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Clinical Paper
TMJ Disorders

Long-term evaluation of the stability of reconstructed condyles by transport distraction osteogenesis

E. Xiao, Y. Zhang, J. An, J. Li, Y. Yan
Department of Oral and Maxillofacial Surgery, School and Hospital of Stomatology, Peking University, Beijing, China

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Abstract. This retrospective longitudinal study evaluated the long-term stability of reconstructed condyles by transport distraction osteogenesis of the mandibular ramus in patients with unilateral temporomandibular joint (TMJ) ankylosis. 7 patients were followed up for 16–92 months (mean 39.4 months). The mean age of the patients at the time of distraction was 22.9 years (range 7–44 years). Maximal mouth opening and panoramic radiographs were recorded preoperatively, at the time of device removal and several years after removal of distraction device. At follow-up, cone beam CT images of the TMJ were obtained to confirm the changes of the reconstructed condyle. Absolute height (Co–Inc) and relative height (Co–Inc/Co–Go) of the reconstructed condyle and the asymmetric difference ratio (AR) were examined to assess the changes of condylar height and mandibular symmetry. The mean maximal mouth opening was stable during the period of follow-up. The mean absolute height and relative height of the reconstructed condyle decreased significantly ($P < 0.05$). Although no significant difference was found, the mandibular asymmetry difference ratio increased by 16.7%. These results suggested that the heights of reconstructed condyles were not stable in the long-term, and the mandible tended to be asymmetrical.

Keywords: temporomandibular joint ankylosis; condyle reconstruction; transport distraction osteogenesis.

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Temporomandibular joint (TMJ) ankylosis may be defined as 'an inability to open the mouth due to either a fibrous or bony union between the head of the condyle and the glenoid fossa'.[1] It may cause impaired speech, eating difficulties, facial disfigurement, airway compromise and psychological stress.[2,3] It is usually caused by trauma with associated condylar fracture.[4,5] Corrective surgery is usually the treatment of choice. When arthroplasty is performed, it is often accompanied by condylar reconstruction to restore the ramus height and jaw occlusion.

Recently, ramus transport distraction osteogenesis has been utilized to reconstruct condyles.[6–8] Few studies have reported the long-term outcomes of this operation and the sample sizes in these studies have been small.[9–11] The object of this study was to examine the long-term stability of reconstructed condyles and changes in the mandibular symmetry of patients with unilateral TMJ ankylosis.

Patients and methods

Patients with unilateral TMJ ankylosis treated by arthroplasty and transport distraction osteogenesis between 2002 and 2009 were included in this study. Patients with recurrent ankylosis and those with

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systemic diseases that influenced bone physiology were excluded.

For each patient, the ankylotic bone mass was resected through an extended preauricular approach and the resultant gap was larger than 1.5 cm. In the operation, the passive maximal mouth opening was more than 35 mm, which was achieved by placing a mouth-gag in the molar region. The temporal muscle myofascial flap was inserted into the gap by folding it downwards into the fossa. It was sutured with the anterolateral edge of the residual articular disc. The distraction device was attached and the direction of distraction was adjusted in order to transport the segment to the glenoid fossa.

After removal of the device, an L-shape osteotomy was performed. The distraction device was installed in the correct site after the mobility of the segment was tested by activating the distraction device. Figure 1A shows the distraction device installed in the appropriate site.

After a latency period of 5–6 days, distraction of 1 mm per day was divided into 3 times. When the distance between the transport segment and skull base reached 2 mm, the distraction was stopped so that no pressure was created on the flap. During the consolidation period, physical therapy was applied. After a consolidation period of 3–4 months, the distraction device was removed. Figure 1B demonstrates the regenerate bone formed in the distraction gap. The transported segment was remodelled to form a neocondyle.

