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ROLE OF RETENTION OF THE CONDYLAR CARTILAGE IN OPEN TREATMENT OF INTRACAPSULAR CONDYLAR FRACTURES: HISTOPATHOLOGICAL OBSERVATION

Zhiqiang Feng[#], Xufeng Chen[#], Xiaozhen Zhan, Linwei Huang , Qiang Lin, Renfa Lai,
Department of Stomatology of the First Affiliated Hospital of Jinan University. Guangzhou, Guangdong Province 510630, China
[*] Corresponding E-mail: Prof.Dr.Lai@163.com.
[#] Co-first author: Zhiqiang Feng and Xufeng Chen contributed equally to this work.

Abstract: Our aim was to investigate the role of retention of the condylar cartilage in open reduction and internal fixation (ORIF) of intracapsular condylar fractures (ICFs) in growing goat's by histopathological observation. Twelve goats 6 months old were randomly divided into three groups. ICFs were created bilaterally in mandibular condyles and treated with ORIF. On the one side (n= 4) the condylar cartilage was removed, and on the other side (n = 4) it was retained. Condyles in the control group (n = 4) were untouched. Experimental animals were sacrificed at the following intervals, 3 months and 6 months postoperatively. Specimens were harvested for tissue slice observation. Tissue slices of the condyles with the articular cartilage retained showed a normal TMJ structure and no differences with the normal condylar tissue structures. The basic structures of cartilage layer of the condyle with articular cartilage removed disappeared. The surface of mature bone tissue of the condyle directly connected with fibrous tissue of the articular disc. The results of this study suggest that retaining condylar cartilage in the ORIF for ICF of growing goats has no harmful effect on condylar growth, but removal can lead to the articular disc adhesion and limit growth.
Key words: Intracapsular condylar fracture; Open reduction and internal fixation; Temporomandibular joint; Growing goat

1. INTRODUCTION

For both anatomical and mechanical reasons the condylar process is easy to fracture and is a common site of mandibular fractures. It accounts for 26–57% of all mandibular fractures [1-3], and anatomically the site can be classified as intracapsular condylar head, neck, and subcondylar fracture [2,4]. The mandibular condyle is considered as one of the growth center [5,6]. Whether the mandibular condyle and its surrounding tissue are healthy or not during its growth and development has great influence on the face and the dentognathic system. Severe condylar fracture, if temporomandibular joint (TMJ) function was not timely reconstructed or can not be remodeled relying on the body's own adaptation, which may easily lead to TMJ disorders and the condylar degeneration, resulting in the condylar dysplasia.

Generally, Most surgeons advocate closed treatment for condylar fractures in children because they worried that ORIF may injure the growth site of the mandibular condyle and cause the condyle growth disturbance, moreover, the mandibular condyle in children have good functional adaptation regeneration and ORIF for ICFs is also very difficult. So the study of ICFs treated with ORIF in children is fewer. However, there is no evidence that open reduction has a poor outcome [7-9]. And follow-up studies of dislocated condylar fractures managed by non-surgical techniques have commonly resulted in mandibular asymmetry, incomplete remodeling of the condylar process, and even ankylosis of TMJ [10-12], which often happens in children with ICF,

especially bilateral ones [13]. Besides, high intracapsular fractures and fracture dislocations may both lead to damage of the articular cartilage. Does this have impact on the condylar growth and development?

Up to now, there is few related research in this area. So we designed this experiment, the aim of this study was to investigate the effect of retention of the cartilage during ORIF on growing goats by histopathological observation.

