

Effect of stainless-steel wire internal fixation on intracapsular condylar fracture

Efecto de la fijación interna de alambre de acero inoxidable en la fractura condilar intracapsular

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Abstract

Objectives: The aim of the study was to investigate the clinical effect of stainless-steel wire fixation on the early mouth-opening movement of an intracapsular fracture involving the condylar process. **Materials and methods:** In this study, patients who underwent mandibular condylar intracapsular fracture surgery in our hospital from 2012 to 2020 were selected as research subjects. A total of 44 patients received steel wire internal fixation treatment, 32 patients received titanium plate-and-nail rigid internal fixation, and 28 patients underwent conservative non-surgical treatment. **Results:** For the patients in the stainless-steel wire group, the degree of mouth opening reached normal levels of 3.7 cm approximately 10 days after surgery. The recovery time for the patients in the titanium plate-and-nail rigid internal-fixation group was 21 days, while the patients in the conservative treatment group needed 60 days to recover. **Conclusion:** The treatment of fixation with a stainless-steel wire for intracapsular condylar fracture reduced the time taken to perform mouth-opening exercises and improved the recovery rate of patients.

Keywords: Fixation method. Intracapsular condyle fracture. Fixation with stainless-steel wire. Fixation with titanium plate and titanium nail. Conservative treatment.

Resumen

Objetivo: Explorar el efecto clínico de la fijación de alambre de acero inoxidable en el movimiento temprano de apertura de la boca en la fractura interna del cóndilo. **Método:** Este estudio seleccionó a pacientes que se sometieron a cirugía de fractura intracapsular de cóndilo en nuestro hospital de 2012 a 2020 como sujetos de investigación. Un total de 44 pacientes recibieron tratamiento de fijación interna de alambre de acero, 32 recibieron placa de titanio y fijación interna con clavos, y 28 recibieron tratamiento conservador no quirúrgico. **Resultados:** En los pacientes del grupo de alambre de acero inoxidable, alrededor de 10 días después de la cirugía el grado de apertura de la boca alcanzó un valor normal de 3.7 cm. El tiempo de recuperación de los pacientes en el grupo de fijación interna con clavos y placa de titanio fue de 21 días, mientras que los pacientes en el grupo de tratamiento conservador tardaron 60 días en recuperarse. **Conclusiones:** La fijación con alambre de acero inoxidable para el tratamiento de la fractura intracapsular del cóndilo acorta el tiempo hasta la apertura de la boca y mejora la tasa de recuperación de los pacientes.

Palabras clave: Método de fijación. Fractura interna de la cápsula del cóndilo. Fijación con alambre de acero inoxidable. Fijación con placa de titanio y clavos. Tratamiento conservador.

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Introduction

Condylar fracture is a common mandible break with a high incidence, accounting for approximately 30% of mandibular fractures¹⁻⁴. Patients with a condylar fracture experience pain in the temporomandibular joint, localized tenderness in the jaw area, limited mouth movement, prominent local swelling, and occlusion of the teeth. Other symptoms of a condylar fracture include pathological changes of the temporomandibular joint, osteonecrosis, a skewed lower facial area, and true ankylosis of the temporomandibular joint⁵. The clinical treatment of a condylar fracture requires anatomical structural healing and functional reconstruction. On the one hand, after surgical treatment or non-surgical conservative treatment, the condylar fracture site heals anatomically at the temporomandibular joint. Conversely, the dislocation of the two fractured ends of the condylar break relocates due to the action of the lateral pterygoid muscle, necessitating local structural function reconstruction^{6,7}. Hlawitschka and Eckelt⁸ divided intracondylar cyst fractures into the following three types: Type A: a condylar cyst fracture with no displacement, where the height of the ascending ramus of the mandible remains unchanged. Type B: The intracondylar fracture breaks through the joint capsule, and the height of the ascending ramus of the mandible decreases. Type M: Comminuted fractures in the condyle are associated with damage to the joint capsule and disc⁹⁻¹¹.