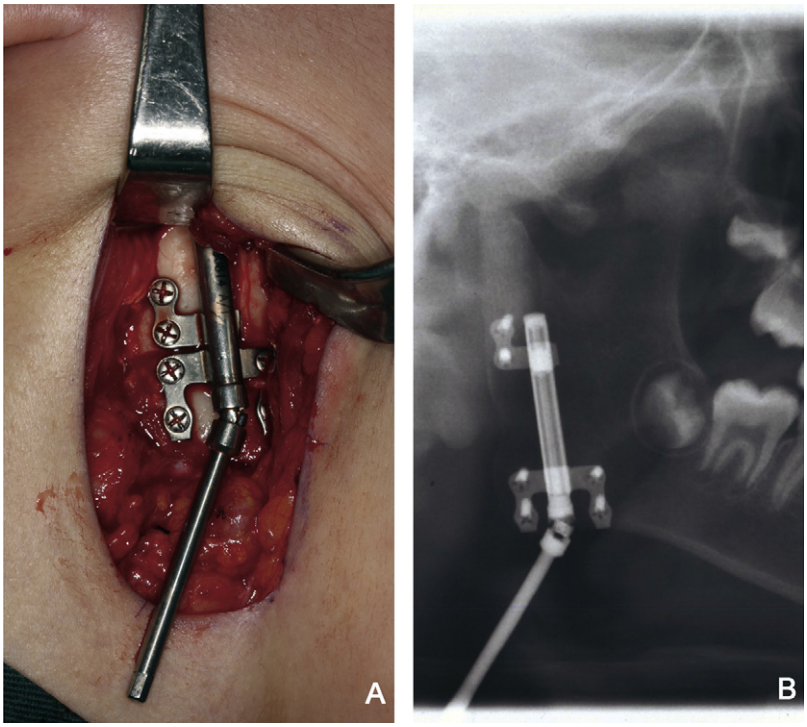

Fig. 1. Operative procedures.

Outcome assessment

Maximal mouth opening was recorded and standardized panoramic radiographs were taken preoperatively, at the time of device removal, and at follow-up for each patient. Cone beam CT images were also obtained at follow-up.

According to the method described by Kambylafkas et al.,[12] the outlines of the condyle and the ascending ramus of both sides were traced using Photoshop software. Line L_1 and line L_2 were drawn and the Co point, Inc point,[13] and Go point were localized. The absolute height (Co–Inc) and ramus height (Co–Go) were measured (Fig. 2). All parameters were measured by two experienced maxillofacial surgeons and were reduced to actual size using the standard height bar on the right edge of the panoramic radiographs. The intra-examiner variation was assessed by asking these two examiners to re-examine the radiographs. The inter-examiner reliability was assessed by intraclass correlation coefficients (ICCs). The relative height of each condyle was calculated using the following formula: Co–Inc/Co–Go.[13] The asymmetry difference ratio (AR) was calculated using the formula: % difference = $(C - A)/(C + A)/2 \times 100\%$[14] where C is controlled side ramus height, and A is affected side ramus height.

Data were analysed for statistical significance using paired t-tests. A P-value of <0.05 was considered to be significant. Statistical analyses were conducted using SPSS 18.0 software (SPSS Inc., Chicago, IL, USA).

Results

7 patients were included in this study. The duration of follow-up was more than

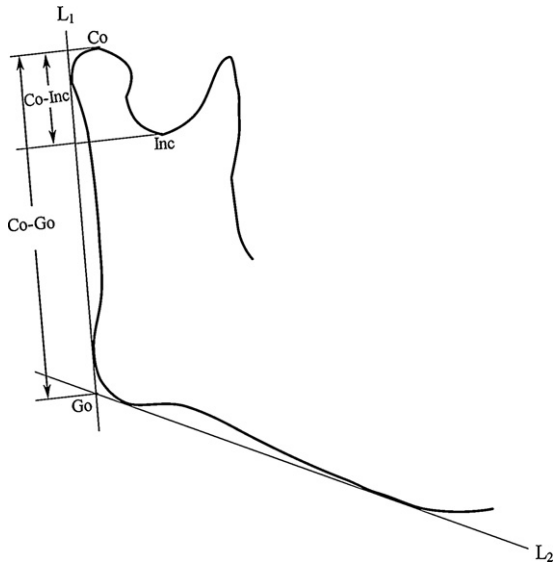

Fig. 2. Methods of measurement. L_1 is a line tangent to most prominent points of the posterior margin of the ramus. L_2 is a line tangent to the most prominent points of the inferior border mandible. Co is the most superior point on the condylar head. Inc is the deepest point between processus coronoideus and processus condylaris. The absolute condylar height (Co–Inc) and the total height of ramus (Co–Go) were measured.

Table 1. Measurement results and details of patients.

Patient	Gender	Age (years)	Affected side	Follow-up duration (months)	Phase 1 MMO (mm)	Phase 2 MMO (mm)	Phase 4 MMO (mm)	Phase 3 Co–IncA (mm)	Phase 4 Co–IncA (mm)	Phase 3 RH (%)	Phase 4 RH (%)	Phase 3 AR (%)	Phase 4 AR (%)
1	Female	7	Left TMJ	92	5.0	35.0	31.0	7.3	0.0	17.3	0.0	38.5	74.8
2	Male	35	Right TMJ	20.5	0.0	40.0	31.0	10.7	2.6	19.2	6.5	22.4	38.3
3	Female	7	Right TMJ	16	8.0	35.0	23.0	9.3	7.9	18.1	15.0	15.0	17.6
4	Male	44	Right TMJ	41	2.0	25.0	30.0	7.0	5.8	11.6	10.4	17.9	15.3
5	Male	19	Right TMJ	24	8.0	35.0	37.0	17.0	5.6	22.5	8.3	4.5	25.4
6	Male	33	Left TMJ	25	4.0	37.0	33.0	9.7	9.3	15.2	13.4	22.5	20.0
7	Male	15	Right TMJ	57	2.0	40.0	35.0	12.8	0.0	31.7	0.0	54.9	100.9
Mean		22.9		39.4	4.1	35.3	31.4	10.5	4.5	19.4	7.7	25.1	41.8
Std.					3.1	5.1	4.5	3.5	3.7	6.4	6.0	16.6	33.2
Sig.						0.113		0.021		0.030		0.061	

