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# *Clinical Comparison of Femtosecond Laser and Conventional Ultrasonic Emulsification Cataract Surgery*

**Bai Liang[1,a], Wang Qinmei[2,b,*]**

*[1]Eye Hospital, WMU Zhejiang Eye Hospital, Wenzhou, Zhejiang, 325027, China*
*[2]Enshi Aier Eye Hospital, Enshi, Hubei, 445000, China*
*[a]386760244@163.com, [b]wqm3@mailcyeac.cn*
*[*]Corresponding author*

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***Abstract:*** Cataract is a common ophthalmic disease among the elderly population, which significantly affects their visual acuity. Therefore, effective measures need to be taken to treat cataracts, eliminate symptoms, and improve visual acuity. Traditional clinical approaches usually involve phacoemulsification, which yields moderate results. Thus, more effective treatment options are required to improve ocular indicators, corneal endothelial cell function, inflammatory markers in tears, and prevent complications. In this study, we compared the therapeutic effects and safety of femtosecond laser-assisted cataract surgery with traditional phacoemulsification in cataract patients. The results indicated that femtosecond laser-assisted surgery yielded superior overall treatment outcomes and higher safety levels compared to traditional phacoemulsification. Therefore, implementing femtosecond laser surgery in cataract treatment can achieve the desired therapeutic results without significant complications, leading to significant improvements in patients' visual acuity.

## 1. Introduction

According to relevant statistics, cataracts are the leading cause of blindness worldwide. This is mainly due to a decrease in the transparency of the lens resulting from various factors, which leads to cloudiness and significantly reduces visual acuity in patients [1]. Currently, our country is experiencing a severe aging population, coupled with the increasing prevalence of modern lifestyles including the widespread use of smartphones and computers. As a result, the incidence of cataracts is gradually rising, and the occurrence of this disease is becoming younger. Currently, there are no specific drugs for treating cataracts, and surgery remains the only effective and comprehensive treatment for patients. Traditional phacoemulsification surgery is the preferred surgical procedure for cataract patients [2]. It involves a small incision, no sutures, fast postoperative recovery, and minimal surgically induced astigmatism. However, according to relevant studies, traditional phacoemulsification surgery may damage the corneal endothelial function to some extent, and there are more postoperative complications such as corneal edema and bullous keratopathy. In recent years, with the advancement of clinical medical technology, femtosecond laser surgery has been widely used in the treatment of cataract patients [3,4]. During the surgery, computer-controlled operations ensure greater safety and precision. In this study, the author aims to analyze the differences in treatment effectiveness between femtosecond laser surgery and traditional phacoemulsification surgery for cataract patients by examining 120 cases treated in our hospital from May 2022 to June 2023 [5].

## 2. Information and Methodology

### 2.1. General information

Table 1: Comparison of various general data of the two groups of patients ( $\bar{x}$ ±s) [n (%)]

| General information | | Observation group(n=60) | Control group (n=60) | $X^2$/t | P |
|---|---|---|---|---|---|
| Gender | Male | 38(63.3) | 40(66.7) | 0.147 | 0.702 |
| | Female | 22(36.7) | 20(33.3) | | |
| Age range | | 39-81 | 40-84 | | |
| Average age (years) | | 64.09±10.65 | 64.52±10.89 | 0.219 | 0.827 |
| Disease duration range | | 0.5-85 | 1.0-8.8 | | |
| Average duration of disease (years) | | 4.29±1.64 | 4.35±1.73 | 0.195 | 0.846 |
| Type of lesion | Senile | 32(53.3) | 33(55.0) | 0.235 | 0.972 |
| | Complications | 13(21.7) | 11(18.3) | | |
| | Traumatic | 9(15.0) | 10(16.7) | | |
| | Congenital | 6(10.0) | 6(10.0) | | |
| Lens nuclear turbidity grading | Grade II | 25(41.7) | 23(38.3) | 0.139 | 0.709 |
| | Grade III | 35(58.3) | 37(61.7) | | |

A total of 120 cataract patients who were admitted to our hospital from May 2022 to June 2023 were selected for this study. They were randomly divided into two groups using a random number table method [6]. The control group (n=60) underwent traditional phacoemulsification surgery, while the observation group (n=60) received femtosecond laser surgery treatment. The general data of the patients in both groups were compared, and there were no significant differences (P>0.05), indicating comparability [7]. The details are shown in Table 1.