2. MATERIALS AND METHODS

2.1. Experiment and surgical technique

The study was approved by the Ethics Committee of Shanghai Jiao Tong University, School of Medicine. Twelve 6-monthold Chinese Shanghai growing goats (10 male and 2 female; their age reflects that of 6-year-old humans) that weighed about 10 kg were randomly divided into two groups: an experimental group (n = 8) and a control group (n = 4). Goats in the experimental group were intubated and operated on under general anaesthesia with 2.5% phenobarbital sodium. An oblique vertical osteotomy was made from the lateral pole of the condyle to the medial side of the condylar neck bilaterally as described by Long and Goss [14]. A two-hole, 2-mm plate was attached with one screw to each fragment and a 0.5 mm cerclage steel wire was used to help stabilise rotation and fix the fragment (Figure 1). Condylar cartilage from one randomly selected side of the condyle was removed while that on the other side was retained. Penicillin 800 000 units was given intramuscularly as prophylaxis after intubation and before the incision was made. The operating time was in the range of 60–75 min. The control group had no surgical intervention. Goats were housed in separate cages and fed soft food pellets for 4 weeks from the day after the operation. They were then transferred back to the farm and were given free access to grass.

Fig.1. The operation of the TMJ (A) Stripping the articular cartilage (white arrow indicates the cartilage) (B) ICF created (white arrow indicates fracture line) (C) ORIF of the condyle with the articular cartilage retained (D) ORIF of the condyle with the articular cartilage removed

2.2. Specimen Collection

All goats were sacrificed to obtain specimens with a lethal dose of pentobarbitone sodium given through the external jugular vein after 3 month and 6 month. The entire TMJ including the glenoid fossa, articular disc and mandibular condyle in each goat was harvested, and the soft tissues were stripped off. And specimens were cut into two parts in the coronal or sagittal direction. These specimens were used for soft tissue slices and they were decalcified in 10% EDTA+ 0.1%DEPC solution; 5um-thick semi-serial sections were cut and stained with hematoxylin eosin.

3. RESULTS

During the experimental period, there was no infection or limitation of mouth opening in the experimental group. The weights of all goats remained constant throughout the experiment.

Gross observation: After 3 months, in cartilage retained group, the condylar morphology was normal, growth of the condyle appeared normal and the ascending ramus significantly increased in height. In cartilage removed group, the condylar morphology was poor, the condylar neck was relatively thick. And the ascending ramus compared with group of cartilage retained was shorter. The adhesion in lower articular spaces was occured which the articular disc combined with condylar surface directly. After the disc was separated, the condylar process showed rough uneven surface. After 6 months, in cartilage retained group, there was a further increase in height of the ascending ramus. The ratio between the condylar head and neck was coordination. There was an anterior-inferior shift of the fixed plate, and it had already been covered by the new bone tissues (Figure 2, 3). In cartilage removed group, the ratio between the condylar head and neck was poor and the condylar neck was short and thick. The fixed plate was also completely covered by the new bone tissues. The intracapsular adhesion was

more closely, and the disc obviously thickened (Figure 4, 5).

Fig.2 3 months postoperative gross specimen of TMJ with the articular cartilage retained (A) lateral view (B) posterior view (C) upper view

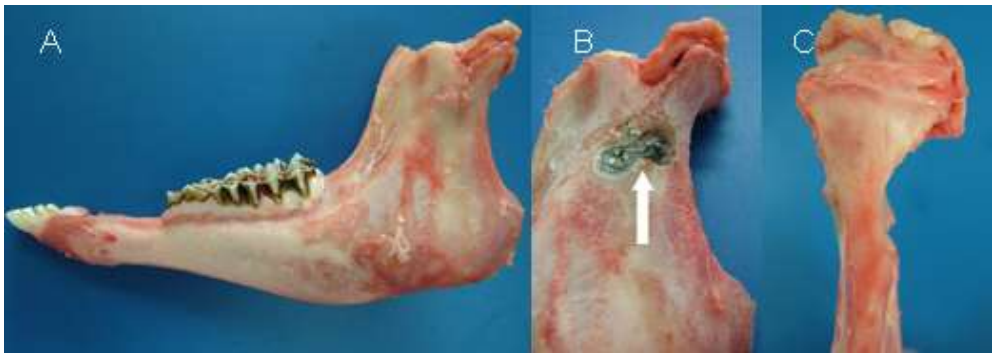

Fig.3. 6 months postoperative gross specimen of TMJ with the articular cartilage retained (A and B) lateral view (C) posterior view (white arrow indicates the titanium plate and screws completely covered by new bone tissue)

