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Occlusal adjustment after local resection of type 1 condylar osteochondroma

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Abstract

To evaluate the feasibility of the orthodontic traction after local resection of the condylar osteochondroma (OC).

From November 2011 to September 2016, consecutive patients with condylar OC who underwent orthodontic extraction after local resection of the mass were reviewed. Clinical data and cone-beam computed tomography (CT) were obtained before treatment (T0), 1 week after surgery (T1), and at least 6-month follow-up after OC resection (T2). Repeated-measures analysis of variance with Bonferroni multiple-comparison test was used to compare the 3-dimensional cephalometric variables at different time points and the paired *t* test was used to compare changes of temporomandibular joint (TMJ) space between the 2 sides at T1 and T2.

The sample consisted of 23 patients (16 females and 7 males). The mean postoperative follow-up interval was 10.9 months. No recurrence was observed during the postoperative follow-up period. Facial symmetry and occlusion were greatly improved. B deviation and the distance of gonion on the OC-affected side to the Frankfort horizontal (FH) were significantly improved from T0 to T1 and T2 ($P < .01$). The anterior space (AS) and superior space (SS) of the OC-affected side were significantly larger than that of the contralateral side at T1 in parasagittal CT views ($P < .05$), while no difference was found between the two sides at T2.

Local resection is an effective technique with less damage to the condyle. The application of postoperative directional traction could guide the condyle into the fossa, achieve normal TMJ space and stable occlusion, and eventually provide functional and esthetic outcomes.

Abbreviations: AS = anterior space, CBCT = cone-beam computed tomography, FH = Frankfort horizontal, Go = gonion, N = nasion, OC = condylar osteochondroma, Or = orbitale, Po = porion, PS = posterior space, S = sella, SS = superior space, TMJ = temporomandibular joint.

Keywords: local resection, mandibular condyle, orthodontic traction, osteochondroma

1. Introduction

Osteochondroma (OC) is one of the most common benign tumors of long bones, but it rarely occurs in the maxillofacial skeleton.[1] The most common site of the craniofacial region is the mandibular condyle. However, mandibular condylar OC could result in a progressive facial asymmetry, prognathic deviation of the chin, cross-bite to the contralateral side, and malocclusion with an open-bite on the affected side.[2] Therefore, the treatment of condylar OC should include the correction of the dento-maxillofacial deformities as well as resection of the tumor.

There are 2 types of condylar OC: type 1 (protruding expansion) and type 2 (globular expansion).[3] Type 1 OC with a narrow stalk on the condyle may result in dislocation of the condyle out of the fossa, especially for the common location of the anteromedial protruding expansion.[4] The deformity is mainly involving the mandible along with chin deviation and contralateral cross bite. Occasionally, a compensatory down growth of the maxilla due to the open bite may give rise to an obvious canting of the maxillary occlusal plane. However, pronounced compensatory maxillary changes are not common, especially in type 1. Therefore, local resection of the mass is a favorable alternative treatment modality, which involved removing the neoplasm and a small portion of the condylar head only and preserving the healthy portion of the condyle.[5–10] In our previous study, we found 68.4% (26/38) cases could obtain a stable occlusion immediately after the local resection.[5] But in some cases, occlusal discrepancy may still persist for a long time because of imbalance of bilateral muscles. How to reach a stable occlusion has become an important factor to evaluate the surgical treatment outcomes.

The orthodontic traction technique is thought to be a quicker, easier, and less invasive method for occlusal adjustment. Could it achieve a stable result if local resection of the mass combined with directional orthodontic traction? There are no sufficient

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literatures or guidelines available to answer this question. The purpose of this article was to evaluate the effect of postoperative orthodontic traction after local resection of type 1 OC and also to discuss considerations of this treatment modality.

2. Patients and methods

2.1. Study design

The patients were selected during November 2011 to December 2016 from the Department of Oral Surgery, Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine. This study was approved by the ethics committee of our institution. Patients who met the inclusion criteria were asked to complete an informed consent form.

