

Original Article

Factors affecting the outcomes of non-surgical treatment for intracapsular condylar fractures

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Abstract: This study aims to investigate the factors affecting non-surgical treatment for intracapsular condylar fractures. Patients and method: 106 patients with intracapsular condylar fractures (145 sides) who received non-surgical treatment were recruited. Coronal computed tomography (CT) images were used to evaluate the the fracture healing. Results: Thirty-one sides (21.4%) achieved grade 1 healing, 66 sides (45.5%) exhibited grade 2 healing, 43 sides (29.7%) exhibited grade 3 healing, and 5 sides (3.4%) exhibited grade 4 healing. A significant difference was observed in the fracture-healing grade according to age, fracture type, and relative position of the mandibular ramus stump and the articular fossa. Conclusion: Age, fracture type and relative position of the mandibular ramus stump and the articular fossa were important factors in the healing of intracapsular condylar fractures that were treated non-surgically.

Keywords: Temporomandibular joint, condylar fractures, intracapsular fractures, trauma

Introduction

The condylar process is an important part of the temporomandibular joint. It is a growth and development centre of the mandible and is vulnerable to damage and fracture; 26%-72% of mandibular fractures occur at the condylar process [1-5]. Improper handling of a condylar fracture can lead to serious complications such as traumatic osteoarthritis of the temporomandibular joint and ankylosis, which affect patients' oral motor function. If the fracture occurs during the growth period, it can also lead to mandibular growth restriction, maxillofacial deformity and sleep apnoea syndrome. Depending on the location of the fracture lines, condylar fractures can be classified as intracapsular fractures, condylar neck fractures or subcondylar fractures [6-8]. Our previous study of condylar fractures using coronal CT suggested that intracapsular condylar fractures accounted for 65% of all condylar fractures [9]. The incidence of complications, such as osteoarthritis of the temporomandibular joint and joint ankylosis, was much higher for intracapsular fractures

than for the other two types of fractures. Therefore, the factors that affect the outcomes of non-surgical treatment for intracapsular condylar fractures need to be clarified. However, few previous studies with a large sample size have addressed this issue.

This study aimed to collect a large sample of intracapsular fracture cases treated non-surgically and to perform a long-term follow-up to determine the factors that affect the fracture healing process, including age, gender, type of fracture and the relative position of the ramus stump and the articular fossa.

Materials and methods

Patient data and inclusion criteria

Patients with intracapsular condylar fractures who received non-surgical treatment at the Department of Oral Surgery, the Ninth People's Hospital of Shanghai Jiaotong University School of Medicine between January 2003 and July 2014 were recruited. General information, in-

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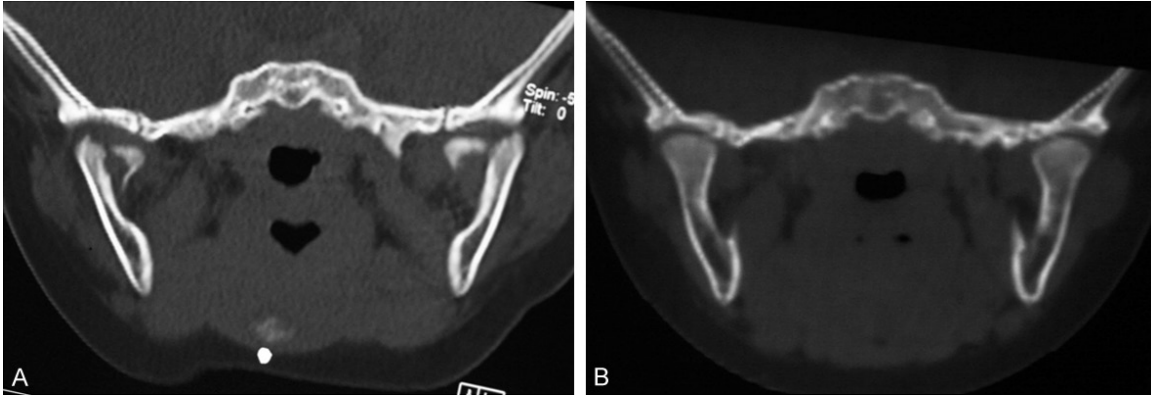


Figure 1. A 1-year-old female with bilateral intracapsular condylar fracture shows a complete reconstruction 6 months after non-surgical treatment. A. Coronal CT shows bilateral condylar fractures. B. CT image shows a complete reconstruction of the bilateral condylar processes 6 months after trauma.

