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Condylectomy as the treatment for active unilateral condylar hyperplasia of the mandible and severe facial asymmetry: retrospective review over 18 years

J.-Y. Kim, T.-W. Ha, J. H. Park, H.-D. Jung, Y.-S. Jung
Department of Oral and Maxillofacial Surgery, Oral Science Research Centre, Yonsei University College of Dentistry, Seoul, Republic of Korea

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Abstract. Unilateral condylar hyperplasia (UCH) of the mandible is a disorder affecting the condyle size, resulting in facial asymmetry. This study was a retrospective review of 27 patients with UCH who underwent condylectomy between 2000 and 2017 at Yonsei University Dental Hospital. Patient demographic characteristics were summarized. UCH was divided into three subtypes: hemimandibular elongation (HE, n = 15), hemimandibular hyperplasia (HH, n = 4), and osteochondroma (OC, n = 8). Of the 27 patients, only one with the HE type and five (18.5%) with the OC type complained of joint pain. Bone scans of all patients showed higher uptake on the UCH side. Lip and maxillary canting was prominent in the HH and HE types. Five patients (18.5%) underwent condylectomy alone, 13 (48.1%) underwent condylectomy with orthodontic treatment, and nine (33.3%) underwent adjunctive jaw surgery with orthodontic treatment. The treatment modalities varied according to the subtype. In all OC type patients, removal of the hyperplastic condyle treated the facial asymmetry. Additional post-surgical orthodontic treatment was necessary in only three cases (37.5%). All HH type patients required mandibuloplasty. All patients showed a stable occlusal outcome without relapse and an improvement in subjective symptoms, despite a decrease in mouth opening of 2.2 mm. These findings might be useful in treatment planning for UCH patients.

Key words: condylectomy; temporomandibular joint; unilateral condylar hyperplasia; facial asymmetry; orthognathic surgery.

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Facial asymmetry can affect not only aesthetics but also the patient's occlusion, temporomandibular joint (TMJ), masticatory function, and speech[1]. Unilateral condylar hyperplasia (UCH), one of the causes of facial asymmetry, refers to a disorder in which the head and neck of the condyle on one side increase in size. Although UCH can have several causes, the aetiology remains unclear[1,2]. Osteochondroma, which predominantly occurs in patients between 30 and 50 years of age, is a non-self-limiting condition and may also be regarded as a type of UCH[3].

Obwegeser and Makek classified condylar hyperplasia into three main categories[4]. Type 1 includes hemimandibular elongation, in which there is condylar neck elongation with a normal condylar head, prominent horizontal growth, and displacement of the chin and midline to the contralateral side. Type 2 includes hemimandibular hyperplasia, in which the asymmetry is more prominent and complicated due to the excessive growth of the condylar head, neck, and the ascending ramus. The vertical vector dominates and affects the mandibular body and angle. Due to increased growth at puberty, type 2 cases of condylar hyperplasia present with a more prominent compensatory downward growth, as well as maxillary molar supra-eruption, compared to type 1 cases. Type 3 condylar hyperplasia cases present as a mixture of types 1 and 2.

In 2014, Wolford et al. classified condylar hyperplasia based on clinical features, imaging, and histology. Condylar hyperplasia that was non-self-limiting with unilateral vertical elongation was regarded as type 2, and histologically confirmed as an osteochondroma[5]. Osteochondroma usually occurs in the mandibular condyle, which develops by endochondral ossification in the facial bone. Although osteochondroma rarely recurs, it is a neoplastic growth that requires surgical removal by condylectomy.

The most important determinant in the diagnosis of facial asymmetry with UCH is the assessment of condylar growth activity. In the case of active condylar growth, the treatment plan must aim to correct the asymmetry and avoid recurrence. For growth analysis, bone scintigraphy is performed to determine whether the isotope uptake is increased[6,7].

Condylectomy is considered the treatment of choice in the case of active condylar growth, based on the understanding that resection of the growth centre is necessary in order to prevent relapse after surgery[8]. Conversely, when condylar growth has stabilized, the need for a condylectomy is reduced, and conventional orthognathic surgery is preferred for treatment of the facial asymmetry.

