RESEARCH ARTICLE

Correlation between the disc status in MRI and the different types of traumatic temporomandibular joint ankylosis

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Objectives: We aimed to investigate the correlation between the disc status in MRI and the different types of traumatic temporomandibular joint (TMJ) ankylosis.

Methods: 51 consecutive patients (69 joints), diagnosed with traumatic TMJ ankylosis with a residual condyle (Types A2 and A3), were included in this study. All patients had pre-operative MRI, which was reviewed to determine the disc shape, length and position. The results were compared using the Mann–Whitney test.

Results: There were 37 joints of Type A2 ankylosis and 32 joints of Type A3. All joints of Type A2 and 27 joints of Type A3 (84.4%) definitely had a discernible disc, while 5 joints of Type A3 had no discernible discs. Among the discernible discs, the lateral disc of Type A2 and the whole disc of Type A3 had severe deformity, while the medial disc of Type A2 had mild deformity. The mean (standard deviation) disc length was 10.88 (1.19) mm in Type A2, but 7.50 (0.82) mm in Type A3. There was a significant difference between Types A2 and A3 ($p < 0.05$). As for the disc position, the intermediate position was found in all joints.

Conclusions: There is a correlation between the disc status and the different types of traumatic TMJ ankylosis. Therefore, MRI examination is needed to help treatment planning and predict post-operative TMJ function.

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Keywords: traumatic temporomandibular joint ankylosis; MRI; disc shape; length; position

Introduction

Temporomandibular joint (TMJ) ankylosis is a common disease in TMJs. TMJ ankylosis usually causes mouth-opening limitation and facial deformity, especially in young patients. The most common cause of TMJ ankylosis is trauma, accounting for 75–98% of the

cases.^{1,2} According to the results of our previous study,³ two types of traumatic TMJ ankylosis exist. In one type of TMJ ankylosis, the residual condyle is located on the medial side of the joint and bony fusion is present on the lateral side. Alternatively, in the other type of TMJ ankylosis, bony fusion is complete and the residual condyle is not observed.³

These two types can be treated with gap arthroplasty, interpositioning arthroplasty and TMJ reconstruction with autogenous or alloplastic materials.^{1,4,5} However, these techniques, used to release the ankylosis, have shown variable and often unsatisfactory results.^{4,6} Nevertheless, Nitzan et al⁶ tried to resect the lateral

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bony fusion and retain the displaced condyle and disc. The condyle and disc were left untouched in their precarious medial position so as to provide normal function and growth. Zhang and He⁷ demonstrated that the disc played a critical role in blocking the formation of a bony bridge between the condylar stump and the articular surface in traumatic TMJ ankylosis. Therefore, a specific treatment protocol with preservation of the residual condyle and disc has been given more attention.^{4,5,8} In 2011, Yang et al.³ proposed a further classification for TMJ ankylosis based on the size of the residual condyle in coronal CT. If the residual condyle was big enough, we attempted to remove the lateral bony fusion only, preserving the medially displaced residual condyle and disc, and then sutured the disc with a temporalis myofascial flap or masseter muscle flap as a barrier between the TMJ fossa and the stump of the mandibular ramus. Therefore, it is necessary for surgeons to focus on the disc status in these two types of ankylosis, which helps treatment planning and predicts the post-operative TMJ function. To our knowledge, the disc status in TMJ disc displacement with or without reduction and intracapsular fracture has been discussed in many studies.^{9–13} However, there is no study discussing the disc status in various types of traumatic TMJ ankylosis.

The aim of this study was to investigate the correlation between the disc status (including lateral and medial disc shapes; disc position relative to the residual condyle and eminence; and disc length) and the different types of traumatic TMJ ankylosis.

Methods and materials

Subjects

A total of 51 consecutive patients (69 joints), diagnosed with traumatic TMJ ankylosis with a medially displaced residual condyle from January 2009 to November 2013, were included in the study. There were 62 joints in 45 male patients and 7 joints in 6 female patients. The mean age at first visit was 30.4 years (range, 5–50 years). The mean traumatic interval was 21.6 months (range, 10–41 months). The main aetiologies for traumatic TMJ ankylosis were falls, sports or traffic-related injuries. All patients fulfilled the following selection criteria: (1) had received no treatment for traumatic TMJ ankylosis before visiting the TMJ division of Ninth People Hospital; (2) had pre-operative CT, especially coronal scans, and MRI, especially parasagittal images. All CT scans and MRI were assessed by two experienced oral and maxillofacial surgeons and a radiologist. They judged the images together and made similar evaluations. Two surgeons were members in the Department of Oral and Maxillofacial Surgery, Ninth People Hospital, and had routinely dealt with TMJ disorders for more than 10 years. The radiologist was a member of the Department of Radiology and had been engaged in TMJ radiographic examinations for at least 5 consecutive years.

This study was conducted in accordance with the ethics committee of Shanghai Jiao Tong University School of Medicine, Shanghai, China.