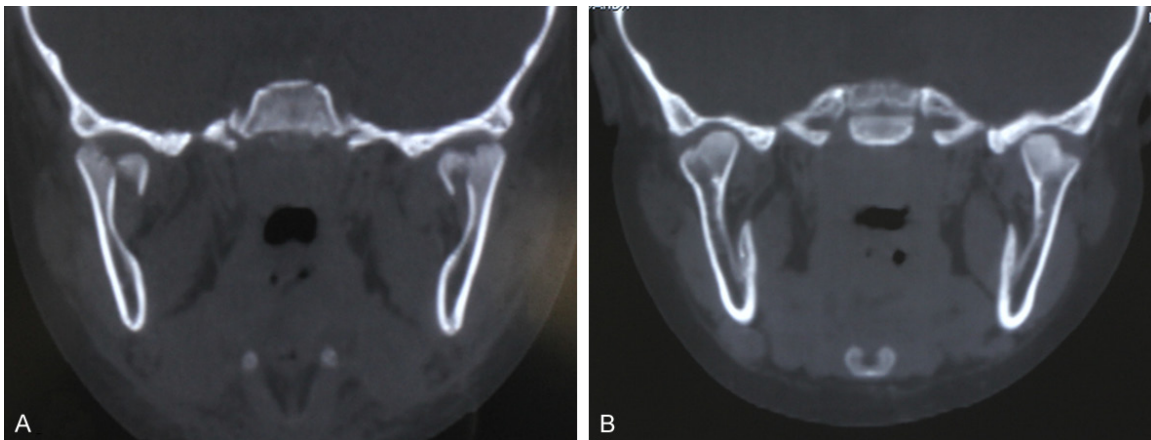


Figure 2. A 5-year-old female shows incomplete healing and reconstruction 1 year after bilateral condylar fractures were treated non-surgically. A. CT shows bilateral condylar fractures at the time of the injury. B. CT shows that the bilateral condylar processes was not fully healed 1 year later.

cluding the patient's medical records, specialist examination results and imaging studies, was collected.

Inclusion criteria: (1) Patients with intracapsular fractures who underwent coronal CT imaging at the time of injury and at a follow-up appointment at least 3 months after the non-surgical treatment. (2) Coronal CT with no significant dislocation of fracture fragments in the intracapsular fracture and no superolateral dislocation of the mandibular ramus stump. (3) Patients who suffered from a significant dislocation of intracapsular fracture fragments and a superolateral dislocation of the mandibular ramus stump but could not undergo surgery for various reasons, including brain injury, surgical contraindications, old fractures, and severe

fragmentation of the fracture. These situations were indicators for non-surgical treatment.

Exclusion criteria: Patients for whom no coronal CT images were available or who did not undergo follow-up exams at least 3 months after the injury.

Non-surgical treatment

For patients who showed occlusal disorders as early as the first week after trauma, intermaxillary elastic traction was used for occlusal correction. Depending on the occlusion condition, missing teeth, periodontal conditions, and similar factors, orthodontic brackets, arch bar, intermaxillary traction screws and splind were applied for traction and treatment. Patients

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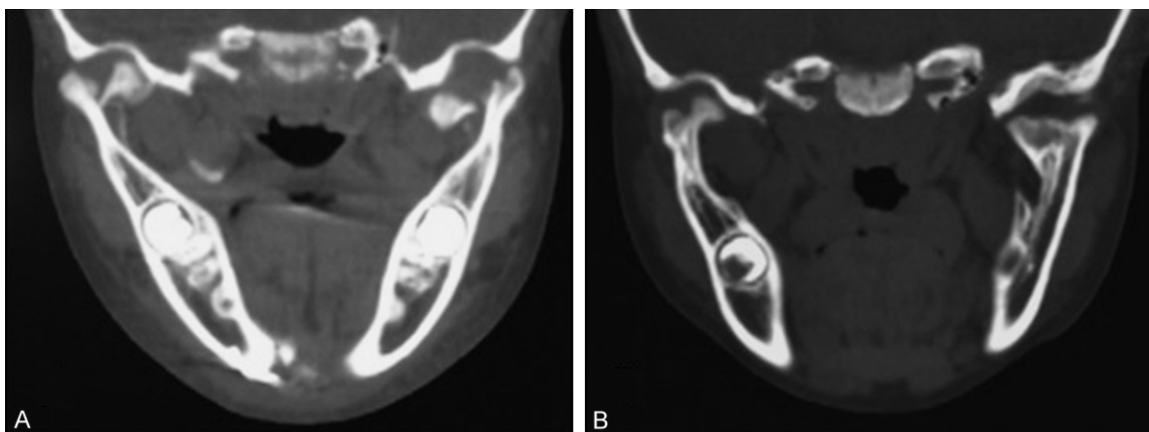