If the correct treatment is not applied following a condylar fracture, the patient will experience dyskinesia related to the opening and closing of the mouth as well as condylar malunion; furthermore, the growth of the mandible will be affected¹². Due to the complex anatomical structure of the area near the temporomandibular joint, surgery can easily cause a series of complications, such as intraoperative bleeding and postoperative facial paralysis; therefore, most doctors recommend non-surgical conservative treatment¹³. Other oral and maxillofacial surgeons prefer surgical treatment of intracapsular condylar fractures. During surgery, the displaced fracture piece is relocated to its original position by the accurate anatomical reduction of soft and hard tissue, reliable fixation, and minimal injury. At present, the main fixation methods for the clinical surgical treatment of intracapsular condylar fracture are lag screws, steel wires, and miniature titanium plates^{14,15}, with different fixation methods having their own advantages and disadvantages. As for the choice between reduction and internal fixation,

there is no research showing which fixation method has the best effect. In addition, different types of condylar fractures have different clinical symptoms and treatment plans¹⁶. Therefore, the treatment plan should be determined according to the type of condylar fracture. Different types of condylar fractures can be treated differently. At present, the treatment of intracondylar type-B fractures remains controversial in both research and clinical contexts.

This study aimed to compare the effects of two different fixation methods (stainless-steel wire internal fixation and titanium plate-and-nail rigid internal fixation) and non-surgical conservative treatment on Type-B intracapsular condylar fractures of the mandible and explore the effects of the two different fixation methods in the surgical treatment of intracapsular condylar fractures to provide a reference for the treatment of such injuries.

Materials and methods

Research subjects

Patients with unilateral intracondylar capsular Type-B fractures who were admitted to the oral and maxillofacial surgery ward of our hospital between 2012 and 2020 were analysed retrospectively. Of these, 104 patients met the inclusion criteria of this study, and their complete clinical data were obtained. A total of 44 patients received steel wire internal fixation treatment, 32 patients received rigid internal fixation with a titanium plate/titanium nail, and 28 patients undertook conservative non-surgical treatment. Oral mandibular computed tomography images or curved mandibular tomography images were obtained for all the participants with intracapsular condylar fractures before surgery to identify the location of the fracture and the subsequent displacement resulting from the break. This study was conducted in accordance with the principles of the Declaration of Helsinki and approved by the ethics committee of our hospital. All participants signed an informed consent form for inclusion in the study.

Inclusion and exclusion criteria

The inclusion criteria were as follows: (1) Patients who were diagnosed with an intracapsular condylar fracture, (2) patients who had stable vital signs without other surgical contraindications, (3) patients who were older than 18 years, and (4) patients with complete medical records and available relevant imaging data.

The exclusion criteria were as follows: (1) patients with severe heart, liver, or kidney dysfunction, (2) patients with an advanced malignant tumor, (3) patients with incomplete data, and (4) patients with other surgical or non-surgical treatment failures before admission.

Treatment protocols

STEEL WIRE INTERNAL FIXATION

The procedure for intracapsular condylar fracture with stainless-steel wire fixation was as follows. The skin was incised along the fracture site, the subcutaneous tissue was separated, and the joint capsule was exposed. The exposure range of the surgical field was up to the zygomatic temporal process and down to the sigmoid notch. The fracture fragment was looked for intraoperatively, and the reduction was accompanied by a repair of the joint disc. Holes were drilled with a high-speed power handpiece at two broken end-to-end marks and fixed with a 0.2-cm stainless-steel wire. The teeth were examined to be in good apposition and were sutured in layers, and drainage was maintained for 24-48 h after surgery.

TITANIUM PLATE-AND-NAIL INTERNAL FIXATION

The procedure for the titanium plate-and-nail rigid internal fixation for the treatment of intracapsular condylar fractures was as follows. An incision in the skin and subcutaneous tissue was made at the fracture site. The condylar tissue structure was anatomically separated, and on reaching the outside of the condylar joint capsule, the adhesion of the joint disc and the ends of the fracture were peeled. The ends of the intracapsular condylar fracture were fixed using small or miniature titanium plates (0.2 mm) and nails (6, 8, and 10 mm). After surgery, it was important to suture the tear or the joint disc that had been cut during the operation.

CONSERVATIVE NON-SURGICAL TREATMENT

The conservative non-surgical treatment of intracapsular fractures was as follows: rather than using the open reduction method, local anti-inflammatory and detumescence drugs were applied to the fracture. The maxillary and mandibular teeth were tractioned and fixed using circular rubber wire to maintain the occlusion function and stabilize the mandible. The typical traction time was 2-3 weeks. At the end of the

elastic intermaxillary traction period, the patient was guided to perform mouth-opening exercises.