The aim of this study was to evaluate the clinical manifestations and treatment outcomes following condylectomy in patients diagnosed with UCH by bone scintigraphy. It appears that few previously reported studies have compared the three subtypes of UCH. Thus, it was also sought to explore how the treatment protocol may be altered for the management of the different UCH subtypes including hemimandibular elongation, hemimandibular hyperplasia, and osteochondroma. A treatment algorithm to further help in decision-making and treatment planning is proposed.

Materials and methods

Subjects and assessment

This retrospective study included 27 patients (16 male, 11 female) with a diagnosis of facial asymmetry with UCH, who underwent condylectomy between 2000 and 2017 in the Department of Oral and Maxillofacial Surgery, Yonsei University Dental Hospital. Patients diagnosed with UCH who underwent orthognathic surgery without condylectomy were excluded from the study. These patients were diagnosed on the basis of clinical, radiographic, and facial photographic evaluation. Computed tomography (CT) scans and cephalograms were obtained, and bone scanning with technetium 99 m (^{99m}Tc) scintigraphy was performed to determine whether the growth centre of the condyle head was active. In the early 2000s, a planar whole-body bone scan was used. Starting in 2010, single photon emission computed tomography (SPECT) was widely used, and three-dimensional (3D) analysis was performed using SPECT–CT.

The medical charts, facial photographs, and radiographs were reviewed and analyzed retrospectively. A detailed diagnosis was performed and the cases were divided into three subtypes based on clinical and radiographic examinations, as follows: (1) hemimandibular elongation (HE) type; (2) hemimandibular hyperplasia (HH) type; (3) osteochondroma (OC) type.

Osteochondroma was confirmed by histological examination of the resected condyle. Dental casts were used for occlusion and dental evaluation. Preoperative and postoperative TMJ function, including maximum mouth opening, joint sounds, and pain, was also assessed. Transverse canting of the lip and maxilla were measured. Lip canting was determined using a 1:1 ratio frontal photograph. The inter-pupillary line was set as a reference line. Maxilla canting was measured using a posteroanterior cephalogram (Fig. 1). The ramus height was measured on a panoramic X-ray to evaluate the change in vertical dimension due to remodelling of the mandibular condyle. The distance from the tip of the condylar head to the antegonial notch was measured manually. To minimize the radiological distortion, the length of the first molar was measured and the distortion ratio was examined. The difference in measured values between the immediate postoperative and last follow-up was calculated.

All of the following data were recorded: age, sex, chief complaint, affected side, diagnosis, bone scan, pre- and post-treatment TMJ evaluation, compensatory growth, extent of condylectomy, adjunctive surgery, total treatment time, duration of follow-up, relapse, and ramus height.

Surgical procedure and postoperative procedure

The treatment plan was established according to the condylar growth activity and the degree of asymmetry. In the early 2000s, when there was no access to 3D simulation using a computer, virtual surgery was performed with a rapid prototype model. Using this, it was possible to determine the amount of resection during condylectomy. Starting in 2010, 3D simulation for surgical planning was performed using DICOM files from CT. For two patients, simultaneous orthognathic surgery with condylectomy was performed.

For all patients, the pre-auricular approach was used to expose the condylar head on the affected side, and the condylectomy was performed based on the amount of resection required for each patient. The resection performed was more than 15 mm in all cases, and included the cartilaginous cap. The ablation volume was adjusted for each individual and a proportional condylectomy was performed. To prevent TMJ ankylosis, the discs were preserved and procedures such as disc repositioning were not performed. Active physiotherapy using intermaxillary elastic therapy was conducted, and re-evaluation was carried out periodically. Most of the patients were treated with orthodontic treatment during this period[9]. The need for additional surgery was evaluated after about 6 months. In some patients, secondary orthognathic surgery was performed to correct the residual