MMO, maximal mouth opening; RH, relative height of condyle; AR, mandible asymmetry difference ratio. Co–IncA, affected side Co–Inc. Phase 1, preoperative; phase 2, intraoperative; phase 3, removal of device; phase 4, follow-up period. The age of each patient was recorded at the time of operation.

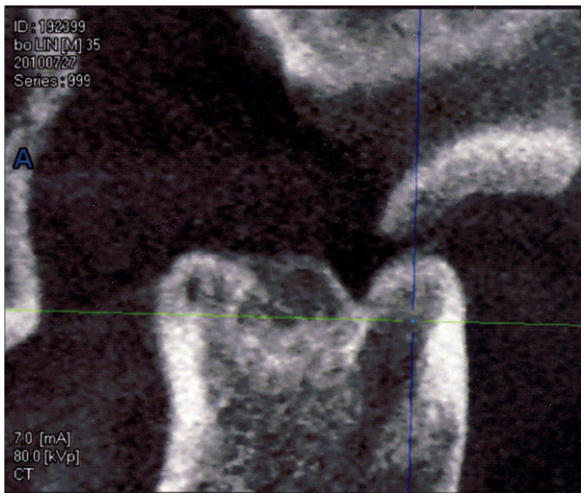

Fig. 3. Cone beam CT showing that the distraction process appears to have remodelled to form a neocondyle, situated in the glenoid fossa. A new cortical outline was found to have formed on the surface of neocondyle after distraction.

1 year (range 16–92 months; mean 39.4 months). This sample comprised 2 females and 5 males. Their mean age was 22.9 years (range 7–44 years) at the time of distraction. The mean maximal mouth opening was 4.1 mm (range 0.0–8.0 cm) preoperatively, 35.3 mm (range 25–40 mm) during the operation, and 31.4 mm (range 23–37 mm) at follow-up. The intra-examiner repeatability was tested by paired *t*-test. For examiner A, two times' measurements: Std. = 1.19 mm, Sig. = 0.277 > 0.05. For examiner B, two times' measurements: Std. = 1.18 mm, Sig. = 0.422 > 0.05. ICC results showed the measurements examined by these two examiners agreed extremely well (ICCs = 0.99). From the time of device removal to follow-up, the mean absolute height of the reconstructed condyle reduced by 6 mm (from 10.5 mm to 4.5 mm); the mean relative height decreased by 11.7% (from 19.4% to 7.7%); and the mandibular asymmetry difference ratio increased by 16.7% (from 25.1% to 41.8%). Table 1 shows the measurements and details for each patient.

The amount of condylar resorption was not obvious in the panoramic radiographs of 3 patients. This result was confirmed by the cone beam CT images; Fig. 3 shows the slight resorption of a reconstructed condyle. In 4 patients, the panoramic radiographs showed that the reconstructed condyles were obviously resorbed. This result was also confirmed by cone beam CT images; Fig. 4 shows the severe resorption of reconstructed condyles.

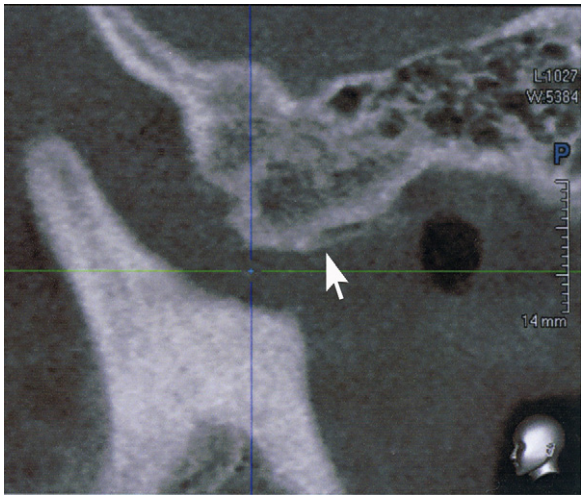

Fig. 4. Cone beam CT showing that the skull base of the glenoid fossa was thickened, the fossa shape had disappeared and a prominent bone mass (arrow) was located in the glenoid fossa next to the residual ramus.