Inclusion criteria were as follows: patients had a chief complaint of a gradual facial asymmetry and chin deviation over years; patients had complete records of facial photographs and cephalograms before and after treatment; an open bite on the affected side and a cross-bite on the contralateral side without an obvious occlusal canting(less than 4°); a stable occlusion or a minimal occlusal discrepancy could also be regained based on the dental model for the preoperative simulation; the diagnosis of type 1 OC was confirmed by pathological examination and local resection of the mass was performed in all patients by the same surgeon under general anesthesia; the unstable occlusion persisted 1 week after surgery. Patients were excluded if they had: craniofacial anomalies; pathologic background that could compromise bone healing; orthognathic surgeries or reconstruction with bone grafts or joint prosthesis; the active preoperative orthodontic treatment.

2.2. Surgical protocol

All patients underwent open surgeries under general anesthesia through nasotracheal intubation, using the modified preauricular incision approach. After the exposure of the affected condyle and the tumor stalk, a sagittal saw was used to resect the tumor in accordance with the designed angles and depth (Fig. 1). After the resection of the bony mass, the ramus stump was also trimmed. The space after tumor removal was filled with a free fat flap or a temporalis myofascial flap. Finally, normal occlusion and proper midline relationship were checked. In all, all cases with local resection of the mass and preservation of the condylar head were the core concerns during the operation.

2.3. Orthodontic traction

If the malocclusion was persistent 1 week after the surgeries, the orthodontic traction can be performed. For the clinical procedure, passive surgical wires can be ligated into the brackets. Stainless steel standard straight wire appliance with a slot size of 0.022-in (3M Unitek, California) was used. Different from the typical orthodontic approach, the orthodontic appliances were used here not for alignment of the teeth, but for guidance of the jaw. Because teeth acted as a handle to reposition the jaw, a rectangular 0.018×0.025-in stainless steel archwire was bent according to alignment of the teeth. It is recommended that brackets be bonded nearly in line while at the same time minimizing occlusal interference. The arch wire was fixed with ligature wire, so as not to express torque or rotation force on the teeth, and then traction hook was fixed on the arch wire. First, oblique elastic traction (1/4″, 3.5 OZ, Unitek Elastics, 3M Unitek) with a continuous light force was used to overcorrect the chin deviation after surgery for 2 to 6 weeks. Then vertical maxillomandibular elastics (3/16″, 3.5 OZ, Unitek Elastics, 3M Unitek) were applied to further adjust the occlusion for 4 to 6 weeks. Adjustments performed at 2-week intervals, with elastic traction applied 24 hours. When the occlusion was stable with tight contact and mandible did not relapse to a deviated position after 8-week follow-up without elastic traction, the treatment could be considered to be finished (Fig. 2).

3. Evaluation

3.1. Clinical evaluations

The surgical technique of different types of condylar OC was recorded. Clinical features including facial morphology,