Figure 3. Male, 17 years old. A. Bilateral intracapsular condylar fractures at the time of the injury. B. 6 months after trauma, CT shows that the bilateral condylar morphology is very different from that of a normal condyle, and the right side shows a bifid condylar deformity.

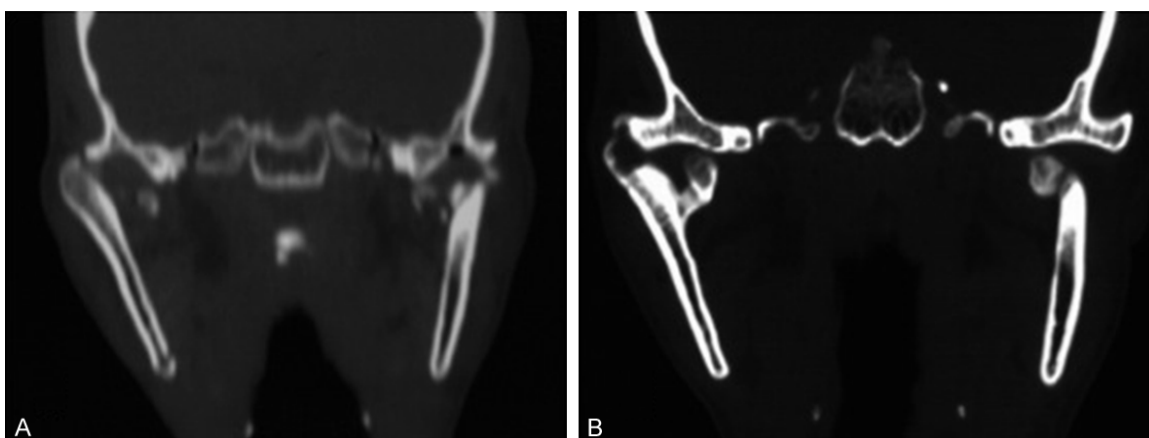


Figure 4. Male, 24 years old, A. Bilateral intracapsular condylar fracture; the right mandibular branch shows external dislocation. B. CT shows ankylosis in the right side 8 months later.

without an occlusal disorder did not receive any special clinical treatment, but health education and functional training were provided.

CT examination method

The patients were placed in a supine position, and plain axial CT scans were performed. The scanning started at the mandibular chin and ended at the superior orbital rim. A GE Light Speed CT machine was used and was set to KV 120, 250 mA and 5-mm scanning intervals. Sixteen layers were scanned and reconstructed at a thickness of 1.25 mm. The data were transferred to an AW4.1 workstation for a coronal reconstruction of the condylar region with 3-mm-thick layers.

Classification of fracture healing in condylar fractures

Fracture healing was classified as grades 1-4.

Grade 1: Complete reconstruction of the condyle. The condylar surface was smooth, with integrity and without radiolucent lines. The morphology, size and location of the fractured condyle process were consistent with those of a normal condyle (**Figure 1**).

Grade 2: Partial reconstruction of the condyle. The condylar surface was not smooth, but the morphology, size and position of the condyle were similar to those of a normal condyle (**Figure 2**).

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Table 1. Statistical analysis of the radiological follow-up time for the 4 groups of patients

Fracture healing grade	Number of sides (%)	Average follow-up time ($\bar{x} \pm S$; months)
Grade 1	31 (21.4%)	16.65 \pm 21.75
Grade 2	66 (45.5%)	10.95 \pm 10.72
Grade 3	43 (29.7%)	9.58 \pm 10.59
Grade 4	5 (3.4%)	7.8 \pm 4.60
Total	145 (100%)	11.66 \pm 13.82

$P=0.134$.

Grade 3: Condylar dislocation during the healing process. The surface of the condyle was not smooth. There was a certain degree of bone absorption or hyperplasia. The morphology and size of the condylar process were different from those of a normal condyle, but no bony adhesion was observed (**Figure 3**).