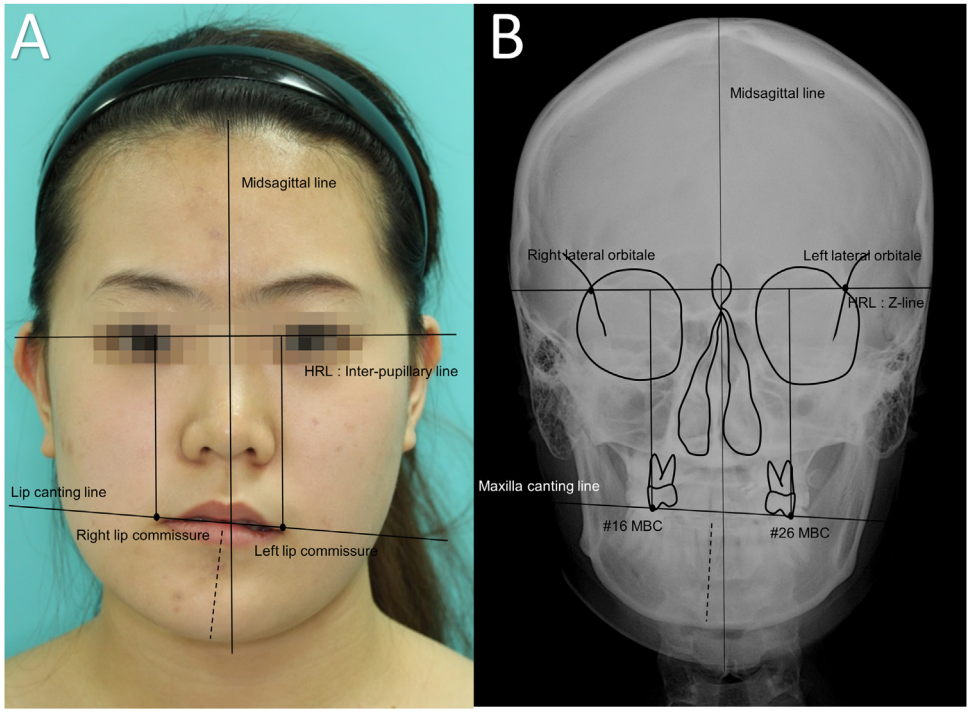

Fig. 1. Methods for the measurement of lip and maxilla canting. (A) Lip canting was evaluated as the difference in the vertical distance from the inter-pupillary line to the lip commissures on the two sides. (B) Maxilla canting was evaluated as the difference in the vertical distance from the reference line passing through the internal-most points of the two frontozygomatic sutures to the mesiobuccal cusp of each of the upper first molars. Abbreviations: HRL, horizontal reference line; Z-line, line passing through the internal-most points of the two frontozygomatic sutures (lateral orbitale); MBC, mesiobuccal cusp.

asymmetry or anteroposterior skeletal discrepancy.

Follow-up

All patients underwent periodic follow-up for a duration ranging from at least 2 years to 18 years. At Yonsei University College of Dentistry, patients are followed up for at least 2 years after the treatment, and then it is recommended that they attend the clinic once a year. Patients with at least 2 years of follow-up were included in this study. For each patient, periodic radiographs and facial photographs were taken to examine the condyle and monitor for a relapse of the condylar hyperplasia. In addition, post-treatment TMJ evaluation was performed after the completion of treatment.

Results

The mean age at the time of diagnosis was 22.8 years (standard deviation (SD) 3.85) for the HE subtype patients (13 male, 2 female), 21.5 years (SD 2.38) for HH subtype patients (1 male, 3 female), and 47.0 years (SD 8.22) for OC subtype patients (2 male, 6 female). All patient demographic data, as well as details including the complaint, compensatory growth, type of adjunctive surgery, TMJ evaluation, maximum mouth opening, treatment time, and follow-up period, are shown in Tables 1–3. The average height and width of the condyle resection were 21.3 mm (SD 3.19) and 16.4 mm (SD 3.14), respectively.

Chief complaint

All patients with HE and HH complained of facial asymmetry, with an additional complaint of a prognathic mandible or malocclusion. For both of these types, only one patient complained of joint pain. In the OC type, five patients (62.5%) complained of joint pain.

Bone scan

When the difference in activity level between the two sides was more than 10%, it was judged that there was a significant uptake. For all patients, the uptake was higher on the side with condylar hyperplasia.

