ORIGINAL ARTICLE

Efficacy of Femtosecond Laser-Assisted Phacoemulsification for Cataract Patients and its Influence on Serum Levels of Inflammatory Factors

Jianming Chen, Dengting Wang, Jiqi Zheng and Chen Gao

ABSTRACT

Objective: To investigate effect of femtosecond laser-assisted phacoemulsification in treating cataract patients, and to analyse its influence on serum inflammatory factors IL-6, IL-1β, TNF-α.

Study Design: An analytical, descriptive study.

Place and Duration of Study: The Ophthalmologic Center, Rehabilitation Center Hospital of Gansu, China, from January 2016 to September 2017.

Methodology: A total of 94 eyes were randomly divided into control group (47 cases) and observation group (47 cases). Control group was treated with traditional phacoemulsification. The observation group was added with femtosecond laser based on the treatment of the control group. Clinical efficacy of two groups was compared.

Results: Surgery time of the observation group was longer than that of the control group ($p<0.001$). Effective phacoemulsification time, cumulative dissipated energy, and liquid flow of the observation group were all less than those of the control group (all $p<0.001$). One day after surgery, aqueous flare and rate of corneal endothelium loss in the observation group were less than those of the control group (both $p<0.001$). Seven days after surgery, serum levels of IL-6, IL-1β and TNF-α in the observation group were lower than those of the control group (all $p<0.001$).

Conclusion: Femtosecond laser-assisted phacoemulsification has better clinical effect in treating cataract, and can reduce the energy and time cost in the phacoemulsification, decrease the serum levels of inflammatory factors and cause less postoperative complications. But it takes longer operation time and relatively higher treatment cost.

Key Words: *Femtosecond laser, Phacoemulsification, Cataract, Inflammatory factor.*

INTRODUCTION

Cataract leads to lens opacity, hinders the entry of light, thus affecting the patient's vision.[1,2] Main causes of cataract are lens capsule damage and the degeneration of crystallin protein due to lens aging or inheritance, metabolic abnormalities, trauma, radiation, poisoning, local malnutrition and other factors. The main symptom of cataract is visual impairment that is related to the degree of opacification of the lens and lesion site of opacification. Severe cataract can cause blindness.[3] With the average prolongation of world life expectancy, cataract patients are continuously increasing. Phaco-emulsification is a currently common method in treating cataract. As shown from previous studies, complications such as incision leakage and increased astigmatism may occur after traditional phaco-emulsification, which may affect the visual quality of patients.[4,5]

The femtosecond laser is an ultra-short pulse laser, with high precision and strong penetrating power as well as the ability to accurately cut the corneal tissue and the lens, that has gradually been applied to the field of cataract surgery.[6] With the higher requirement in accuracy of cataract surgery by patients, cataract surgery assisted by femtosecond laser has become a trend in cataract surgery globally.

The objective of this study was to compare the femto-second laser-assisted phacoemulsification cataract surgery with traditional phacoemulsification for efficacy and safety and influence on the serum levels of inflammatory factors in patients with cataract.

METHODOLOGY

This study was conducted at the Ophthalmologic Center, Rehabilitation Center Hospital of Gansu, China, from January 2016 to September 2017. The study was approved by the Hospital Ethics Committee, and all patients volunteered to participate in this study. Inclusion criteria were patients who were clinically diagnosed with cataract, specifically, all with monocular cataract; age >18 years; and patients who were willing for cataract surgery and ready for 6 months follow-up. Exclusion criteria were age < 18 years, with severe mental illness, systemic disease; patients with history of eye diseases such as keratopathy, glaucoma, and retinopathy; nystagmus, strabismus and amblyopia, inability of poor pupil dilatation; history of previous eye trauma and

Ophthalmologic Center, the Rehabilitation Center Hospital of Gansu, 730000, China

Correspondence: Dengting Wang, Ophthalmologic Center, The Rehabilitation Center Hospital of Gansu, 730000, China
E-mail: swo2jd@163.com

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surgical history; and patients with blepharospasm, corneal degeneration, hyphema, conjunctivochalasis, deffective phacoemulsification time of anterior chamber <2.4 mm. A total of 94 cataract patients with (94 eyes) were randomly divided into control group (47 cases) and observation group (47 cases).

Control group was treated with traditional phaco-emulsification: the patient was lying in the supine position, the surface was anesthetised twice, the drape was disinfected, the eyelid was opened, the transparent cornea on the temporal side was cut 2.2 mm, visco-elastic agent was injected into the anterior chamber, the annular capsulorhexis was 6 mm in diameter, water separation was performed, the capsular bag was broken, the broken nucleus was sucked out by the method of splitting nucleus, the cortex was sucked out, the capsule membrane was polished, viscoelastic agent was injected, the folded intraocular lens was implanted, and the incision was watertight.