Inclusion Criteria: ①Diagnosis of cataract confirmed through various clinical manifestations and ophthalmic examinations; ②Patients classified as Grade II to III based on nuclear opalescence of the lens; ③Patients without contraindications for phacoemulsification surgery and femtosecond laser surgery; ④No missing clinical data for eligible patients; ⑤Patients and their families are informed about the study and have given their consent to participate [8].

Exclusion Criteria: ①Patients with mature cataracts; ②Patients with corneal endothelial cell-related diseases, including diabetic retinopathy, corneal dystrophy, and glaucoma; ③Patients who have undergone corneal refractive surgery or retinal laser surgery in the past; ④Patients with systemic infectious diseases or immune system abnormalities; ⑤Patients who have used medications that affect tear secretion or tear film stability before enrollment in the study; ⑥Patients with psychiatric disorders [9].

### 2.2. Methodologies

① Preoperative Preparation: Before surgery, various examinations should be conducted, including complete blood count, urinalysis, liver and kidney function tests, coagulation function tests, electrocardiogram, and ophthalmic examination. The main examination contents include visual acuity, intraocular pressure, corneal, anterior chamber, lens opacification, vitreous, and fundus examination using a slit lamp microscope after pupil dilation. The corneal endothelial microscopy is performed to exclude surgical contraindications. Additionally, optical coherence biometry is used to measure the axial length and corneal curvature of the patient's operative eye. The artificial lens power is calculated using the Berrett Universal 2 FORMULA, and the appropriate intraocular lens is selected. Patients should also be given antimicrobial medication for infection prevention. One day before surgery, the patient's eyelashes should be trimmed, and levofloxacin eye drops should be used to clean the conjunctival sac and lacrimal passage. Half an hour before surgery, a combination of tropicamide eye drops is applied to achieve mydriasis. Patients undergoing femtosecond laser surgery should use sodium diclofenac eye drops one day before the procedure. Local infiltration anesthesia is performed for the surgery, and the surgical procedures are conducted by the same group of surgeons in both groups [10].

② Surgical method for the control group: Conventional phacoemulsification technique: The procedure involves the patient lying flat. After successful anesthesia, a 2.2mm clear corneal tunnel incision is made at the 10-12 o'clock position, followed by puncture into the anterior chamber. An auxiliary incision is made at the 2-3 o'clock position using a 15° knife at the corneal edge. Hyaluronic acid is injected into the anterior chamber. Hydrodissection and hydrodelineation of the lens are performed. The lens is emulsified and removed using an ultrasonic emulsification device. The residual lens cortex is aspirated with a suction tip. Hyaluronic acid is injected into the anterior chamber and capsular bag, and the intraocular lens is implanted and adjusted. The residual viscoelastic is aspirated to maintain the anterior chamber depth [11]. After the surgery, the wound is watertight, and the eye is covered with a dressing before transferring the patient to the ward.

Observation team: Treatment with femtosecond laser surgery. The patient is positioned in a supine position. After successful anesthesia, the ophthalmic femtosecond laser treatment machine (Catalys Precision Laser System, manufactured by EyeTech Inc., USA) is used to perform the surgery. An eyelid opener is used to open the eyelids, and the patient is instructed to focus on the target light. A disposable negative pressure fixation device is applied to attract the surgical eye. The anterior segment optical coherence tomography device is used to scan the anterior eye structures of the patient. The femtosecond laser is used to create an incision and divide the nucleus, with the main corneal incision located at 120° and the side incision at 20°. The diameter of the incision in the anterior capsule is 5.2mm. For Grade II patients, nucleus division is performed using a square grid pattern, while Grade III patients undergo division using a four-quadrant pattern. After setting the parameters, the laser is fired, and after the release of negative pressure, the negative pressure ring is removed. A spatula is used to separate the main incision and side incision, and viscoelastic substance is injected into them to remove the anterior capsular flap [12]. Capsulorhexis and hydrodissection of the lens are performed under the bag, and then ultrasonic emulsification is used to remove the lens and cortex. The remaining viscoelastic substance is injected into the anterior chamber and capsule, and an artificial lens is implanted and positioned. The residual viscoelastic substance is aspirated to ensure the depth of the anterior chamber. After the surgery, the incision is sealed, and the patient is transferred to the ward with an eye pack applied.