Grade 4: Adhesions between the mandibular ramus stump and the articular bone and observable ankylosis (**Figure 4**).

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Gender: The effect of gender on the prognosis of the patients with intracapsular condylar fractures was examined.

Age: The patients were divided into four groups according to age: the 1-6 years group, the 7-12 years group, the 13-18 years group and the >18 years group. The differences in fracture healing among the age groups were evaluated.

Fracture type: The intracapsular condylar fractures were classified to the methods of Chi Yang et al [9]. Four types of fractures (A, B, C and M) were determined based on the fracture lines on the CT images. The relationship between the type of intracapsular condylar fracture and the fracture healing grade was determined.

Type A: On the coronal CT, the fracture line crossed the superior 1/3 of the condylar head, and the mandibular ramus height was decreased.

Type B: On the coronal CT, the fracture line crossed the medial 1/3 of the condylar head, and the mandibular ramus height showed no change.

Type C: On the coronal CT, the fracture line crossed the inferior 1/3 of the condylar head, and the mandibular ramus height showed no change.

Type M is a comminuted fracture.

Relative position of the mandibular ramus stump and the articular fossa: According to Yang Chi et al [10], the relative position of the mandibular ramus stump and the articular fossa after intracapsular condylar fractures was classified into 3 grades, and the influence of each type on fracture healing was determined.

Grade 0: The mandibular ramus stump is located within the articular fossa, the highest point of the stump has no contact with the articular fossa, and the posterior ligaments of the articular disc are stretched.

Grade 1: The mandibular ramus stump is located within the articular fossa, the highest point of the stump has contact with the articular fossa, and the posterior lateral ligaments of the articular disc show tear and perforation.

Grade 2: The mandibular ramus stump shows superolateral dislocation from and is in contact with the articular fossa. The posterior lateral ligaments of the articular disc show tear.

Statistical analysis

SPSS 18.0 software was used for the comparison and analysis of the relationship between the above four factors and fracture healing. $P<0.05$ was considered a significant difference.

Results

General information

One hundred six patients (145 sides) with intracapsular fractures were included in the study; 75 (70.7%) were males, and 31 were females (29.3%). The patients' ages ranged from 1 to 82 years (average 22 years). The trauma causes included 44 cases resulting from falls, 43 cases resulting from traffic accidents, 15 cases resulting from falling from a height, and 4 cases resulting from injury by heavy objects. Eighteen patients had occlusal disorders that persisted 1 week after the injury. Six

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Table 2. Statistical analysis of the gender structure of 106 patients (145 sides) with intracapsular condylar fractures

Gender	Sides	Fracture healing grades			
		Grade 1 (%)	Grade 2 (%)	Grade 3 (%)	Grade 4 (%)
Male	101	19 (18.8%)	45 (44.6%)	32 (31.7%)	5 (4.9%)
Female	44	13 (29.55%)	22 (50%)	9 (20.45%)	0 (0%)

$P=0.292$.

Table 3. Statistical analysis of the differences in follow-up time between the age groups

Age classification	Cases (sides)	Follow-up time ($\bar{x}\pm S$; months)
1-6 years	21 (31)	18.57 \pm 24.66
7-12 years	20 (25)	12.85 \pm 12.89
13-18 years	13 (17)	9.38 \pm 11.52
>18 years	52 (72)	8.50 \pm 5.60

$P=0.036$.

patients underwent orthodontic bracket traction, 4 patients received arch bar traction, three were treated with intermaxillary anchor screws traction, and another 2 were treated with splint.

The maximum mouth opening of the 106 patients at clinical follow-up ranged from 2.4 cm to 5.1 cm, with an average of 3.82 cm. The radiological follow-up period was 3 to 96 months (average 11.6 months). CT showed that the grades and percentages of each fracture healing type were as follows: grade 1 for 31 sides (21.4%), grade 2 for 75 sides (51.7%), grade 3 for 34 sides (23.5%) and grade 4 for 5 sides (3.4%). There was no statistical difference in the follow-up time for all grades of fracture healing (**Table 1**).

Correlation between gender and fracture healing

In the 106 patients, 101 fracture sides were from males and 44 sides were from females. No statistical difference was observed in fracture healing grades between two gender groups (**Table 2**).