Early postoperative mouth-opening exercise

The mouth-opening exercise procedure was as follows: mandibular opening and closing training began on day 4 after surgery for an intracapsular condylar fracture using the stainless-steel wire internal-fixation method. Mouth-opening training was performed using a mouth-opening device from day 4 until day 7 after surgery. Five to seven days after mouth-opening training, the extent of mouth opening and the occlusion function of all patients were examined. A curved mandibular tomogram was obtained after surgery to determine the fixation of the condylar structure for the intracapsular condylar fracture and determine whether the mandibular ascending height was normal.

Observational indicators

The main observational indicators included condylar function, the degree of mouth opening and the time required to reach the mouth-opening exercise standard.

The secondary outcome indicator included postoperative complications. For the observation of complication indicators, the presence of infection and facial paralysis was observed within 1 week after surgery, and the presence of occlusal relationship disorder, joint popping, joint pressure pain, and joint ankylosis complications were examined 6 months after surgery.

Statistical analysis

We used the SPSS Statistics 20.0 (IBM, Chicago, USA) software program for the statistical analysis. The continuous variables of a normal distribution were expressed as mean \pm standard deviations, the continuous variables of a non-normal distribution were expressed as medians (interquartile range), and the categorical variables were expressed as frequencies (percentage). For multiple comparisons, each value was compared using a one-way analysis of variance following Dunnett's test when each datum conformed to a normal distribution; non-normally distributed continuous data were compared using non-parametric tests. Count data were tested using the Chi-squared test or Fisher's exact test. A value of $p < 0.05$ was considered statistically significant.

Table 1. Information of all patients in the groups of Stainless steel-wire internal fixation, titanium-plate and nail rigid internal fixation, and conservative treatment

Index	Stainless steel-wire internal fixation group (n = 44)	Titanium plate and nail rigid internal fixation group (n = 32)	Conservative non-surgical treatment group (n = 28)	p-value
Type of fracture				0.052
Intracapsular condyle fractures (left)	14	14	14	
Intracapsular condyle fractures (right)	18	18	14	
Intracapsular condyle fractures (bilateral)	12	0	0	
Gender				0.700
Male	30	18	16	
Female	14	14	12	
Age	19-58	22-45	11-36	
Average age	31.8	29.7	22.6	0.447

Results

General characteristics

The characteristics of the study participants are listed in table 1. There were 44 patients in the stainless-steel wire internal-fixation group, 32 patients in the titanium plate-and-nail rigid internal-fixation group and 28 patients in the conservative non-surgical treatment group.

In the stainless-steel wire internal-fixation group, there were 44 cases of intracapsular condylar fractures, of which 32 were unilateral fractures, and 12 were bilateral fractures. Among the 32 patients with unilateral intracapsular condylar fractures, 14 had left intracapsular fractures, and 18 had right intracapsular fractures. The patients ranged in age from 19 to 58 years, with an average age of 31.8 years.

In the intracapsular condylar fracture with a titanium plate-and-nail treatment group, 32 patients had a unilateral intracapsular condylar fracture. Among them, 18 were male, and 14 were female; there were 14 cases of a fracture in the left condylar sac and 18 cases of a fracture in the right condylar sac. The age of the patients ranged from 22 to 45 years, with an average age of 29.7 years.

In the non-surgical conservative treatment group, all 28 patients had a unilateral intracondylar fracture; 14 were on the left, and 14 were on the right side of the temporomandibular joint. Among these 28 patients, 16 were male, and 12 were female; their ages ranged between 11 and 36 years, with a mean age of 22.6 years.

Comparison of the degree of mouth opening between different groups

The degree of mouth opening of the patients is shown in table 2. The results reveal that the degree of mouth opening for the patients treated with stainless-steel wire fixation reached 3.7 cm, which is the normal extent, after only 10 days after surgery, while the titanium plate-and-nail fixation group required 21 days to achieve the same result. The conservative treatment group required the longest time, with patients needing 60 days to recover. The best post-operative bone reconstruction results of the condylar fractures were in the stainless-steel wire internal-fixation group compared with the other two treatment methods.

Comparison of recovery at 8 months after surgery between different groups

Of the patients, 90.9% (40/44) were healed within 8 months after surgery in the stainless-steel wire fixation group. A total of 62.5% (20/32) of patients in the titanium plate-and-nail group and 50.0% (14/28) of patients in the conservative treatment group were healed within 8 months after surgery. The stainless-steel wire internal-fixation group had a much higher cure rate than the other two groups ($p = 0.016$) (Table 3). The incidence rate of temporomandibular joint ankyloses was 0% after surgery for all three treatment methods.