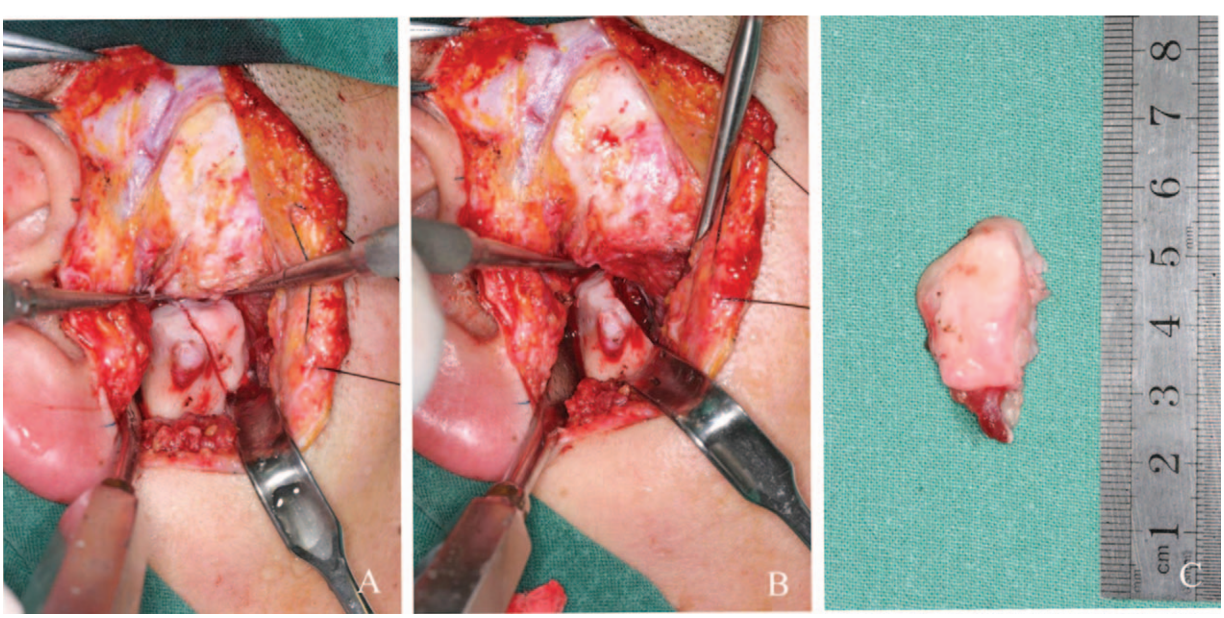

Figure 1. Local resection of the mass. (A) Bony incision, (B) after resection, and (C) the gross specimen.