③ Postoperative care: After the surgery, both groups of patients need to use regular steroid eye drops, four times a day, gradually reducing the dosage, and continue to use them for one month. Patients should be instructed to maintain regular living habits and avoid strenuous activities. Unless there are special circumstances, patients can be discharged. It is required for patients to have a follow-up visit at 6 weeks and 12 weeks after the surgery [13]. If patients experience eye pain or headache after the surgery, they should seek immediate medical attention at the hospital.

### 2.3. Observation Indicators

① Preoperative and postoperative eye indicators (uncorrected visual acuity, best-corrected visual acuity (BCVA), intraocular pressure, anterior chamber depth): Use international standard visual acuity charts to test patients' uncorrected visual acuity and BCVA. Measure intraocular pressure using a non-contact tonometer. Use an IOLmaster to measure anterior chamber depth [14,15].

② Preoperative and postoperative corneal endothelial cell count (CECs), central corneal thickness, ocular surface disease index score (OSDI): Use an automated cell analyzer to observe CECs. During the examination, instruct the patient to adjust the analyzer for imaging examination according to the injection indicator light [16]. Analyze the images using the system's built-in analysis system to obtain CECs. Measure using Ultrascan A/B ultrasound. A score of 0 indicates no discomfort, 1 indicates discomfort occurring once or twice a week, 2 indicates discomfort occurring three to four times a week, and 3 indicates discomfort occurring six times or more per week [17].

③ Preoperative and postoperative tear inflammation indicators (interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF-α), transforming growth factor-beta 1 (TGF-β1)): Obtain tears from the patient's operated eye through capillary suction. Use ELISA to test the patient's tear inflammation indicators.

④ Incidence of complications (posterior capsule rupture, iris injury, corneal edema, hyphema, intraocular infection).

### 2.4. Statistical Processing

SPSS 20.0 statistical analysis software was used, and the count data were expressed as %, $\chi 2$ test; the measurement data were expressed as ($\bar{x} \pm s$), t test; $P < 0.05$ was regarded as the difference was statistically significant.

## 3. Results

### 3.1. Comparison of ocular indices before and after surgery

Preoperatively, the ocular indexes of the two groups of patients were compared ($P > 0.05$), and at 6 weeks postoperatively and 12 weeks postoperatively, the naked-eye visual acuity, BCVA, and anterior chamber depth of the patients in the observation group were better than those of the control group ($P < 0.05$), and the intraocular pressures of the patients in the two groups were compared ($P > 0.05$), as shown in Table 2.

Table 2: Comparison of preoperative and postoperative ocular indices ($\bar{x} \pm s$)

| Eye Indicators | Time | Observation group(n=60) | Control group (n=60) | t | P |
|---|---|---|---|---|---|
| Naked Eye Vision | Preoperative | 0.17±0.03 | 0.16±0.04 | 1.549 | 0.124 |
| | 6 weeks after surgery | 0.58±0.13 | 0.49±0.07 | 4.722 | 0.000 |
| | 12 weeks after surgery | 0.73±0.16 | 0.60±0.10 | 5.337 | 0.000 |

| | | | | | |
|---|---|---|---|---|---|
| BCVA | Preoperative | 0.28±0.14 | 0.26±0.11 | 0.870 | 0.386 |
| | 6 weeks after surgery | 0.93±0.22 | 0.79±0.21 | 3.566 | 0.001 |
| | 12 weeks after surgery | 1.04±0.26 | 0.95±0.22 | 2.047 | 0.043 |
| Intraocular Pressure (mmHg) | Preoperative | 33.66±8.93 | 33.69±9.03 | 0.018 | 0.985 |
| | 6 weeks after surgery | 16.01±4.03 | 15.89±4.24 | 0.159 | 0.874 |
| | 12 weeks after surgery | 17.24±4.78 | 16.98±4.35 | 0.312 | 0.756 |
| Anterior chamber depth (mm) | Preoperative | 1.66±0.32 | 1.63±0.35 | 0.490 | 0.625 |
| | 6 weeks after surgery | 3.28±0.35 | 3.00±0.28 | 4.839 | 0.000 |
| | 12 weeks after surgery | 3.46±0.33 | 3.13±0.25 | 6.174 | 0.000 |