Observation group was treated with femtosecond laser on the basis of the control group: compound tropicamide was used to dilate the pupil 30 minutes before surgery, surface anesthesia was performed once 10 minutes before operation, the limbal position of the eye was marked, and the conjunctival sac was rinsed. The parameters of the femtosecond laser were set, the diameter of the capsulorhexis was 5 mm, the mode of nucleus fragmentation was set, and the temporal stepped corneal incision was taken, with a length of 2.3 mm and a lateral corneal incision of 1 mm. The patient was lying in the supine position, opened the eyelid, connected with the patient interface (PI), connected with the laser probe on one side, embedded with a corneal contact lens on the other side, lowered the laser probe, started aspiration, turned on negative pressure aspiration after PI contacted the eyeball, fixed the eyeball, and anchored it. According to the laser imaging system, the cornea, anterior capsular incision, and nucleus fragmentation parameters were finely tuned, the laser was turned on, then negative pressure aspiration was released, surface anesthesia was performed, transferred to the phacoemulsification room, disinfected and draped, opened the eyelid, separated the corneal incision, injected with viscoelastic agent, determined that the capsular removal was complete, and separated with water. The remaining operations were the same as those of the control group.

Operation time, effective phacoemulsification time, cumulative dissipated energy and fluid amount were compared between the two groups. At one day after surgery, visual acuity, intraocular pressure, corneal endothelium count, aqueous flare and slit lamp were measured and compared between the two groups. The rate of corneal endothelium loss was recorded. The rate of corneal endothelium loss = (preoperative corneal endothelium count - postoperative corneal endothelium count) / preoperative corneal endothelium count x 100%. At 7 days after surgery, enzyme linked immunosorbent assay was used to compare the level changes of serum inflammatory cytokines IL-6, IL-1β and TNF-α. Incidence rates of complications were observed between the two groups at 3 months after surgery.

Data was processed using SPSS 21.0 statistical software. Measurement data was expressed as mean ±SD, using independent sample t-test for the comparison between the two groups. Count data was represented by n (%), and X^2 test was used for comparison between the two groups. The p-values less than 0.05 were regarded as significant.

RESULTS

Among 94 cases, 60 cases (60 eyes) were males, accounting for 63.83%; and 34 cases (34 eyes) were females, accounting for 36.17%. The patients were 24-73 years old, with an average age of 52.75 ±3.18 years.

Surgery time of the observation group was longer than that of the control group ($p<0.001$). Moreover, effective phacoemulsification time, cumulative dissipated energy, and liquid flow of the observation group were all less than those of the control group (all $p<0.001$, Table I). At one day after surgery, the difference of intraocular pressure between the two groups had no statistical significance ($p=0.362$); aqueous flare and rate of corneal endothelium loss in the observation group were less than those of the control group (both $p<0.001$, Table II). At seven days after surgery, serum levels of inflammatory factors IL-6, IL-1β and TNF-α of the observation group were lower than those of the control group (all $p<0.001$, Table III).

The frequency of complications in the observation group was 8.51% (4 eyes), namely, corneal edema occurred in 2 eyes (4.26%) at 3 days after surgery, macular edema occurred in one eye (2.13%) at 7 days after surgery, and one eye (2.13%) got high intraocular hypertension at one month after surgery; all complications returned to normal on their own. Frequency of complications in the control group was 21.28% (10 eyes), namely, corneal edema occurred in 4 eyes (8.51%) at 3 days after surgery, macular edema occurred in one eye (2.13%) at 7 days after surgery, and 4 eyes (8.51%) got high intra-ocular pressure at 1 month after surgery. The above-mentioned complications returned to normal on their own. Retinal detachment occurred in one eye (2.13%) at two months after surgery and was successfully reset on receiving conservative treatment. The incidence of complications of the observation group was lower than that of the control group ($p=0.082$).

Table I: Comparison of surgical indices between two groups of patients.

Groups	Number of eyes	Surgery time (s)		Effective phacoemulsification time (s)		Cumulative dissipated energy		Liquid flow (mL)	
		Mean ±SD	p-value	Mean ±SD	p-value	Mean ±SD	p-value	Mean ±SD	p-value
Control group	47	415.78 ±46.34	<0.001	36.06 ±4.17	<0.001	14.39 ±5.92	<0.001	64.84 ±11.80	<0.001
Observation group	47	901.95 ±55.95		17.33 ±4.41		7.24 ±2.77		50.97 ±8.89	

Table II: Comparison of intraocular pressure, aqueous flare and the rate of corneal endothelium loss between two groups at 1 day after surgery.

Groups	Number of eyes	Intraocular pressure (mmHg)		Aqueous flare (ph/ms)		Rate of corneal endothelium loss (%)	
		Mean ±SD	p-value	Mean ±SD	p-value	Mean ±SD	p-value
Control group	47	14.63 ±2.23	0.362	19.15 ±5.93	<0.001	6.43 ±1.20	<0.001
Observation group	47	15.02 ±1.88		14.28 ±2.51		1.57 ±0.30	

Table III: Comparison of serum levels of inflammatory factors between two groups at 7 days after surgery.

