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Remodelling in young sheep: a histological study of experimentally produced defects of the TMJ

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Summary

Questions under study: In this study, experimentally induced surgical defects of the mandibular condyle were evaluated histologically 3, 6 and 9 months postoperatively to investigate the capacity for remodelling which is one of the most important features of the temporomandibular joint.

Methods: In three healthy sheep standardised surgical defects were produced on each right condylar head. The left temporomandibular joints served as controls. No treatment was performed on the surgical defects and function was not restricted postoperatively. At the end of the experimental period the sheep were sacrificed and a histological evaluation was carried out.

Results: Histologically, no disturbance was observed during the healing process in bone and cartilage. Although function was not limited throughout the study, it was observed that the experimental surgical defects had healed completely.

Conclusions: This result points to the condyle's high capacity for repair and remodelling.

Key words: mandibular condyle; remodelling; sheep

Introduction

Temporomandibular joint dysfunction may be caused by an abnormal relationship between disc and condyle. The resolution of this condition is often achieved by remodelling and adaptation rather than actual correction of the anomaly [1]. Trauma to the chin may cause injury to the articular tissues, resulting in condylar fractures and posttraumatic arthritis [2]. Condylar fractures are often followed by displacement of the condylar head. During the healing period, remodelling of the joint may occur. In children, extensive remodelling resulting in almost complete restoration of joint anatomy takes place in many cases [3]. Remodelling has also been observed in adult patients, but to a lesser degree [4]. Trauma to the TMJ, including microtrauma, has been suggested as a possible cause of osteoarthrotic changes of the condylar head. In this context there is still debate as to whether the degenerative changes to the TMJ occur as a result of damage to the mandibular condyle cartilage or of damage to the articular disc.

The objective of the present study is to analyse remodelling of the TMJ after surgical trauma in an experimental model.

Methods

This study was supported by the Ankara University Research Fund (project 95-30-00-18) Ankara, Turkey.

Three young adult sheep aged 12 months and weighing approximately 50 kg were used. The right-side joints were surgically altered and the left-side joints served as controls. Anaesthesia (4 mg ketamine HCL and 0.05 mg xylazine HCL per kilogram) was induced intravenously into the external jugular vein. The skin over the TMJ region was shaved and prepared with betadine solution. Following a preauricular incision, the condylar process was exposed and the inferior joint space opened by a horizontal incision through the capsule. A 0.5 cm wide and 0.5 cm deep mediolateral groove was cut at the top of the condyle midline of the articular surface (Fig. 1) with a 1.5 mm diameter fissure bur using copious amounts of saline for cooling. The condylar surfaces were irrigated with saline

and the joint capsule and overlying tissues repaired in layers. The animals' preoperative and postoperative diet was the same. Postoperatively 2 ml of clindamycin was given twice daily for 7 days intramuscularly. No wound became infected and all the sheep did well following surgery.

The sheep were killed by anaesthetic overdose after 3 months, 6 months and 9 months. The specimens were placed in 10% neutral formaldehyde solution and decalcified in nitric acid solution. All specimens were embedded in paraffin. Serial sections were cut at 5 μm and stained with haemotoxylin and eosin.

Results

After creation of the surgical trauma the animals continued to gain weight. The histopathological findings in all TMJs were as follows:

1. At the third postoperative month, microscopic examination of the joint surface revealed that the defect extended to the cancellous bone and was filled with connective tissue containing blood vessels. Since the defect was distant from the attachment of the synovial membrane, it was thought that the connective tissue cells originated from the osteogenic cells surrounding the bony trabeculae. A surplus of connective tissue mass developed at the defect and caused doming at the joint surface (Fig. 2).
2. At the sixth postoperative month the defect was filled with connective tissue. At some sites formation of cartilage tissue from the base of the defect was observed (Fig. 3).
3. At the ninth postoperative month histopathological examination showed persistent slight doming at the surface of the defect site. The greater part of the defect was filled with cartilage. Only the central part of a small area at the joint surface consisted of loose connective tissue. Undifferentiated cells resembling cartilage cells were seen parallel to the joint surface, and cellularity was increased close to the surface. Spongious bone developed via endochondral ossification at the base of the defect (Fig. 4).

Figure 1

Surgically created defect on the condylar head.

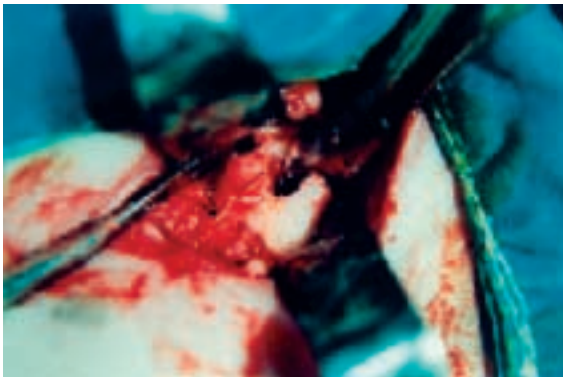


Figure 2

3 months: Infiltration of the prepared defect and surrounding joint surface with connective tissue containing blood vessels. H E. Magnification × 80.