Lip and maxillary canting

A vertical difference of $\leq$2 mm was classified as mild canting, a difference of 2–4 mm as moderate, and a difference of $\geq$4 mm as severe. As shown in Tables 1–3, the lip and maxillary canting were more prominent in the HH type compared to the other types. In the OC type, canting was mild in most cases, and no canting was observed in two of the patients.

Adjunctive surgery

Nine (33.3%) of the 27 patients in this study required orthognathic surgery; the remaining 18 patients (66.7%) did not require adjunctive surgery. Of these latter patients, condylectomy alone was performed in five (18.5%) with the OC subtype; the other 13 patients (48.1%) underwent orthodontic treatment to treat the remaining malocclusion.

Second stage orthognathic surgery was performed in four of the 15 HE patients (26.7%), and surgically assisted rapid palatal expansion (SARPE) was performed for the relief of crowding and arch width discrepancy correction in one patient (6.7%). All four HH type patients underwent orthognathic surgery, of whom two (50%) had second stage orthognathic surgery and two (50%) had simultaneous orthognathic surgery with condylectomy (Fig. 2). Of particular note is that mandibuloplasty including border shaving was performed in all HH-type patients.

Table 1. Clinical data and demographic features of patients with hemimandibular elongation.

Patient	Age (years)	Sex	Other complaint except asymmetry	Affected side	Compensatory growth (maxilla and lip cant)	Adjunctive surgery	TMJ evaluation (Sound or pain)		MMO (mm)		Treatment time (months)	Follow-up (years)
							Before	After	Before	After		
1	24	M	Clicking sound on left side	Left	Moderate	Secondary orthognathic surgery (Le Fort I + SSRO + advancement genioplasty)	Clicking	None	55	53	30	5
2	20	M	None	Left	Mild	Secondary SARPE for relief of crowding	Clicking	None	58	55	22	2
3	20	M	Progressive prognathic mandible	Right	Moderate	Secondary orthognathic surgery (Le Fort I + SSRO + advancement genioplasty)	None	None	51	50	28	10
4	19	M	Long face	Left	Mild	Secondary orthognathic surgery (Le Fort I + IVRO + advancement and reduction genioplasty)	Pain Clicking	None	53	50	20	13
5	19	M	None	Right	Severe	None	Clicking	None	51	50	12	2
6	20	F	Progressive prognathic mandible	Left	Moderate	None	None	None	49	43	15	4
7	29	M	None	Right	Moderate	None	Clicking	Clicking	52	55	12	2
8	20	M	None	Left	Severe	None	None	None	65	65	17	3
9	21	M	None	Left	Severe	None	None	None	51	52	38	10
10	21	M	Open bite	Right	Moderate	None	Clicking	None	55	46	36	8
11	22	M	None	Right	Moderate	Secondary orthognathic surgery (Le Fort I + SSRO + advancement genioplasty)	Clicking	None	48	49	24	7
12	30	M	Malocclusion	Left	Moderate	None	Clicking	None	49	42	24	6
13	26	M	None	Left	Moderate	None	Clicking	Clicking	56	56	18	3
14	22	M	None	Left	Moderate	None	Clicking	None	50	48	16	4
15	29	F	None	Left	Mild	None	Clicking	None	40	42	24	18

F, female; IVRO, intraoral vertical ramus osteotomy; M, male; MMO, maximum mouth opening; SARPE, surgical assisted rapid palatal expansion; SSRO, sagittal split ramus osteotomy; TMJ, temporomandibular joint.

Adjunctive surgery was not required for the eight patients with the OC type, and only condylectomy was performed.

Orthodontic treatment and total treatment time

Of the total 27 patients, 22 (81.5%) had post-surgical orthodontic treatment. All HE and HH patients required orthodontic treatment with or without adjunctive surgery, while five (18.5%) of the OC-type patients showed a stable postoperative occlusion without orthodontic treatment at the 6-month follow-up after condylectomy. All five patients treated with condylectomy alone had the OC type, and a stable occlusion was achieved in these patients just with physiotherapy after condylectomy. The three remaining patients with the OC type (37.5%) required orthodontic treatment. The total treatment duration including the orthodontic treatment period varied, and was an average of 22.4 months (SD 7.98) for patients with the HE type, 27.5 months (SD 7.42) for those with the HH type, and 15.6 months (SD 3.21) for those with the OC type.