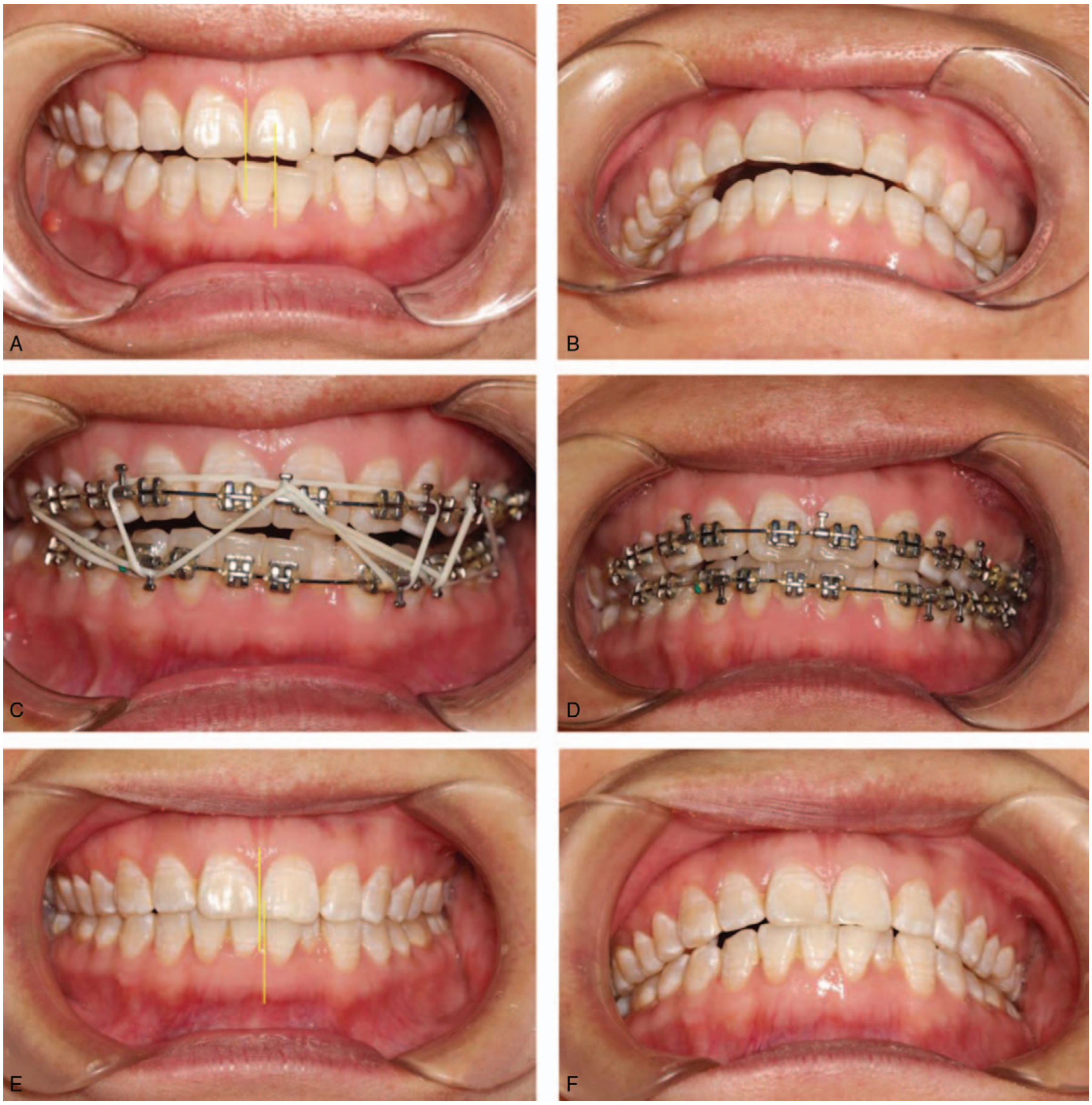

Figure 2. Orthodontic traction for malocclusion after local resection of the OC. (A, B), Malocclusion with deviation of the lower dental midline and regional openbite before surgery. (C) Postoperative directional orthodontic traction was performed to correct the midline and the occlusion. (E, F) Restored occlusion with dental midline correction. OC = condylar osteochondroma.

occlusion, temporomandibular joint (TMJ) pain, swelling, and maximal incisal opening were evaluated during the follow-up period.

3.2. 3-dimensional cephalometry

Cone-beam computed tomography (CBCT) scans were taken preoperatively (T0), 1 week after surgery (T1) and at least 6 months after surgery (T2) for all patients. Patients were scanned while seated in a natural head position using a standard CBCT scanning protocol (field of view: 22 × 16 cm; scan time: 40 seconds; voxel size 0.4 mm; i-CAT, 3-dimensional Imaging System). The data were imported as DICOM format in Dolphin Imaging software (11.7, Chatsworth, CA). Linear and angular measurements were obtained in all 3 planes on 3-dimensional head model similar to the method described by Lee.[11] The Frankfort horizontal (FH) plane was defined through the right and left orbitale and the left porion, and the midsagittal reference plane was defined the plane perpendicular to the horizontal plane passing through nasion and sella. Then, B point and gonion were digitized on each side (Fig. 3). The definitions of the cephalometric variables measured in this study are listed in Table 1.

3.3. TMJ space measurements on CBCT

The measurements of the two sides were taken on the largest parasagittal slice of CBCT imaging at T1 and T2. The linear measurements of OC joint space were assessed and the anterior space (AS), superior space (SS), and posterior space (PS) were measured from the most prominent anterior, posterior, and superior condylar points to that of the glenoid fossa as according to the method of Cohlmia et al.[12] The plane parallel to the FH plane was used as the reference plane (Fig. 4).

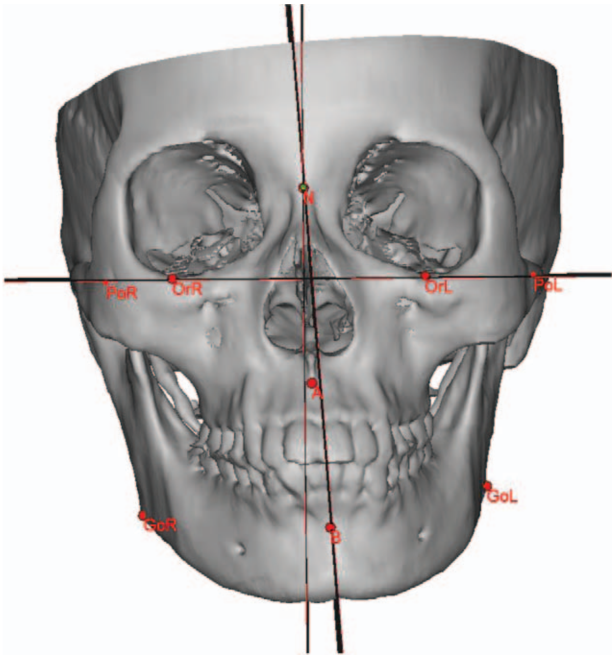

Figure 3. 3-dimensional cephalometric measurements on a virtual model. Go-midsagittal plane, horizontal distance from the gonion to the midsagittal plane; Go-Frankfort horizontal plane, vertical distance from the gonion to the Frankfort horizontal plane; B-midsagittal plane, horizontal distance from the B point to the midsagittal plane; B deviation angle, angle between the midline and the B-nasion vector.