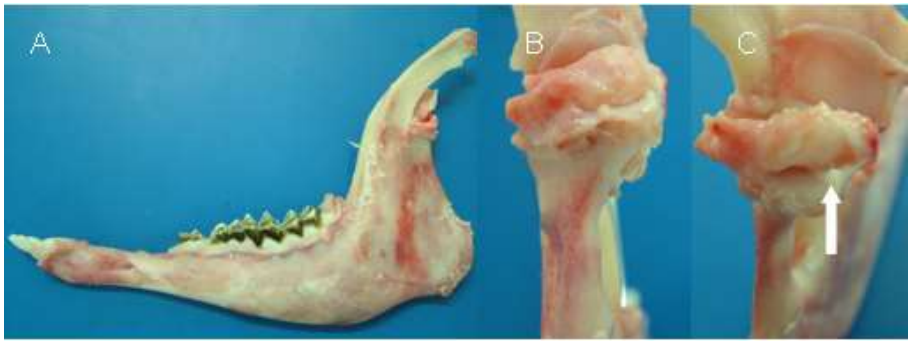

Fig.4. 3 months postoperative gross specimen of TMJ with the articular cartilage removed (A) lateral view (B) posterior view (C) upper view (white arrow indicates the intra-articular adhesion)

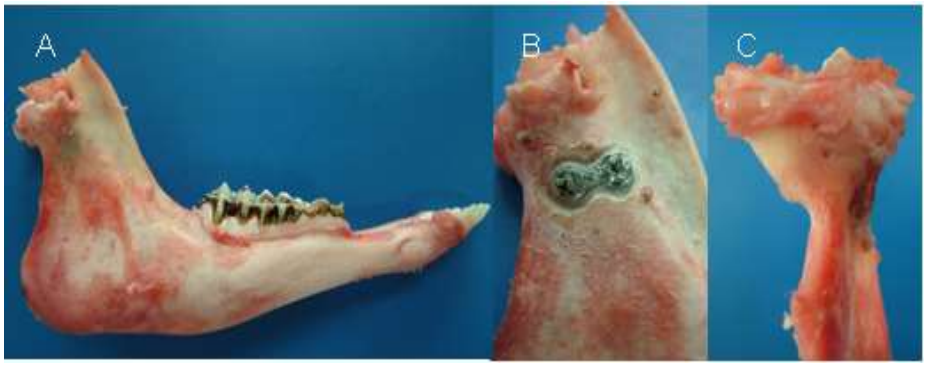

Fig.5. 6 months postoperative gross specimen of TMJ with the articular cartilage removed (A and B) lateral view (C) posterior view

Histopathological findings: After 3 months, in cartilage retained group, the articular surface was also covered fibrocartilage as the normal condyle, which can be divided into four layers: fibrous layer, proliferative layer, mast cell layer and the calcified cartilage layer. And endochondral ossification were active (Figure 6). In cartilage removed group, the basic structure of the fibrocartilage layer disappeared and the articular surface were covered by mature bone cells. And new bone tissues were not observed except that there was only part of cartilage tissues at the edge of the condylar process. The articular surface depression was found and its bone tissues were directly connected to the fibrous of the articular disc (Figure 7). After 6 months, in cartilage retained group, a large amount of immature bone cells were observed in the calcified cartilage layer which showed that the process of endochondral ossification did not cease (Figure 8). In cartilage removed group, there was no much change of the articular cartilage compared with that of 3 months, the fibrocartilage layer was not repaired. The articular surface was covered with mature bone cells and there was also a direct connection between the articular surface and the condylar disc, besides the condylar disc was obviously thickened (Figure 9).