### 3.2. Comparison of CECs, central corneal thickness, and OSDI before and after surgery

Table 3: Comparison of preoperative and postoperative CECs, central corneal thickness, and OSDI ($\bar{x} \pm s$)

| Targets | Time | Observation group(n=60) | Control group (n=60) | t | P |
|---|---|---|---|---|---|
| CECs (pcs/mm2) | Preoperative | 2532.85±275.88 | 2540.35±290.65 | 0.145 | 0.885 |
| | 6 weeks after surgery | 2290.14±222.49 | 2034.26±201.54 | 6.602 | 0.000 |
| | 12 weeks after surgery | 2281.99±197.37 | 2026.65±195.13 | 7.126 | 0.000 |
| Central corneal thickness (mm) | Preoperative | 541.99±9.36 | 540.65±9.03 | 0.798 | 0.426 |
| | 6 weeks after surgery | 552.69±5.36 | 541.35±5.46 | 8.365 | 0.000 |
| | 12 weeks after surgery | 556.91±5.62 | 543.65±5.81 | 12.707 | 0.000 |
| OSDI (points) | Preoperative | 0.29±0.04 | 0.28±0.05 | 1.210 | 0.229 |
| | 6 weeks after surgery | 1.20±0.22 | 1.59±0.38 | 6.880 | 0.000 |
| | 12 weeks after surgery | 0.54±0.13 | 0.95±0.24 | 11.635 | 0.000 |

Preoperatively, the CECs, central corneal thickness, and ocular surface disease index were compared between the two groups ($P > 0.05$), and at 6 weeks postoperatively and 12 weeks postoperatively, the CECs, central corneal thickness, and ocular surface disease index of patients in the observation group were superior to those of the control group ($P < 0.05$), as shown in Table 3 [18].

### 3.3. Comparison of preoperative and postoperative tear inflammation indexes

Preoperatively, the tear inflammation indexes of the two groups of patients were compared ($P > 0.05$), 6 weeks after the operation, the tear inflammation indexes of the two groups of patients were compared ($P > 0.05$), and 12 weeks after the operation, the tear inflammation indexes of the patients in the observation group were better than those of the control group ($P < 0.05$), see Table 4 [19, 20].

Table 4: Comparison of preoperative and postoperative indicators of tear inflammation ($\bar{x}$ ±s)

| Inflammation indicators | Time | Observation group(n=60) | Control group (n=60) | t | P |
|---|---|---|---|---|---|
| IL-6(μg/L) | Preoperative | 1.57±0.30 | 1.59±0.28 | 0.378 | 0.707 |
| | 6 weeks after surgery | 3.24±0.63 | 3.34±0.78 | 0.773 | 0.441 |
| | 12 weeks after surgery | 2.48±0.54 | 2.95±0.54 | 4.767 | 0.000 |
| TNF-α(pg/ml) | Preoperative | 2.11±0.48 | 2.13±0.46 | 0.233 | 0.816 |
| | 6 weeks after surgery | 3.96±1.07 | 4.06±1.25 | 0.471 | 0.639 |
| | 12 weeks after surgery | 3.05±0.66 | 3.61±0.82 | 4.121 | 0.000 |
| TGF-β1(pg/ml) | Preoperative | 83.67±7.72 | 83.79±7.81 | 0.085 | 0.933 |
| | 6 weeks after surgery | 113.25±30.51 | 115.65±32.65 | 0.416 | 0.678 |
| | 12 weeks after surgery | 86.70±19.73 | 103.28±29.10 | 3.653 | 0.000 |

## 3.4. Comparison of complication rates

The perioperative complication rate of the observation group was lower than that of the control group ($P < 0.05$), see Table 5.