3.4. Statistics

All measurements were repeated by the same investigator (ZHM), who had much experience in 3-dimensional technology, and the mean of the 2 measurements was used in the statistical analysis. All analyses were performed with software (version 17.0; SPSS, Chicago, Ill). The Shapiro–Wilk normality test and Levene's variance homogeneity test were also applied to the data, which were found to be normally distributed and to have homogeneity of variance. The repeated-measures analysis of variance was used for 3-dimensional cephalometry at T0, T1, and T2 and multiple comparisons were performed with the Bonferroni test. The joint space of the two sides at T and T2 were also compared using paired *t* tests. The significance level was set at a 2-tailed *P* value of .05. Linear measurements were in increments of 0.01 mm, and angular measurements were in increments of 0.01°.

Table 1

Definitions of the 3-dimensional cephalometric landmarks and measurements.

Landmarkers	Definition
Orbitale (Or)	Most inferior point on margin of orbit
Porion (Po)	Most superior point of outline of external auditory meatus
Nasion (N)	The midpoint of the frontonasal suture
Sella (S)	The center of the hypophyseal fossa (sella turcica)
Gonion (Go)	The most caudal and most posterior point of the mandibular angle
B point	Most concave point on mandibular symphysis
Frankfort horizontal (FH)	The plane through the right and left orbitale and the left porion
Measurement	**Definition**
Go-midsagittal, mm	The shortest distance between the gonion and the midsaggital plane
Go-FH, mm	The shortest distance between the gonion and the Frankfort plane
B-midsagittal, mm	The shortest distance between the B and the midsagittal plane
B deviated angle, °	Angle between the midline and the B-nasion vector

FH=Frankfort horizontal, Go=Gonion, N=nasion, Or=orbitale, Po=porion, S=sella,

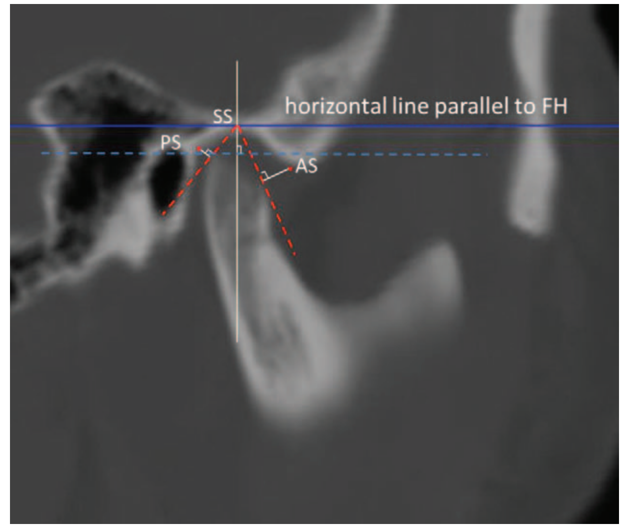

Figure 4. Linear measurements of the joint space in the sagittal CBCT view. Anterior joint space (AS), superior joint space (SS), and posterior joint space (PS) were measured according to the method of Cohlmia et al.[12] AS=anterior joint space, CBCT=cone-beam computed tomography, PS=posterior joint space, SS=superior joint space.

4. Results

Twenty-six cases were performed local resection of the mass and 3 cases were combined with genioplasty. However, 3 cases were lost to follow-up, and 23 patients were included in the final analysis. There were 16 females and 7 males, aged from 21 to 56 years (mean age of 36.2 years). The follow-up after surgery averaged 23.8 months with a range of 6 to 32 months. Seven patients were followed-up for at least 2 years, 7 were 1 to 2 years postoperatively, and 9 were less than 1 year.

4.1. Operative findings

For all cases, there was a stalk existing between the mass and the condylar head, and the condylar surface was involved less than half. The osteotomy approach was dependent on the forms of the mass location. Based on the preoperative CT classification,[4] 11 patients with anterior or anteromedial form of type 1 OC were operated on through local resection of the precondyle. Five patients with posterior or posteromedial form were operated on through local resection of the postcondyle. Three patients with medial form were also operated on through local resection of the postcondyle. Four patients with gigantic form were operated on through local transzygomatic resection.

4.2. Clinical outcomes

Duration of the orthodontic traction ranged from 6 to 12 weeks (mean, 8 weeks) in all patients. Though mandibular deviation was not completely corrected in several patients, favorable

Figure 5. Preoperative and postoperative outcomes. (A) Frontal view showing elongation of the OC-affected side with mandible deviation to the contralateral side; (B) the panoramic radiograph showing a radiopacity located medial to the condyle (yellow arrow); (C) locked occlusion on the OC-affected side, and crossbite on the contralateral side; (D) improved facial appearance; (E) local resection of the OC using a transzygomatic approach; (F) stable occlusion after orthodontic traction. OC = condylar osteochondroma.

change in the facial aesthetics occurred. During the follow-up period, no recurrence was observed and stable occlusions were obtained in all cases. Proper posterior molar overjet and molar contacts were obtained. No patient suffered from obvious occlusal interference or regional openbite (Fig. 5). Their mouth opening was greatly improved. Symptoms including TMJ pain and swelling disappeared after the operation.