TMJ evaluation

The preoperative and post-treatment maximum mouth opening values of the 27 patients were compared and analyzed by paired t-test. The preoperative and postoperative values were 49.8 mm (SD 1.16) and 47.6 mm (SD 1.28), respectively ($P = 0.007$). However, the degree of joint pain and joint sounds either remained stable or improved after the surgery in all patients.

Relapse

After treatment, condylar regrowth was not observed in any of the patients, and long-term stable occlusion was maintained.

Ramus height

The mean interval between the day after the operation and the day of the last follow-up panoramic X-ray was 4.17 years (SD 3.14). The mean mandibular ramus height measured at the last panoramic X-ray was decreased by 0.74 mm (SD 1.26, range –3.01 mm to +2.80 mm) compared to the height on the day after the operation, and this was statistically significant ($P = 0.009$). Although there was a change in the ramus height due to bone remodelling, its correlation with

Table 2. Clinical data and demographic features of patients with hemimandibular hyperplasia.

Patient	Age (years)	Sex	Other complaint except asymmetry	Affected side	Compensatory growth (maxilla and lip cant)	Adjunctive surgery	TMJ evaluation (Sound or pain)		MMO (mm)		Treatment time (months)	Follow-up (years)
							Before	After	Before	After		
16	19	M	Prognathic mandible	Right	Severe	Secondary orthognathic surgery (Le Fort I + IVRO + mandibuloplasty)	Clicking	None	50	46	36	6
17	20	F	None	Left	Moderate	Secondary orthognathic surgery (Le Fort I + SSRO + mandibuloplasty)	Clicking	Clicking	56	53	27	5
18	24	F	None	Right	Moderate	Simultaneous orthognathic surgery (Le Fort I + contralateral IVRO + mandibuloplasty)	None	None	50	43	18	3
19	23	F	None	Left	Severe	Simultaneous orthognathic surgery (Le Fort I + mandibuloplasty)	Crepitus	Clicking	43	50	29	7

F, female; IVRO, intraoral vertical ramus osteotomy; M, male; MMO, maximum mouth opening; SSRO, sagittal split ramus osteotomy; TMJ, temporomandibular joint.

Table 3. Clinical data and demographic features of patients with osteochondroma.

Patient	Age (years)	Sex	Other complaint except asymmetry	Affected side	Compensatory growth (maxilla and lip cant)	Adjunctive surgery	TMJ evaluation (Sound or pain)		MMO (mm)		Treatment time (months)	Follow-up (years)
							Before	After	Before	After		
20	48	F	Recent progressive asymmetry	Left	None	None	Clicking	Clicking	52	50	17	5
21[a]	57	F	Acute malocclusion Left TMJ pain	Left	None	None	Pain	None	40	45	6	3
22	38	F	Posterior open bite Right TMJ pain	Right	Mild	None	Pain	None	40	35	12	4
23[a]	58	F	Recent progressive asymmetry Left TMJ pain	Left	Mild	None	Crepitus Pain	None	40	34	6	2
24[a]	47	F	Recent progressive asymmetry	Right	Mild	None	Clicking	None	50	44	6	2
25[a]	34	M	Left TMJ pain	Left	Mild	None	Clicking Pain	None	42	40	6	2
26[a]	48	F	Posterior open bite Right TMJ pain	Right	Mild	None	Clicking Pain	Clicking	50	42	6	2
27	46	M	Recent progressive asymmetry	Right	Moderate	None	None	None	48	46	18	4

F, female; M, male; MMO, maximum mouth opening; TMJ, temporomandibular joint.
[a] Stable postoperative occlusion without orthodontic treatment.