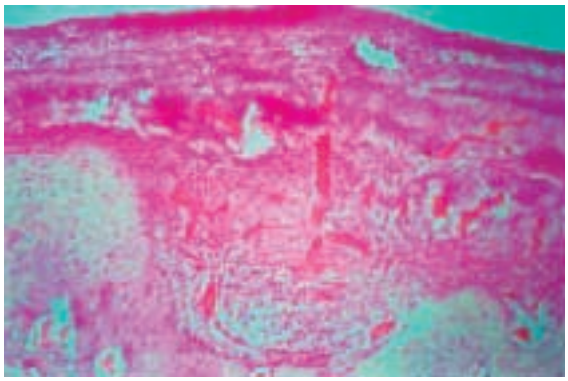


Figure 3

6 months: Formation of cartilage tissue from the base of the defect to the joint surface. H E. Magnification × 80.

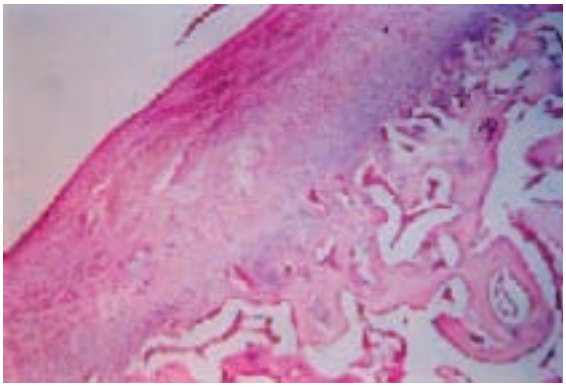
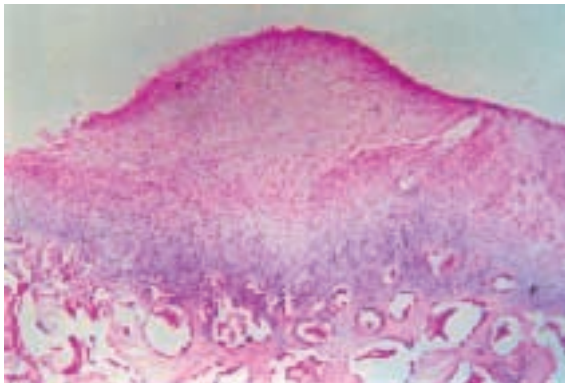


Figure 4

9 months: Appearance of the defect of joint surface. A major portion of the defect was filled with cartilage tissue. The excessive portion at joint surface consisted of loose connective tissue. However, especially in the upper portions, differentiation to cartilage tissue seemed more likely. H E. Magnification × 80.



Discussion

The condylar portion of the TMJ is most commonly affected by disease, such as osteoarthrosis, trauma or errors of development.

In various clinical and experimental studies it has been found that mandibular condylar cartilage has the capacity to remodel after acute or chronic trauma [2–8]. However, complications subsequent to condylar trauma such as ankylosis, osteoarthritis and mandibular deformities have also been described [9–14].

Although remodelling of the condylar process following condylar fracture has been demonstrated [15–17], the repair mechanisms within the TMJ are poorly understood.

In their study Teixeira et al. [18] showed that displaced condylar process fractures in rats healed by callus formation with concurrent repositioning of the condyle. In man remodelling of the joint occurs during the healing of condylar fractures [15, 19, 20]. In growing patients extensive remodelling, resulting in almost complete restitution of the joint, has been noted in many cases. Remodelling has also been observed in adult patients, but to a lesser degree [4].

Hochman and Laskin [21], using rabbits, reported that surgical defects of the mandibular condyle were completely repaired by both adjacent cartilage and reparative tissue from the marrow space. The difference in the repair process can be ascribed to the animals' differing characteristics: rabbits have greater potential for intrinsic repair of bone and cartilage defects, while humans have less. In this respect sheep are similar to man, and thus the choice of animal is important in these experiments if we wish to compare the biological changes with human disease [22]. Bifano et al. [23] report that goats and sheep are well suited as TMJ models due to their relative lack of protection against anteroposterior forces, their relative lack of posterior joint function and the translatory capacity of the joint. They also have the advantage of being plentiful, inexpensive, easily maintained and easily handled. It was for these reasons that we chose sheep for this study.

In the present study it was found that a surgically created defect of the condyle was replaced 3 months postoperatively by fibro-osseous connective tissue associated with new blood vessel formation. Histologically no alteration was observable in the control joints. However, all three articular discs had thinned. Six months postoperatively chondrocyte proliferation and a decrease in the quantity of connective tissue were noted. The chondrocytes probably derived from marrow. In similar fashion to our results, the defect created in the marmoset by Robinson [7] was filled with an increasingly cellular blastema forming new collagen fibres. He reported that these cells appeared to be in continuity with the subchondral bone. According to Ishimaru et al. [24] the residual articular cartilage has less potential for wound repair, with greater potential existing in the bone marrow.

It has been suggested that 90 days is too short a period for the advanced stages to develop, nor do major changes take place over 6 months [22]. However, our studies showed differences between 6 and 9 months postoperatively.