4.3. Changes on 3-dimensional virtual models

The changes of 3-dimensional cephalometric measurements are shown in Table 2. The distance of the gonion to the midsagittal plane of the OC-affected side did not show any significant difference among different time points ($P > .05$). There was also a statistically significant reduction in the vertical distance of the gonion to the FH plane on the ipsilateral side ($P < .01$), with a mean reduction of 3.27 mm from T0 to T1 and 2.84 mm from T1 to T2. With regard to the B position, B deviation angle and B to the midsagittal plane were significantly improved from T0 to T1 and T2 ($P < .05$).

4.4. Joint space changes

Table 3 shows joint space measurements of the 2 sides in the parasagittal view of the CT image. The AS and SS were

Table 2

Comparisons of 3- dimensional cephalometry measurements at T0, T1, and T2.

	T0	T1	T2	*P* value	Multiple comparisons
OC-affected side					
Go-midsagittal	44.49 ± 3.65	46.28 ± 2.32	46.73 ± 4.14	.124	
Go-FH	66.33 ± 4.87	63.06 ± 4.06	60.22 ± 5.64	.001	T0 > T1 > T2
Non-OC-affected side					
Go-midsagittal	52.35 ± 3.91	50.54 ± 2.68	50.71 ± 3.87	.238	
Go-FH	54.36 ± 5.29	55.52 ± 4.76	55.67 ± 5.88	.150	
B-midsagittal, mm	7.72 ± 3.14	4.31 ± 1.24	2.81 ± 2.90	.001	T0 > T1 > T2
B deviated angle, °	4.92 ± 2.68	2.79 ± 1.52	1.93 ± 1.73	.001	T0 > T1,T2

FH = Frankfort horizontal, Go = gonion, OC = condylar osteochondroma, T0 = pretreatment, T1 = 1 week after surgery, T2 = at least 6-month follow-up after surgery.
Data are presented as mean ± standard deviation. Repeated-measures analysis of variance and Bonferroni multiple comparison test were performed.

Table 3

Comparison of the joint space at T1 and T2.

	T1				T2				
	OC-affected side	Unaffected side	Difference	*P*	OC-affected side	Unaffected side	Difference	*P*	*P*
AS, mm	3.44±1.15*	2.12±0.51	1.32±1.35	.037	2.57±0.60*	2.04±0.86	0.53±0.82	.562	.036
SS, mm	4.15±1.22†	3.04±1.08	1.11±0.93	.024	2.83±1.27†	2.42±1.03	0.41±1.07	.305	.014
PS, mm	2.43±1.45	1.83±1.33	0.59±1.49	.316	2.18±1.27	2.05±1.18	0.13±0.96	.759	.764

AS=anterior space, OC=condylar osteochondroma, PS=posterior space, SS=superior space, T1=1 week after surgery, T2=at least 6-month follow-up after OC resection.
Data are presented as mean±standard deviation. Paired *t* tests were performed.
* $P<.05$ between T1 and T2 in AS for the OC-affected side.
† $P<.05$ between T1 and T2 in SS for the OC-affected side.

significantly larger on the OC-affected side than on the contralateral side at T1. There were statistically significant differences in the AS and SS reduction ($P<.05$) for the OC-affected side from T1 to T2. Conversely, the PS did not present any significant change ($P>.05$). No significant differences were found between the 2 sides regarding the AS, SS, and PS at T2 ($P>.05$). This indicated that the remaining condyle was nearly in the anatomic position during the follow-up CT examination and no evidence of any mass growth or resorption occurred at the condylar region (Fig. 6). The relationship between the joint space and malocclusion at T0, T1 and T2 was illustrated in Figure 7.