Effect of age on fracture healing

The age grouping, fracture composition and radiological follow-up time for the 106 patients (145 sides) are shown in **Table 3**. Statistical differences were observed between the age

groups in terms of follow-up time ($P=0.036$). Pairwise comparisons of the age groups showed that the 1-6 years group had the longest follow-up time, which differed significantly from the >18 years group ($P<0.05$). No statistical differences were observed between the other groups.

The healing conditions of the age groups are shown in **Table 4**. According to Spearman's rank correlation calculated with SPSS 18.0, age was positively correlated with the fracture healing grade (correlation coefficient =0.53, $P<0.001$). With increasing age, the percentage of grade 1 healing decreased, while the percentage of grade 2 and 3 healing increased. The incidence of ankylosis (grade 4) was 3.4%.

Effect of fracture type on fracture healing

The relationship between intracapsular fracture type and fracture healing grade for the 106 patients (145 sides) is shown in **Table 5**. There was a significant difference in fracture healing according to fracture type ($P=0.001$), and the prognosis of the patients with type M fractures was worse than that of the patients with other fracture types. Pairwise comparison showed significant differences between type A and type M fractures and between type B and type M fractures. There was no significant difference in fracture healing grade between type A and type B injuries. Type C fractures, which were represented by the smallest number of cases, showed no significant differences from other 3 fracture healing grades.

Effect of the relative position of the mandibular ramus stump and the articular fossa on fracture healing

The correlations between the relative position of the mandibular ramus stump and the articular fossa with fracture healing among the 106 cases (145 sides) are shown in **Table 6**. There were significant differences in the fracture healing grades between various positions of the mandibular ramus stump ($P<0.001$). Pairwise analyses of the 3 types of relative positions of the mandibular ramus stump and the articular fossa revealed significant differences between every pair of groups. No ankylosis occurred when the mandibular branch stump

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Table 4. Analysis of the fracture healing conditions of the age groups after non-surgical treatment

Age group	Sides	Fracture healing grades			
		Grade 1 (%)	Grade 2 (%)	Grade 3 (%)	Grade 4 (%)
1-6 years	31	18 (58.1%)	11 (35.5%)	2 (6.4%)	0 (0%)
7-12 years	25	8 (32%)	13 (52.0%)	3 (12.0%)	1 (4.0%)
13-18 years	17	4 (23.5%)	11 (64.7%)	2 (11.8%)	0 (0%)
>18 years	72	1 (1.4%)	31 (43.1%)	36 (50.0%)	4 (5.6%)
Total	145	31 (21.4%)	66 (45.5%)	43 (29.7%)	5 (3.4%)

P<0.001.

Table 5. Fracture types and fracture healing conditions for 145 sides

Types	Sides	Fracture healing grade			
		Grade 1 (%)	Grade 2 (%)	Grade 3 (%)	Grade 4 (%)
Type A	52	16 (30.8%)	24 (46.2%)	12 (23.1%)	0 (0%)
Type B	47	13 (28.3%)	20 (43.5%)	13 (28.3%)	0 (0%)
Type C	8	0 (0%)	7 (87.5%)	1 (12.5%)	0 (0%)
Type M	38	2 (5.1%)	15 (38.5%)	17 (43.6%)	5 (12.8%)
Total	145	31 (21.4%)	66 (45.5%)	43 (29.7%)	5 (3.4%)

P=0.001.

did not contact the articular fossa, but the incidence of ankylosis was 3.4% when there was contact. In addition, the incidence of ankylosis was 51.7% when the mandibular ramus stump exhibited superolateral dislocation from the articular fossa (Table 6).

Discussion

Condylar fracture is a common fracture in the oral and maxillofacial region that accounts for approximately 26%-72% of all mandibular fractures. Intracapsular fracture is a common type of condylar fracture; it accounts for 65% of all condylar fractures. The condyle is the part of the temporomandibular joint that is the most important development centre for mandibular growth. Condylar damage may lead to abnormal temporomandibular joint function or even ankylosis, which may cause facial development anomalies in paediatric patients. Radiological studies have revealed different healing outcomes in patients with different types of intracapsular fractures. Some patients showed good bone reconstruction with condylar morphology and position that were similar or equal to normal. However, other patients exhibited absorption, destruction and adhesion of the condylar bone. The factors causing these differences were not clear.

