studies, the FLACS method is described as having no benefit [10-12]. In our view, our own results of better postoperative uncorrected visual acuity in the FLACS group are a consequence of the statistically significantly lower postoperative refraction in the FLACS group, as well as selection bias; FLACS tends to be preferred by younger patients because they are more often able to afford it. However, it is necessary to state that this is real clinical practice. At our centre we unequivocally recommend FLACS for hypermetropias with good access to the eyeball, while we do not recommend this method for myopic patients. Nevertheless, the actual choice of the method used remains down to the patients and their options. Before surgery patients are instructed that the use of FLACS has no influence on the quality of postoperative vision, and that we recommend its use rather due to the increased safety of the operation itself.

We retrospectively evaluated pupil width and its influence on postoperative vision, and we found a significant positive correlation in the FLACS group 1 month after surgery. Otherwise, pupil width did not correlate with better postoperative vision in any group. We assume that with the given pupil widths, postoperative refraction is a more influential factor.

In our group the quantity of OZIL energy was significantly lower in the patients who underwent FLACS: 2.2 ±3.1 in comparison with 3.5 ±3.1 (p = 0.005) upon standard phacoemulsification, while in the FLACS group it is necessary to factor in the use of femtosecond laser energy of 14.8 μJ.

In the one-year observation period, four cases of NdYAG laser capsulotomy due to secondary cataract were recorded equally in both groups, and in one case in the FEMTO group it was necessary to perform additional LASEK correction due to patient dissatisfaction (the results were assessed before the procedure). No serious side effects were recorded such as retinal detachment or endophthalmitis.

CONCLUSION

In our opinion, as well as in the view of other surgeons [8], the use of FLACS with phacoemulsification is a useful method in surgery on complicated cataracts. A problem is presented by the price of the instrument itself as well as the subsequent procedure, since FLACS is not covered by public health insurance, and so in the period of 2017–2019 patients paid an additional 390 Euro per one eye for FEMTO laser treatment. On the other hand, if a centre has such an instrument at its disposal, it is possible to increase the probability of a good result also in patients who have a complicated cataract, whether this concerns PEX syndrome and the thus ensuing problems with the quality of the zonules, or patients with very hard nucleii or an anterior polar cataract, in whom thanks to the creation of capsulorhexis and pre-fragmentation of the nucleus we can prevent subluxation of the lens, lesions on the posterior capsule or lesions on the anterior capsule caused by poor quality capsulorhexis as a consequence of fibrotic changes in the anterior capsule. The utility of the corneal incision and paracentesis with the aid of FLACS is contentious due to the proximity of the incision, since a manually performed incision shows a higher degree of proximity than in the case of a FLACS corneal incision [9]. Our clinical experiences are in accordance with these findings.

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