5. Discussion

To correct facial deformity, most studies focus on surgical approaches for the treatment of type 1 OC including conservative condylectomy or total condylectomy. Wolford[2] reported bilateral mandibular ramus osteotomies to increase the occlusal

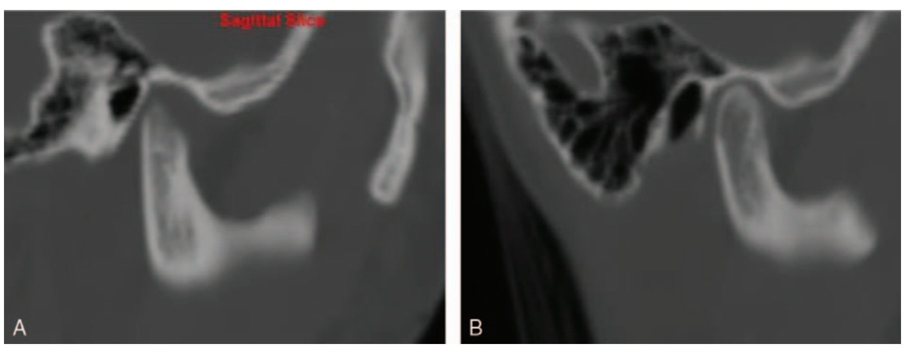

Figure 6. TMJ space at T1 and T2. (A) Enlarged AS and SS at T1; (B) normal joint space distribution at T2. AS=anterior joint space, SS=superior joint space, TMJ=temporomandibular joint. T1=1 week after surgery, T2=at least 6-month follow-up after surgery.

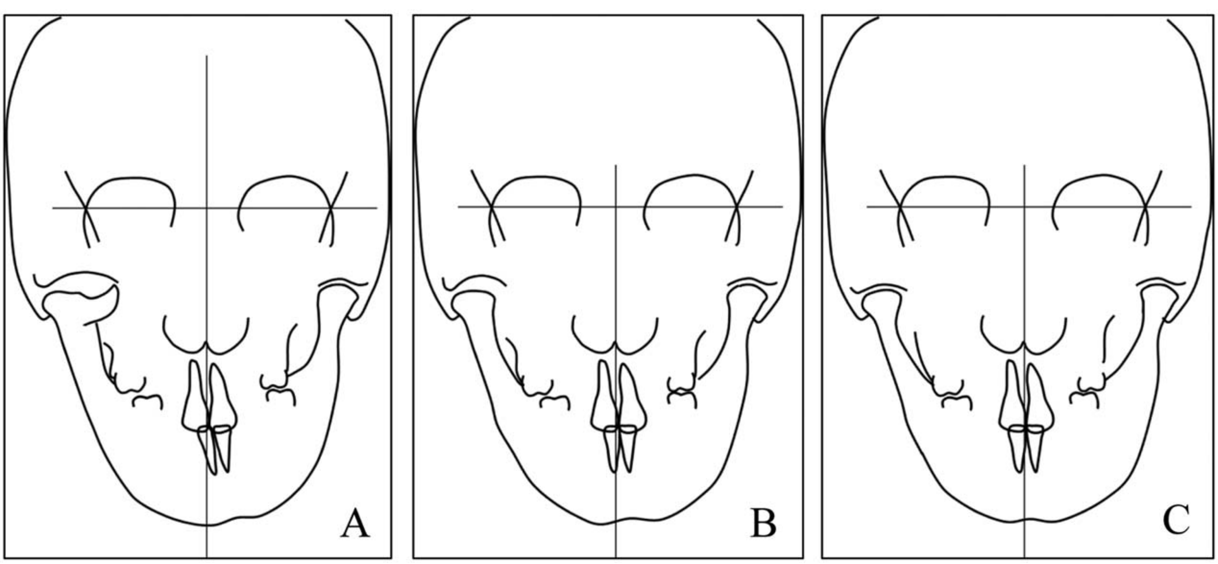

Figure 7. Schematic diagram of OC at T0, T1, and T2, respectively. (A) Facial asymmetry and malocclusion with ipsilateral OC and contralateral crossbite; (B) enlarged joint space on the ipsilateral side after OC resection with improved midline deviation at T1; (C) normal joint space with corrected facial symmetry and stable occlusion at T2. OC=condylar osteochondroma, T0=before treatment, T1=1 week after surgery, T2=at least 6-month follow-up after surgery.