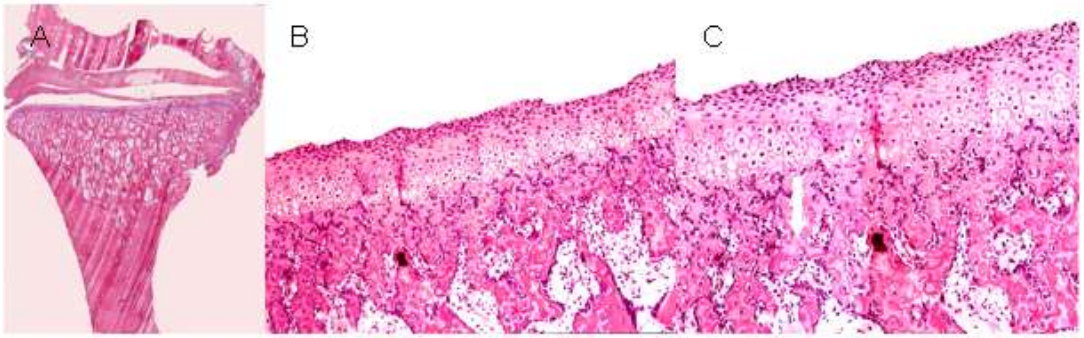

Fig.6. 3 months of decalcified tissue slice of TMJ with the articular cartilage retained (HE stain) (A) ×50 (B) ×100 (C) ×200 (white arrow indicates new bone tissue)

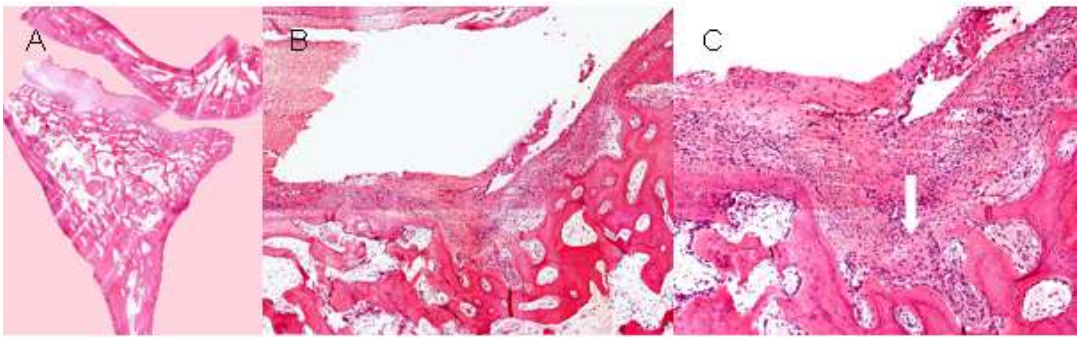

Fig.7. 3 months of decalcified tissue slice of TMJ with the articular cartilage removed (HE stain) (A) ×50 (B) ×100 (C) ×200 (white arrow indicate condylar sag)

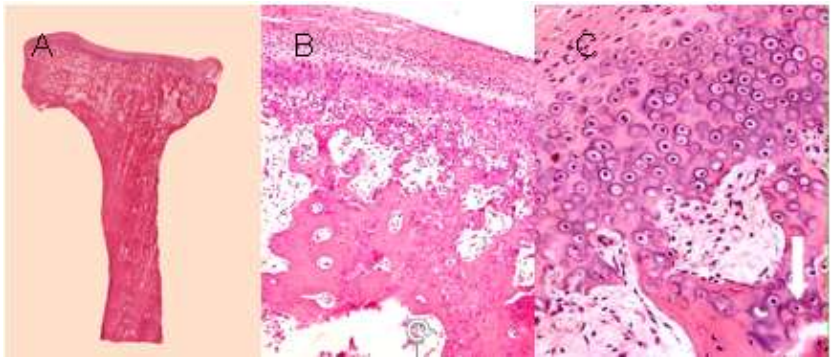

Fig.8. 6 months of decalcified tissue slice of TMJ with the articular cartilage retained (HE stain) (A) ×50 (B) ×100 (C) ×200 (white arrow indicates new bone tissue)