Traumatic temporomandibular joint ankylosis classification based on coronal CT

CT scans were reviewed to classify traumatic TMJ ankylosis with a residual condyle into Types A2 and A3 based on the classification of Yang et al.³ Type A2 is the ankylosis with bony fusion on the lateral side of the joint, where the residual condylar fragment is bigger than one-half of the condylar head on the medial side; and Type A3 is similar to A2 but the residual condylar fragment is smaller than one-half of the condylar head (Figure 1).

Radiographic analysis of MRI

The MR images obtained with a 1.5-T Signa MRI imager (General Electric, Milwaukee, WI) with bilateral 3-inch TMJ surface coil receivers was also reviewed to assess the disc status (including the lateral and medial disc shapes; disc position relative to the residual condyle and eminence; and disc length) in Types A2 and A3. The protocol of MRI was introduced in detail in the study of Cai et al.¹¹ To summarise, the disc shape was evaluated before editing the disc contour. Then, some points, reference lines or planes, and the contour of the residual condyle and eminence, were defined using Adobe® Photoshop® v. 7.0 (Adobe Systems Inc., San Jose, CA). Radiographic observation for linear measurements of disc length and position was obtained by the use of MB-Ruler software (accurate to 0.01 mm) (Markus Bader, Berlin, Germany).

Lateral and medial disc shapes

The disc was divided into two halves: lateral and medial parts, from coronal MRI (Figure 2). Then, each patient's parasagittal image was shown to the examiners for a period of 20 s under adequate lighting conditions to determine whether there was a discernible disc. If there was a discernible disc, the lateral and medial disc shapes (including biconcave, biplanar, hemiconvex and amorphous) were documented according to the method of Hirata et al.¹⁴

Disc length

The disc length was assessed in the parasagittal MRI slice, exhibiting the largest residual condyle at the closed-mouth position. Three points (A, B and C) were defined in the parasagittal image. A was the midpoint on the most anterior bulge of the anterior band of the disc. B was the midpoint on the most posterior bulge of the posterior band of the disc. C was the midpoint of the intermediate zone of the disc. Linear measurements were carried out for AC and CB, and the summation of these two distances was determined as the disc length. If the disc was obviously deformed and the intermediate zone could not be distinguished, the distance of AB was measured directly based on the method of Cai et al.¹¹ (Figure 3).

Figure 1 Demonstration of Types A2 and A3 of traumatic temporomandibular joint ankylosis from coronal CT. (a) Type A2, (b) Type A3. Arrows indicate residual condyle.

Disc position relative to the residual condyle and eminence

The disc position, relative to the residual condyle and the articular eminence, was assessed in the parasagittal MRI, according to the methods set by Murakami *et al.*^{14,15} Besides points A, B and C, an additional line (line P) was noted, passing through the point at which the contour of the residual condylar head was closest to the contour of the articular eminence surface. If point B was anterior to this line, it was considered as an anterior

position; if point A was posterior to this line, it was considered as a posterior position; whereas if point A was anterior to this line and point B was posterior, it was considered as an intermediate position (Figure 4).

Statistical analysis

The SAS[®] software package v. 9.0 (SAS Institute Inc., Cary, NC) was used for statistical analysis of the results, which were compared using the Mann–Whitney test. A significant difference was set at $p < 0.05$.

Figure 2 Demonstration of the lateral and medial disc halves in coronal MRI.

Figure 3 Determination of points A, B and C and quantitative assessment of the disc length (AC + CB).

Figure 4 Line P passing through the point at which the contour of the residual condyle was closest to the contour of the articular eminence to determine the disc position.

Results

There were 37 joints of Type A2 ankylosis and 32 joints of Type A3. All joints of Type A2 (100%) and 27 joints

of Type A3 (84.4%) definitely had a discernible disc, while 5 joints of Type A3 did not have discernible discs in MRI.

For Type A2 ankylosis, the lateral disc had a hemiconvex shape in 14 joints (37.8%), biplanar in 13 joints (35.1%), biconcave in 6 joints (16.2%), biconvex in 2 joints (5.4%) and amorphous in 2 joints (5.4%) (Figure 5), while the medial disc had a hemiconvex shape in 4 joints (10.8%), biplanar in 5 joints (13.5%) and biconcave in 28 joints (75.7%) (Figure 6). In Type A3 ankylosis with discernible discs, the lateral disc had a hemiconvex shape in 7 joints (21.9%), biplanar in 9 joints (28.1%), biconvex in 4 joints (12.5%) and amorphous in 7 joints (21.9%) (Figure 7), whereas the medial disc had a hemiconvex shape in 2 joints (6.3%), biplanar in 11 joints (34.4%), biconcave in 9 joints (28.1%) and amorphous in 5 joints (15.6%) (Figure 8, Table 1).

The mean (standard deviation) disc length was 10.88 (1.19) mm in Type A2 ankylosis, while it was 7.50 (0.82) mm in Type A3. There was a significant difference between Types A2 and A3 ankylosis ($U = 8.000$; $p < 0.0001$). For disc position, the intermediate position was determined in all joints of Types A2 and A3 ankylosis.