plane and transversely level the mandible. Yu et al[13] have reported condylar OC resection combined with two-jaw orthognathic surgery in the treatment of asymmetric prognathism caused by condylar OC. Tanaka et al[14] performed ipsilateral condylectomy and contralateral ramus osteotomy to treat unilateral OC. However, it is undeniable that surgical trauma and complications are increased. It was reported that 64% to 80% of the asymmetry was solely detected in the mandible and both the maxilla and the mandible were involved in the minority.[15,16] Similarly, type 1 OC often leads to mandibular asymmetry without an obvious occlusal plane canting, so the local resection of the mass with the condylar head preserved can be performed, which is of a great benefit for facial symmetry.[5]

When a proper occlusion could not be spontaneously recovered after local resection of the OC, malocclusion will affect jaw function and life quality. Therefore, patients with malocclusion accompanied with the condyle in an eccentric position often require an orthodontic treatment. Recently, combined surgical and orthodontic treatment is an effective procedure in treatment of OC accompanied with facial deformity.[13] However, orthodontics is linked to increased treatment duration and higher care cost with masticatory discomfort,[17] which often meet with patients' direct refusal. In the present study, orthodontic appliances were used here not for alignment of the teeth, but for guidance of the jaw, which was vastly different from the typical orthodontic approach. Elastic traction with a continuous light force was applied to help to resist the muscular forces and the tendency of the skeletal relapse.[18]

Compared with 2D cephalometric analyses, a 3-dimensional radiologic examination permits an accurate landmark location and avoids overlapping structures. Moreover, to the best of our knowledge, few previous studies have evaluated the effect of orthodontic directional traction assisted with local resection of the mass using CBCT as a 3-dimensional and objective measuring tool. In this study, 3-dimensional cephalometric results indicated an improvement of the B deviation after surgery. Furthermore, the position of B point and the gonion of the OC-affected side to the FH were significantly changed by the orthodontic traction. Thus, a significant benefit in achieving facial symmetry in the final treatment was observed. The B point instead of the menton point was selected in evaluating the facial symmetry to avoid the influence of chin surgery on the pogonion for OC patients.

In the current study, presurgical data were excluded in TMJ space analyses because it was difficult to evaluate the OC side. The AS and SS were significantly greater on the OC-affected side than those on the contralateral side, which also demonstrated the larger AS and SS were associated with malocclusion after surgery. This can be explained by the fact that the muscular force generating by altering the mandibular position might have changed the re-established occlusion, diminishing the surgery outcomes. No statistically significant differences were found in the joint space between the 2 sides during follow-up. It was indicated that normal condylar position with balanced distribution of joint space occurred after the orthodontic traction.

In the present study, on the basis of the dental models, cephalometric analysis and 3-dimensional reconstructions, we recommended several factors pertinent to the postoperative directional traction assisted in local resection of the mass should be considered as follows: the occlusal canting should be $<4°$, because cants $>4°$ have been considered as the threshold for recognition of occlusal cant by 90% of observers;[19] the mandible could be fitted to the maxilla according to the coordination of the dental midline and chin with the facial midline for preoperative planning; the upper and lower arches could be coordinated and a stable occlusion could be also obtained according to the dental model; and CBCT examination revealed enlarged anterior and posterior joint space at 1 week postoperatively.

Therefore, an orthodontic directional traction could gradually adjust the affected condyle within the glenoid fossa, facilitate TMJ remodeling, and eventually contribute to regaining the anatomic condylar position. Postoperative and follow-up results showed meaningful clinical improvement with stable results in all cases without tumor recurrences and patients were satisfied with their results. Despite local resection of the mass combined with postoperative directional orthodontic traction seem a feasible and a more conservative alternative in the management of type 1 OC, which could become a new treatment modality for OC patients. However, the main limitation of this report is the lack of a control group. If occlusal discrepancy still persisted or became worsen 1 week postoperatively, it may not be feasible to have such a group due to ethical reasons of no treatment offered.

6. Conclusions

This study demonstrates ipsilateral local resection of the mass is adequate to treat type 1 OC (protruding expansion) with a stalk, revealing a less invasive approach to the condyle and no recurrence of lesion during follow-up. The application of postoperative directional traction could guide the condyle into the fossa, achieve the normal TMJ space and stable occlusion, and eventually provide functional and esthetic outcomes. Therefore, local resection and combined with postoperative orthodontic traction provides us with a relative conservative and feasible alternative, which could be recommended as a new modality for treating type 1 OC.

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