Table 5: Comparison of complication rates [n (%)]

| Group | Number of cases | Posterior capsule rupture | Iris injury | Corneal edema | Anterior chamber hemorrhage | Intraocular infection | Incidence |
|---|---|---|---|---|---|---|---|
| Observation Group | 60 | 1 | 0 | 1 | 0 | 0 | 2(3.3) |
| Control group | 60 | 2 | 0 | 4 | 0 | 3 | 9(15.0) |
| $X^2$ | - | - | - | - | - | - | 4.904 |
| P | - | - | - | - | - | - | 0.027 |

## 4. Discussion

Cataracts are a common disease in clinical ophthalmology, with relatively high incidence and blindness rates. They are the most common cause of blindness worldwide. Currently, medication and surgery are commonly chosen for treatment in clinical practice. Medication treatment focuses on combating oxidative damage and controlling disease progression, but it cannot fundamentally reverse the opacity of the lens. Therefore, if the patient's physical condition allows for it, surgery remains the most direct and effective method to improve visual acuity. The main surgical methods for early cataracts are intracapsular and extracapsular cataract extraction. Although both methods can correct visual acuity, they involve longer incisions, longer postoperative recovery time, higher likelihood of postoperative astigmatism, and higher incidence of complications. Therefore, these two surgical methods are not recommended in clinical practice. In recent years, with the gradual development of modern medical technology, cataract surgery has also evolved. Currently, ultrasonic phacoemulsification is generally used in clinical practice. This surgery utilizes ultrasonic waves to fragment the lens and vacuum systems to remove the emulsified lens fragments and cortex. It has the advantages of a smaller incision, lower postoperative astigmatism rate, and faster recovery, making it widely used in clinical practice.

During the implementation of phacoemulsification, it mainly relies on manual manipulation, which tests the clinical experience and surgical skills of the surgeon. This also leads to limitations in the treatment of cataract patients with phacoemulsification. For example, during ultrasonic emulsification treatment, the generation of energy can damage corneal endothelial cells. Different patients may have different eye structures, making it difficult to effectively tear the anterior capsule and subsequently affecting postoperative visual quality. Femtosecond laser surgery belongs to modern medical technology and does not have the limitations mentioned above. This study found that the eye indicators of the observation group were better than those of the control group. The CECs, central corneal thickness, and ocular surface disease index of the observation group were all superior to those of the control group. This indicates that femtosecond laser surgery for cataract patients can effectively improve postoperative visual acuity and anterior chamber depth. At the same time, femtosecond laser-assisted phacoemulsification can reduce the use of ultrasonic energy during surgery and minimize the loss of corneal endothelial cells.

Application of femtosecond laser, when emitted from the laser, can generate large transient power. The tissues that are irradiated can absorb a large number of photons, forming plasma. Plasma can create a micro-explosion effect, connecting multiple points of explosion to form precise tissue cutting lines and surfaces. With femtosecond laser, high-performance transparent films can be produced. Doctors can also create relatively perfect capsulotomies and pre-chop nuclei using femtosecond laser, reducing the release of ultrasound emulsification power and avoiding further damage to the corneal endothelium, thus significantly improving postoperative visual quality and preventing surgical complications. This study found that the inflammatory markers in the observation group were better than those in the control group, and the incidence of complications in the observation group was lower than that in the control group. This indicates that femtosecond laser surgery can effectively alleviate inflammatory markers and prevent complications. The reason is that phacoemulsification involves more surgical procedures and is prone to damage to the cornea and other ocular structures, leading to inflammation. Femtosecond laser technology can create capsulotomies with suitable shapes and appropriate sizes. Furthermore, the application of femtosecond laser surgery is completed with the eye fully closed, without the use of a blade, which further reduces the degree of corneal shape change and lowers the incidence of complications.

In conclusion, in the treatment of cataracts, femtosecond laser surgery has superior efficacy and safety compared to phacoemulsification, and it has higher practical value and deserves promotion.

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