Groups	Number of cases	IL-6 (ng/mL)		IL-1β (ng/mL)		TNF-α (ng/mL)	
		Mean ±SD	p-value	Mean ±SD	p-value	Mean ±SD	p-value
Control group	47	33.43 ±4.62	<0.001	34.87 ±3.73	<0.001	70.25 ±4.66	<0.001
Observation group	47	27.37 ±2.34		28.16 ±1.40		61.48 ±5.01	

DISCUSSION

The femtosecond laser has been confirmed to have the shortest pulse, and could release energy in the quarter-thousandth of a second at the soonest, which is very suitable for ophthalmic surgery with the utmost requiring for high accuracy.[7,8] Femtosecond laser could provide the repeatability, safety, and accuracy needed for cataract surgery. Femtosecond laser-assisted cataract phacoemulsification is a revolutionary result of cataract surgery in recent years that uses femtosecond laser to replace the traditional scalpels, thus to make key steps such as incision, capsulorhexis and chopping with the aid of computerised imaging system, which were previously completed by manual work in conventional phacoemulsification. It could avoid manual error, so as to achieve accurate, minimally invasive, safe and rapid surgical results.[9,10]

In the traditional cataract phacoemulsification, the surgery steps mostly rely on the operator to complete it manually. In particular, using scalpels to make incisions and tearing anterior lens capsule by hand are largely dependent on the surgeons' experience and skills, which is hard to ensure the accuracy of the position and completeness and leads to intraoperative complications such as accidental laceration of the capsular tissue, affecting the location of other surgical procedures and implantation of the intraocular lens, and finally affecting postoperative visual quality.[11,12] The use of femtosecond laser technology allows precise cutting and near-perfect capsulorhexis after scanning the patient's eyes, replaces traditional cataract scalpels and most of manual, unstable procedures, reduces surgical trauma, improves postoperative visual quality and decreases surgical risks.[13] Nasrollahi *et al*. revealed MyoRing implantation employing femtosecond laser technology would be a harmless, effective, and predictable method to treat selected subjects of keratoconus.[14]

The result of this study showed that the surgery time of the observation group was longer than that of the control group, but the effective phacoemulsification time, cumulative dissipated energy and fluid amount were all less than those of the control group. This confirms that femtosecond laser-assisted phacoemulsification can reduce energy and time cost in phacoemulsification, and reduce the damage of eye tissues. The results were in line with previous studies.[15]

TNF-α is a kind of pyrogen that could increase the secretion of IL-1β by stimulating Macrophages, while IL-1β can stimulate other cells to release IL-6.[16] IL-1β can cause inflammation and the induction of inflammatory responses, induce IL-6 and TNF-α expression, stimulate immune cells and stroma cell to produce IL-1β; more worse, the property of IL-6 is similar to that of IL-1β, thus forming a vicious circle and accelerating the inflammatory response.[17,18] The results of this study showed that the levels of IL-6, IL-1β, and TNF-α of the observation group were lower than those in the control group at 7 days after the surgery. This indicated that femtosecond laser-assisted phacoemulsification surgery for cataracts can effectively reduce the level of serum inflammatory factors and reduce inflammatory symptoms.

In addition, the transparent corneal incision in the traditional cataract phacoemulsification is often made by the tunnel knife in the corneal layers of the patient, causing the higher incidence of hypotony, corneal astigmatism and intraocular infection after surgery.[19] The femtosecond laser can fully protect the sealing degree of corneal incision and safety by firstly producing ladder at the interval of the corneal surface and stroma, and then making the incision through the tunnel supplemented by microsurgical equipment after the completion of capsulorhexis and nucleus chopping.[20,21]

The results of this study showed that there was no statistically significant difference in intraocular pressure

between the two groups at 1 day after surgery, suggesting that femtosecond laser has no significantly negative effect on intraocular pressure in cataract patients. The aqueous flare and the rate of corneal endothelial loss in the observation group were lower than those in the control group, which confirmed the safety of femtosecond laser-assisted phacoemulsification surgery.

The monitoring results of postoperative complications showed that the incidence of complications in the observation group was lower than that in the control group, indicating that the addition of femtosecond laser-assisted treatment, after the completion of tearing and chopping, could use microsurgical instruments to pass through the incision tunnel, thus to preserve the sealing degree of the corneal incision, improve the safety of the surgery, and reduce postoperative corneal edema, macular edema, intraocular hypertension and other complications. In the control group, retinal detachment occurred in 1 eye, which was related to the rupture of the posterior lens capsule accompanied with vitreous prolapse in the surgery. To avoid affecting the patient's visual quality, regular fundus examinations should be performed after surgery to perform detailed screening on patients who had a history of retinal detachment or intraoperative complications of the rupture of the posterior lens capsule accompanied with vitreous prolapse.

It is worth noting that the femtosecond laser is operated on a dedicated operating table in femtosecond laser-assisted surgery, and then the patient was moved to traditional operating table for cataract phacoemulsification. Therefore, the actual operation takes much longer time of the patient and the surgeon. It is still worth the repeated studies and joint discussion of the surgeons and the machine manufacturers that whether the femtosecond laser can be combined with the traditional phacoemulsification on the same surgical bed.

CONCLUSION

The femtosecond laser-assisted phacoemulsification has better clinical effect in treating cataract, and can reduce the energy and time cost in the phacoemulsification, decrease the serum levels of inflammatory factors, and cause less postoperative complications. It is safe and reliable but takes longer operation time and relatively higher treatment cost.

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