This study indicated a close correlation between the healing of condylar fractures and age. Previous studies showed that condylar fracture healing was correlated with age and that the healing and reconstruction of condylar fractures in children were generally better than those in adults [11-17]. In the 1970s, Lindahl [11] performed a follow-up study of 67 cases (76 sides) of condylar fractures. Patients of different ages were placed in various groups to assess the differences in fracture healing and reconstruction conditions between different ages. In the 3-11 year age group, 74% of patients showed complete reconstruction of the condyle, while most of the patients in 12-19 year age group showed incomplete reconstruction, and the adult patients showed very little reconstruction.

In this study, the proportion of young children (under 6 years old) with condylar process reconstruction was the highest, accounting for 58%. In adolescent patients, partial and complete reconstruction was also observable (23.5%-32%). These results showed some disagreement with the study by Lindahl. The reason for the difference may be that the two studies were based on different image evaluation methods. The patients in Lindahl's study suffered from condylar fractures that included intracapsular fractures and condylar neck and subcondylar fractures and were evaluated using plain X-ray films, which involved serious image interference from adjacent tissues. This method could easily fail to diagnose intracapsular and sagittal fractures, CT scans provide greater accuracy of diagnosis, sensitivity, and specificity than panoramic radiographs in the assessment of condylar fractures [18]. Especially in cases of condylar process fracture, coronal computed tomography scans were more useful than conventional radiographs in the determination of type of condylar fracture [19]. In this study, 106 patients (145 sides) all suffered from condylar intracapsular fractures. The fracture was evaluated by coronal CT images at the time of the injury and follow-up period. This study found that good fracture healing can be achieved even without treatment for paediatric patients.

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Table 6. Correlation of the relative position of the mandibular ramus stump and the articular fossa and the fracture healing grade

Relative position of the mandibular ramus stump and the articular fossa	Side	Fracture healing grade			
		Grade 1 (%)	Grade 2 (%)	Grade 3 (%)	Grade 4 (%)
No contact (grade 0)	109	29 (26.6%)	58 (53.2%)	22 (20.2%)	0 (0%)
Contact (grade 1)	29	2 (6.9%)	8 (27.6%)	18 (62.1%)	1 (3.4%)
Superolateral dislocation (grade 2)	7	0 (0%)	0 (0%)	3 (42.9%)	4 (57.1%)
Total	145	31 (21.4%)	66 (45.5%)	43 (29.7%)	5 (3.4%)

P<0.001.

atric patients (under 6 years old) as long as the mandibular ramus stump and articular fossa showed no contact and fracture were not dislocated. Approximately 58% of the patients healed with complete reconstruction and a complete recovery of condylar morphology and position. Approximately 35.5% of the patients achieved grade 2 healing, and their condylar morphology and location were similar to those of a normal condyle. For the adolescent patients, fracture healing was primarily grade 2 (52%-64.7%), and a considerable proportion of these patients achieved grade 1 healing (23.5%-32%). The adult patients mainly achieved grade 2 healing (50%) and grade 3 healing (43.1%). In addition, the condylar surface was not smooth after fracture healing, showing some bone absorption or hyperplasia, and the fracture healing time was longer than that of the children. In this study, full condylar reconstruction similar to that of a child was rare among the adult patients; only 1 adult patient achieved complete condylar reconstruction because the fracture fragments on the fracture side had no dislocation. This may be the result of the fully developed adult condylar cartilage layer, in which the physiological reconstruction and regeneration abilities had disappeared. Consequently, the healing of the fracture appeared mainly as functional adaptive reconstruction.

The fracture-healing grade was also correlated with the condylar fracture type. A previous study by He D [20] showed that condyles with sagittal fractures and lateral condylar stump dislocation easily formed adhesions, resulting in ankylosis. In this study, the condylar fractures were classified into 4 types (A, C, B, and M) according to the method of Yang Chi. Type A, B and C fractures primarily healed at grade 2. In this study, none of the type A, B, and C fractures developed into ankylosis. The healing of

M type fracture was mainly grade 3, which accounted for 43.6% of all type M cases. In this study, all 5 sides with ankylosis resulted from type M intracapsular fractures. Pairwise comparison showed significant differences between types A and M and between types M and B. Type M fractures demonstrated generally poor healing, which easily led to ankylosis. The reason may be that comminuted fractures severely damaged the condylar articular surface, which made the fracture healing, repair and reconstruction processes rather difficult and lead to complications from osteoarthritis and ankylosis. It is worth noticing that the incision restoration fixation operation was relatively difficult in cases of comminuted fractures with their multiple fragments. In most cases, non-surgical treatment was preferred. As a result, long-term clinical follow-up is more necessary for patients with comminuted intracapsular fractures so that an early intervention and treatment can be introduced.