Table 2. Comparison of the effectiveness of three groups

Number of days after the clinical treatment	Extent of mouth opening (mm) for stainless steel wire internal fixation	Extent of mouth opening (mm) for titanium plate and nail rigid internal fixation	Extent of mouth opening (mm) for conservative non-surgical treatment
3	15.12 ± 2.12	0	0
7	25.32 ± 1.98	15.62 ± 0.54	0
10	35.52 ± 1.76	21.16 ± 0.84	0
14	37.62 ± 1.72	25.52 ± 0.54	15.06 ± 0.50
21	37.58 ± 2.08	37.55 ± 0.48	32.74 ± 0.26
30	37.08 ± 1.78	36.85 ± 0.64	36.32 ± 0.24
60	37.42 ± 1.92	37.22 ± 1.96	37.02 ± 0.22

Table 3. Comparison of recovery at 8 months after operation between different groups

Index	Stainless steel-wire internal fixation group (n = 44)	Titanium plate and nail rigid internal fixation group (n = 32)	Conservative non-surgical treatment group (n = 28)	p-value
Number of healing cases (n [%])	40 (90.9%)	20 (62.5%)	14 (50.0%)	0.016

Comparison of mouth-opening degree and lateral mandibular shift at 30 days after treatment

After 30 days of treatment with the three methods, the measurement results for the degree of mouth opening and the lateral mandibular shift during mouth opening in the stainless-steel wire internal-fixation group were 37.08 ± 1.78 mm and 7.04 ± 1.08 mm, respectively. In the titanium plate-and-nail rigid internal-fixation group, the extent of mouth opening was 36.85 ± 0.64 mm, and the lateral mandibular shift was 6.76 ± 0.32 mm. In the conservative treatment group, the extent of mouth opening was 36.32 ± 0.24 mm, and the lateral mandibular shift was 6.27 ± 0.32 mm. These details are listed in table 4.

Comparison of the incidence of post-operative complications

In this study, two cases in each of the stainless-steel wire internal-fixation group and the titanium plate-and-nail rigid internal-fixation group developed infections, eight cases in the stainless-steel wire internal-fixation group had joint popping, 10 cases in the titanium plate-and-nail rigid internal-fixation group had joint popping, and six cases in the conservative non-surgical

treatment group had joint popping. Two cases of facial palsy were observed in each of the three groups. There was no statistically significant difference in the incidence of postoperative infection, joint popping, joint tenderness and facial palsy among the three groups ($p > 0.05$), and no joint ankylosis or disturbed occlusal relationship occurred in any of the three groups (Table 5).

Discussion

For the surgical treatment of intracapsular condylar fractures, based on the condylar and extraportal muscles in the joint capsule, it is necessary to perform a surgical reduction of the fracture in the joint capsule to ensure the stability of the biomechanical functioning of the temporomandibular joint¹⁷⁻¹⁹. For the surgical reduction of the ends of the intracapsular fracture, efforts should be made to minimise damage to the temporomandibular joint capsule and the mandibular joint disc during surgery and achieve the safest and most effective treatment for each patient²⁰.

The results of this study showed that the new stainless-steel wire internal-fixation method is an effective treatment for intercapsular condylar fractures, with less trauma, earlier recovery of mouth opening and no temporomandibular joint ankyloses. The performance of this method exceeded that of the titanium plate-and

Table 4. Comparison of the mouth opening degree and the lateral mandibular shift during mouth opening at 30 days after the treatments between different groups

Index	Stainless steel wire internal fixation group (n = 44)	Titanium plate and nail rigid internal fixation group (n = 32)	Conservative non-surgical treatment group (n = 28)	p-value
Extent of mouth opening	37.08 ± 1.78 mm	36.85 ± 0.64 mm	36.32 ± 0.24 mm	0.039
Lateral mandibular shift	7.04 ± 1.08 mm	6.76 ± 0.32 mm	6.27 ± 0.32 mm	<0.001

Table 5. Comparison of the incidence of post-operative complications

Index	Stainless steel-wire internal fixation group (n = 44)	Titanium plate and nail rigid internal fixation group (n = 32)	Conservative non-surgical treatment group (n = 28)	p-value
Infection (n [%])	2 (4.55%)	2 (6.25%)	0	0.657
Facial paralysis (n [%])	2 (4.55%)	2 (6.25%)	2 (7.14%)	0.944
Occlusal relationship disorder (n [%])	0	0	0	/
Joint pressure pain	4 (9.09%)	6 (18.75%)	4 (14.29%)	0.686
Joint ankylosis	0	0	0	/
Joint popping	8 (18.18%)	10 (31.25%)	6 (21.43%)	0.631

nail rigid internal fixation and conservative treatment methods and is thus a promising candidate for the treatment of intracapsular condylar fractures. The new surgical method for the treatment of intracapsular condylar fractures with stainless-steel wire fixation is easy to perform and reduces surgery time compared with using titanium plates and nails in rigid internal-fixation procedures.