The study's purpose was to observe the remodelling capability of condylar cartilage in the repair of standardised full-thickness articular bone and cartilage defects. It illustrates the effect of a situation similar to an intraarticular fracture of the condyle, either a microfracture from repeated overloading or a fracture from acute mandibular trauma.

Although the functioning of the TMJ was not limited throughout this study, complete healing of the experimental surgical defects was observed. This points to the condyle's high capacity for repair and remodelling, a factor which should be considered in the management of trauma and other disorders of the TMJ.

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References

1 Blaustein DI, Scapino RP. Remodelling of the temporomandibular joint disk and posterior attachment in disk displacement specimens in relation to glycosaminoglycan content. Plast Reconstr Surg 1986;78:756-4.
2 Luz JGC, Jaeger RG, De Araujo VC, De Rezende RJV. The effect of immobilisation on the rabbit temporomandibular joint. Int J Oral Maxillofac Surg 1991;20:48-2.
3 Güven O, Keskin A. Remodelling following condylar fractures in children. J Cranio-Maxillofac Surg 2001;29:232-7.
4 Mongini F. Remodelling of the mandibular condyle in the adult and relationship to the condition of the dental arches. Acta Anat 1972;82:437-3.
5 Avrahami E, Frishman E, Weiss-Peretz J, Horowitz I. Computed tomography of healing condylar fractures with some clinical correlations. Clin Radiol 1993;47:269-3.
6 Leake D, Doykos J, Habal MB, Murray JE. Long term follow-up of fractures of the mandibular condyle in children. Plast Reconstr Surgery 1971;47:127-1.
7 Robinson PD. Articular cartilage of the temporomandibular joint: Can it regenerate? Ann R Coll Surg 1993;75:231-6.
8 Yasuoka T, Oka N. Histomorphometric study of trabecular bone remodelling during condylar process fracture healing in the growing period. J Oral Maxillofac Surg 1991;49:981-8.

9 Norholt SE, Krishnan V, Sindet-Pedersen S, Jensen AI. Pediatric condylar fractures: A long term follow-up study of 55 patients. J Oral Maxillofac Surg 1993;51:1302-9.
10 Proffit WR, Vig KWL, Turvey TA. Early fracture of the mandibular condyles: Frequently an unsuspected cause of growth disturbances. Amer J Orthod 1980;78:1–4.
11 Sawhney CP. Bony ankylosis of the temporomandibular joint: Follow-up of 70 patients treated with arthroplasty and acrylic spacer interposition. Plast Reconstr Surg 1986;77:29-8.
12 Wu XG, Hong M, Sun KH. Severe osteoarthrosis after fracture of the mandibular condyle: A clinical and histological study of seven patients. J Oral Maxillofac Surg 1994;52:138-2.
13 Güven O. A clinical study on temporomandibular joint ankylosis. Auris Nasus Larynx 2000;27:27-3.
14 Güven O. Acrylic spacer in treatment of TMJ ankylosis (a technical report). Balkan J Stomatology 2000;4:40-1.
15 Feifel H, Albert-Deumlich J, Riediger D. Long term follow up of subcondylar fractures in children by electronic computer-assisted recording of condylar movements. Int J Oral Maxillofac Surg 1992;21:70-6.
16 Sahm G, Schuknecht B, Eberhardt K. Zur Remodellation nach Kondylusluxationsfracturen bei Heranwachsenden. Dtsch Zahnarztl 1990;45:403-5.
17 Zou ZJ, Wu WT, Sun GX, et al. Remodelling of the temporomandibular joint after conservative treatment of condylar fractures. Dentomaxillofac Radiol 1987;16:91-8.
18 Teixeira ACB, Luz JGC, Aaujo VC, Araujo NS. Healing of the displaced condylar process fracture: an experimental study. J of Cranio-maxillofac Surg 1998;26:326-0.
19 Kahl-Nieke B, Fischbach R, Gerlach KL. CT analysis of temporomandibular joint state in children 5 years after functional treatment of condylar fractures. Int J Oral Maxillofac Surg 1994;23:332-7.
20 Kahl-Nieke B, Fischbach R, Gerlach KL. Temporomandibular joint morphology in children after treatment of condylar fractures with functional appliance therapy: a follow up study using spiral computed tomography. Dentomaxillofac Radiol 1995;24: 37-5.
21 Hochman LS, Laskin DM. Repair of surgical defects in the articular surface of the rabbit mandibular condyle. Oral Surg 1965;19:534-2.
22 Ishimaru J, Goss AN. A model for osteoarthritis of the temporomandibular joint. J Oral Maxillofac Surg 1992;50:1191-5.
23 Bifano C, Hubbard G, Ehler W. A comparison of the form and function of the human, monkey, and goat temporomandibular joint. J Oral Maxillofac Surg 1994;52:272-5.
24 Ishimaru JI, Kurita K, Handa Y, Goss AN. Effect of marrow perforation on the sheep temporomandibular joint. Int J Oral Maxillofac Surg 1992;21:239-2.