In this study, the relative position of the mandibular stump and the articular fossa was also a factor that affected fracture healing. According to classification of intracapsular fractures by Yang Chi [10], the relative position of the mandibular ramus stump and the articular fossa was classified as no contact (grade 0), contact (grade 1) or dislocation (grade 2). In a previous retrospective study, He D investigated 13 cases (24 sides) of intracapsular fractures resulting in ankylosis of the temporomandibular joint. An analysis of trauma CT images found that all of the patients displayed contact or dislocation between mandibular ramus stump and the articular fossa. In this study, 109 sides (75.2%) of intracapsular fractures showed no contact between the mandibular ramus and the articular fossa. The results showed that 29 sides (26.7%) exhibited grade 1 healing, 58 sides (53.2%) achieved grade 2 healing and 22

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sides (20.1%) achieved grade 3 healing. No side developed ankylosis. The 29 sides with contact between the mandibular ramus stump and the articular fossa mainly resulted in grade 3 healing (62.1%). Among the 7 sides with superolateral mandibular ramus stump dislocation, 4 sides developed ankylosis. For the other three sides, although no ankylosis was observed, the condylar bone changed, with apparent bone absorption and hyperplasia. Except in the cases of condylar bone and cartilage destruction during intracapsular fractures, the reason for these changes may be that the contact between the ramus stump and the articular fossa or the ramus stump dislocation also destroyed the articular disc and the articular surface of the temporal bone, resulting in a torn or shifted temporomandibular joint disc. A previous study by He D showed that soft tissue injury in the cartilage area, such as articular disc displacement or destruction, easily led to osteoarthritis of the temporomandibular joint and fibrous ankylosis [21]. Mandibular ramus stump superolateral dislocation was generally a surgical indication. However, in this study, among 7 cases (7 sides) of mandibular ramus superolateral dislocation, 4 cases (4 sides) were intracapsular comminuted fractures. Because severe fragmentation of the fractures made relocation operations difficult, non-surgical treatment was selected. One of the 7 patients (1 side) showed severe brain injury, which was obviously a contraindication for surgery. For the other 2 patients (2 sides), the injuries had occurred more than 2 months before the treatment and were considered old fractures. Therefore, these patients missed the opportunity for surgical treatment. In addition to superolateral dislocation of mandibular ramus stump from the articular fossa, the majority of the cases were associated with fractures of the mandibular body, mostly in the form of mandibular symphysis fractures. For patients with intracapsular fractures with mandibular symphysis and body fractures that resulted in broadening of the mandibular dental arch and the superolateral dislocation of the mandibular ramus stump, measures such as resetting the body and symphysis fractures and restoring the mandibular dental arch width as soon as possible can help reset the dislocated mandibular ramus stump back to the articular fossa and facilitate good healing of intracapsular fractures.

Fracture healing should be closely related to the displacement of the fracture fragments. Fractures with no displacement or slight displacement are believed to heal relatively well. Fractures with severe displacement or dislocation show poor healing [22]. In this study, 145 cases of intracapsular fractures were treated using non-surgical means. Most of the fracture fragments were displaced but still located within the articular fossa. For intracapsular fractures with severe fragment displacement and dislocation, open reduction and fixation surgery was often the choice. Therefore, in this study, the displacement of the fracture fragments was not compared and analysed.

In summary, intracapsular fracture healing is a complex process affected by multiple factors. By analysing the fracture healing of a large sample of patients who suffered from intracapsular fractures and were treated using non-surgical means, the study showed that age, fracture type, and the relative position of the mandibular ramus stump and the articular fossa significantly affected fracture healing. Comminuted fractures, contact between the mandibular ramus stump and the articular fossa and superolateral dislocation of mandibular ramus stump resulted in a poor prognosis and easily developed into osteoarthritis and ankylosis. However, because of the special structure of the temporomandibular joint, intracapsular fractures involved damage to and repair of bone tissue as well as the soft tissue, such as the destruction of the articular disc and articular capsule. Therefore, changes in the soft tissue also greatly impacted fracture healing and prognosis, and further studies are needed to clarify this relationship.

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Disclosure of conflict of interest

None.

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