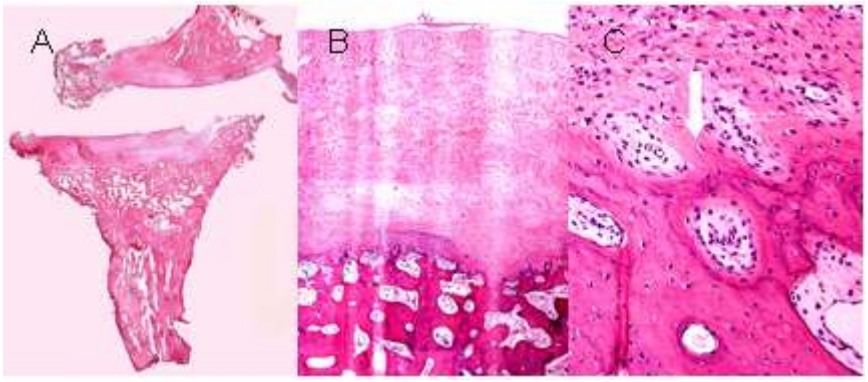

Fig.9. 6 months of decalcified tissue slice of TMJ with the articular cartilage retmoved (HE stain) (A) ×50 (B) ×100 (C) ×200 (white arrow indicates the intra-articular adhesion)

4. DISCUSSION

Because surgeons worried that ORIF may injure the growth site of the mandibular condyle and cause the condyle growth disturbance. Unti the mid-1970s, "closed reduction" and "immobilization with maxillomandibular fixation (MMF)" were used for all types of pediatric fractures [15-17]. Because it avoids the possible disadvantages of ORIF, such as: (1) ORIF would cause a growth disturbance either from the surgical manipulation of the fracture segments or from the placement of rigid hardware across the condylar growth center, (2) surgical stripping may lead to condylar bone necrosis by lack of blood supply, (3) ORIF would cause condylar atrophy, (4) ORIF may lead to facial nerve damage and production of a scar on the face.

Our study has shown that ORIF had no deleterious effects on condylar growth when the cartilage was retained. And a serious adhesion between condyle and articular disc was observed and height of ascengding ramus decreased in group of articular cartilage removed, which confirmed articular cartilage played an important role in the condylar growth and development. It showed that condylar growth did not affect as long as ORIF did not damage the condyle articular cartilage. However, experimental animals did not occur mandibular deviation and deformity or limited mouth opening. It maybe explained as follows: Firstly, the articular disc was left in situ and the superior head of the lateral pterygoid muscle still attached. Although adhesion between the condyle and articular disc occurred but the sliding movement in upper joint cavity and the contralateral joint adjustment would compensate for these effects. Secondly, the articular disc and the lateral pterygoid muscle attachment was left in situ, it provided an "ideal" milieu for the maintenance of normal growth after surgical intervention. Thirdly, the fractures immediately treated with ORIF after created ICFs, it facilitated direct bone healing, allowed improved stability at fracture and reconstructive sites, and permitted an earlier return to function.

In fact, the patients with intracapsular condylar fracture in clinic are quite different from this experiment, especially with displaced or dislocated condylar fractures, the fractures often associated with surrounding soft tissues damages which were accompanied by articular disc displacement, the articular cartilage exfoliated, tears of capsular and haemorrhagic effusion in upper and lower articular spaces. In this case it is prone to severe TMJ complications without effective treatment interventions. In this experiment, ICF were created in such an "ideal" condition and treated with ORIF immediately. Even so, the adhesion and shorting of the ascending ramus were still observed. If the same injuries were created in the experiment, the probability of occurrence of TMJ ankylosis would greatly increase. For example, Long and Gross[14]created and observed the effects of an intracapsular vertical split fracture in the sheep TMJ condylar head. Their experiment demonstrated progressive changes toward ankylosis and pathological changes in sheep TMJ over time consistent with what has been found in humans. It may explaine why a large number of clinical cases of TMJ ankylosis were caused by condylar fractures, especially

bilateral ones.

In conclusion, retaining condylar cartilage during ORIF has an important role in the successful treatment of condylar fractures, and removing it can restrict the growth of the ramus. As ORIF does not damage cartilage, the repair may promote better growth and prevent ankylosis and other complications.

CONFLICT OF INTEREST STATEMENT

The authors report no commercial, proprietary, or financial interest in the products or companies described in this article.

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