However, there is some controversy about the clinical treatment of intracapsular condyle fractures²¹. Some researchers believe that the actual fracture of an intracapsular condylar break cannot be treated with surgery and suggest that intracondylar fracture treatment is best applied using non-surgical conservative treatment, particularly in children^{22,23}. However, in some cases, the non-surgical conservative treatment of these fractures can result in symptomatic temporomandibular joint ankylosis, such as restricted mouth opening²⁴. Other researchers believe that surgical incision reduction should be performed in the early stages of treatment to prevent the development of temporomandibular joint stiffness²⁵. In this study, we also examined the prognosis of the non-surgical conservative treatment of intracapsular condylar fractures. We observed a loss in the vertical mandibular height of the fracture side compared with the healthy side in patients undergoing conservative treatment,

and a significant bulging deformity was observed on the affected side of the jaw. A recent study showed that there are many shortcomings in the non-surgical conservative treatment of intracapsular condylar fractures²⁶. The conservative treatment of intracondylar fractures does not allow precise anatomical repositioning, and it may cause occlusal disorders, restricted opening, chronic joint pain, and joint popping²⁷.

The extensor pterygoid muscle is the mouth-opening muscle. The contraction of one side of the extensor pterygoid muscle turns the mandible to the opposite side, and the contraction of the posterior fibers of the temporalis muscle pulls the mandible backwards²⁸. Occlusal disturbances and restricted opening, which are common sequelae of intracondylar capsule fractures, can occur after both surgical and conservative treatment²⁹. Occlusal disorder after condylar fracture is caused by the fracture block being pulled forward medially by the extra-ptyerygoid muscle and the change in height of the mandibular ascending branch, which makes the affected posterior teeth contact early under the action of the ascending muscle group³⁰. Moreover, following trauma, there may be varying degrees of opening restriction due to muscle spasm, edema and blood accumulation in the joint.

After 30 days of treatment, the degree of mouth opening and the lateral shift were examined for all

three treatment methods (titanium plate-and-nail rigid internal fixation, conservative treatment, and stainless-steel wire internal fixation). There were no differences in the average degree of mouth opening and the lateral shift between the three treatments. This may have been due to the selection of the treatment methods, which strictly followed the symptoms of the fractures in our department. It can be seen that the different methods had little influence on opening tension.

Surgical treatment is performed with stainless-steel wire fixation, and the fracture fragment can produce a micro-movement under the traction of the extensor pterygoid muscle, stimulating the periosteum to form a fibrous crust and cartilage crust, thus promoting fracture healing. The small size of the wire causes less damage to the articular disc, which has the unique advantage of fixation in the case of small fracture fragments, and the degree of tightening of the wire can be controlled during fixation. In practice, the choice of fixation method sometimes depends on the actual situation of the patient. For the treatment of condylar fractures, a treatment plan is determined according to the location of the condylar fracture, the vital signs of the patient and the degree of displacement of the ends of the condylar fracture caused by external force or local muscle traction.

There were several limitations in this study. First, this trial was not a randomized controlled trial. Second, the sample size of this study was limited; therefore, larger trials with more participants should be conducted in the future. Third, the clinical follow-up time was short. In the future, we need to collect data on different fixation methods of intracondylar capsule fractures and study the clinical treatment effects of different fixation methods for intracondylar capsule fractures of the mandible according to the typology of such fractures. In addition, we need to discuss the choice of fixation methods for intracondylar capsule fractures, summarize the advantages and disadvantages of different fixation methods, and provide a reference basis for the treatment of intracondylar capsule fractures.

Conclusion

The treatment of intracondylar capsule fractures with stainless-steel wire fixation facilitates improvement in the degree of opening and promotes patient recovery.

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Conflicts of interest

All the authors had no personal, financial, commercial, or academic conflicts of interest.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors have obtained the written informed consent of the patients or subjects mentioned in the article. The corresponding author is in possession of this document.

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