Discussion

Various types of ankylosis have been classified based on the type of tissue involved and the extent of fusion.¹⁶ Specifically, the types of ankylosis with a medially displaced residual condyle accounted for 75% of traumatic TMJ ankylosis. Accordingly, it is worthy to study the

Figure 5 The lateral disc shape in Type A2 ankylosis. (a) Hemiconvex, (b) biplanar, (c) biconcave, (d) biconvex, (e) amorphous. Arrows indicate the disc.

Figure 6 The medial disc shape in Type A2 ankylosis. (a) Biconcave, (b) biplanar, (c) hemiconvex. Arrows indicate the disc.

disc status in these types of ankylosis.⁷ Since 2009, we have been focusing on the disc status in Types A2 and A3 ankylosis based on the classification of Yang *et al*.³ We found that there were significant differences for disc shape, length and position between these two types of ankylosis.

In our study, the lateral disc in Type A2 ankylosis and the whole disc in Type A3 had severe deformity, while the medial disc in Type A2 had mild deformity. Obviously, the smaller the residual condyle is, the more severe deformity the disc status has. Reviewing the coronal CT again, the disc status might be related to

Figure 7 The lateral disc shape in Type A3 ankylosis. (a) Biplanar, (b) hemiconvex, (c) biconvex, (d) amorphous. Arrows indicate the disc.

Figure 8 The medial disc shape in Type A3 ankylosis. (a) Biplanar, (b) hemiconvex, (c) biconcave, (d) amorphous. Arrows indicate the disc.

the integrity and continuity of the cortical bone of the condylar head and the gap between the condyle and the glenoid fossa. Usually, the residual condyle in Type A2 had the largest size with complete and continuous cortical bone (Figure 9a). Therefore, 75.7% of the medial discs in Type A2 were biconcave in shape. When the gap between the condyle and the fossa was narrow, the medial disc was usually hemiconvex

Table 1 The lateral and medial disc shapes in Type A2 and A3 ankylosis

Disc shape	A2		A3	
	Lateral	Medial	Lateral	Medial
Hemiconvex	14	4	7	2
Biplanar	13	5	9	11
Biconcave	6	28	0	9
Biconvex	2	0	4	0
Amorphous	2	0	7	5
No discernible disc	0		5	
Total	37		32	

(10.8%) or biplanar (13.5%) in shape (Figure 9b). The residual condyle in Type A3 was smaller than in Type A2. When the cortical bone of the small condylar fragment was incomplete and discontinuous and the gap between the condyle and fossa was narrow, the disc was usually hemiconvex, biplanar, biconvex or amorphous shape, with no discernible disc (15.6%) (Figure 10). Only 28.1% of the medial discs in Type A3 were biconcave in shape. In addition, the disc length in Type A3 (7.50 mm) was shorter than in Type A2 (10.88 mm) owing to the smaller condylar size, discontinuity of the cortical bone of the condyle and the narrow gap between the condyle and fossa as previously stated. Therefore, there was a correlation between the disc status (including the disc shape and length) and the different types of TMJ ankylosis. However, the correlation between the disc status and the cortex of the residual condyle or the gap between the condyle and fossa in Types A2 and A3 will be studied, respectively, in future research.

Figure 9 Type A2 ankylosis. (a) The large residual condyle with complete and continuous cortical bone (black arrow). (b) The narrow gap between the fossa and the residual condyle (black arrow).

In Yang's classification and treatment protocol, if the medial condyle in Type A3 is too small to bear the load, it should be resected with the bony mass. Therefore, the joint needs to be reconstructed.³ In this study, the disc deformity was severe because of the smaller residual condyle. It is noted that the bony fusion should be removed completely, and the joint needs to be reconstructed. Therefore, treatment reaches the same protocol in the soft as well as hard tissues.

Furthermore, we found that there were no differences regarding disc position between Types A2 and A3 ankylosis. The residual condyles in combination with the discs were displaced in an anteromedial direction. According to our previous study,¹³ there were >97.3% disc displacements after intracapsular condylar fractures, while there were no disc displacements in this study. The study of Chen *et al*¹³ recorded the disc position relative to the lateral condylar fragment, while

our study recorded the disc position relative to the parasagittal slice exhibiting the largest residual condyle. Therefore, the results were not contradictory. Moreover, should we reposition the disc in combination with the lateral arthroplasty? Zhang and He⁷ resected the lateral bony fusion and repositioned the disc by using a stainless wire, fixed to the lateral border of the fossa. After the mean 2.2-year follow-up, a stable joint function was obtained, but one patient had disc displacement again. Yang *et al*³ released the disc and sutured it with temporalis myofascial flap or masseter muscle flap to fill the gap following lateral bone resection, achieving good results for these types of ankylosis. Therefore, it may not be necessary to reposition the disc in combination with lateral arthroplasty.

In conclusion, the smaller the residual condyle is, the more severe the deformity the disc shape has, and the shorter the disc length is. Moreover, the disc is usually

Figure 10 Type A3 ankylosis. (a) The incomplete and discontinuous cortical bone (black arrow). (b) The narrow gap between the fossa and the residual condyle (black arrow).

located between the eminence and the residual condyle. These results can help treatment planning and predict the post-operative long-term effects. However, whether

there is a correlation between the disc status and TMJ function or reankylosis after surgery needs further study.

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