Discussion

When transport distraction osteogenesis is being performed, panoramic radiography is often used as a tool to assess the position of the transported segment and the profile of the mandibular ramus.[9,10,15] The accuracy of measurements made from panoramic radiographs has been questioned, because the panoramic image is affected by both magnification errors and displacement, which lead to distortion.[16] Horizontal measurements have been shown to be particularly unreliable as a result of the non-linear variation in the magnification at different object depths, whereas vertical measurements are relatively reliable.[16,17] Therefore, many authors have used panoramic radiography to evaluate the vertical heights of the maxilla and mandible.[11,17–20]

Both absolute height and relative height were used in this study to describe the changes in condylar height. The advantage of determining a condylar ratio instead of linear measurements is that differences in magnification can be disregarded.[13] The relative height of the condyle (Co–Inc./Co–Go) is affected not only by the resorption of the reconstructed condyle, but also the growth of the ramus in young patients, whereas the absolute height (Co–Inc) is only affected by the resorption of the reconstructed condyle. This can explain why the reduction in relative condylar height was more than that of the absolute condylar height. Although the decline of these two parameters is unequal, they both decreased significantly, and this result was confirmed by cone beam CT images.

Condyle reconstruction by transport distraction osteogenesis was first described by Stucki-McCormick.[8] Since then, many doctors have applied this method for the condylar reconstruction of patients with TMJ ankylosis.[2,6,7,9,20] Stucki-McCormick[8] reconstructed the mandibular condyle in 2 patients, and reported that their masticatory function was stable during 20 months of follow-up, with increased mouth opening in both patients. Dean and Alamillos[10] studied 3 children for 12–25 months after distraction osteogenesis and reported no changes of mouth opening in the follow-up period. In a sample of 5 patients, after 1–2 years of follow-up, Cheung and Lo[9] concluded that TMJ ankylosis treated by transport distraction could achieve a long-term stable degree of mouth opening. The present results were consistent with their findings. The difference is Cheung and Lo[9] reconstructed condyle without interpositional material. The present authors use a temporalis flap as an interpositional material, because they think the interpositional flap is needed. Firstly, it can be a physical barrier to avoid direct bony contact between the skull base and bony segment. Secondly, it can serve as a cushion to reduce pressure on the reconstructed condyle. In this study, the patients all have satisfactory mouth opening at the end of follow-up. Similar conclusions were also drawn by Dimitroulis[21] and Chossegros et al.[22]

The stability of reconstructed condyle and facial symmetry was less desirable. These results were comparable with the long-term follow-up results of patients with hemifacial microsomia,[14,23–25] which were not completely consistent with the results of Sadakah et al.[19] and Eski et al.[11] Sadakah et al.[19] used distraction osteogenesis before releasing TMJ ankylosis to lengthen the mandibular ramus. After 17 months, the mean relapse was 3 mm compared with the mean distance of 20.7 mm lengthened by distraction. Eski et al.[11] used gap arthroplasty and simultaneous vertical and anteroposterior transport distraction to reconstruct the condyles. They concluded that the reconstructed condyle was stable after 13 months of follow-up.

With regard to patients with TMJ ankylosis, this study quantitatively measured the long-term stability of condyles reconstructed by L-shape osteotomy transport distraction osteogenesis for the first time. The resorption of reconstructed condyles may be explained by several reasons. Firstly, the adequate blood supply of distracted bone segments is a prominent factor in successful distraction osteogenesis.[26,27] When installing the distraction device, a poor blood supply to the distracted segment may be caused by the excessive detachment of the muscle and periosteal envelope. Less vascular soft-tissue attached to a small size transport segment may also contribute to the reduced blood supply. The authors hypothesize that the instability of the reconstructed condyle is related to poor blood supply. Sadakah et al.[19] reported a smaller degree of resorption of the reconstructed condyles than that shown in the present study. As the size of transport segment obtained from transverse osteotomy at the mandibular angle is larger than that from the L-shape osteotomy, there will be more vascular soft-tissue attachment and the blood supply will be adequate. Secondly, the distracted vertical distance may affect the long-term results. If the distracted distance is longer than or equal to the vertical dimension of the transport segment, the transport segment cannot contact the residual native ramus after the activation phase. The transport segment will lose the mechanical supports and blood supply from the native ramus, which may cause condylar resorption.

Transport distraction is generally successful at recovering jaw function in patients with TMJ ankylosis, and can provide long-term restoration of stable mouth opening. The height of the reconstructed condyle may not be stable over long-term follow-up and the mandible tends to be apparently asymmetrical.

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Competing interests

The work this article involved in has no conflict of interest concerned.

Ethical approval

This study was approved by the Ethics Committee of the Peking University Health Science Centre (IRB00001052-11002).

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Address:
Yi Zhang
Department of Oral and Maxillofacial Surgery
School and Hospital of Stomatology
Peking University
22 Zhongguancun Nandajie
Haidian District
Beijing
China
Tel: +86 010 62179977x5624
E-mail: zhangyi2000@263.net