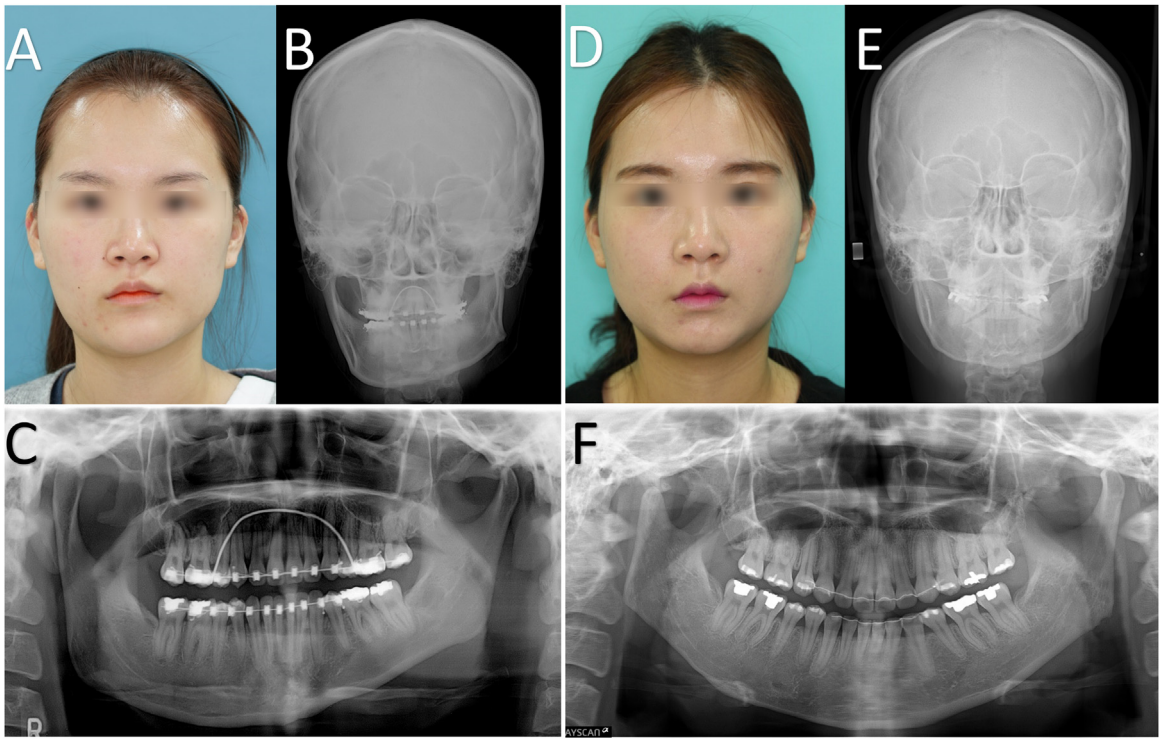

Fig. 2. Long-term follow-up of a hemimandibular hyperplasia case (patient 18). Images obtained preoperatively: (A) frontal photograph, (B) posteroanterior radiograph, and (C) panoramic radiograph. Images obtained at 4 years after condylectomy with simultaneous orthognathic surgery and mandibuloplasty: (D) frontal photograph, (E) posteroanterior radiograph, and (F) panoramic radiograph.

the follow-up period was not statistically significant (P = 0.167).

Discussion

This study was a retrospective review of patients with facial asymmetry due to active UCH. These patients were divided into three subtype groups (HH, HE, OC), and the characteristics of each subtype were analyzed. The subtypes were defined based on a combination of Obwegeser's classification (based on morphology) and Wolford's classification (based on histopathological findings)[4,5,10].

Bone scintigraphy measures increased osteoblastic activity using methylene diphosphonate labelled with ^{99m}Tc, a bone-seeking material[11]. The use of planar scintigraphy for the evaluation of condylar growth was first reported by Kaban et al.[6]. Recently, there has been an increase in the use of SPECT for quantitative evaluation, and Pogrel et al. reported that SPECT is more valuable in obtaining reproducible results compared to planar imaging[12,13]. However, this test can provide false-positive results in the presence of TMJ disease. Therefore, periodic 3D CT or cephalograms are necessary to determine the presence of residual growth. Several authors have previously reported that bone scintigraphy must be measured at least once a year in growing patients. This controversial step could help to predict bone growth and determine the optimal timing for a surgical approach[14].

Various surgical methods for the treatment of UCH have been introduced in many studies, such as high condylectomy, low condylectomy, proportional condylectomy, orthognathic surgery, and TMJ reconstruction surgery[2,15]. Condylectomy can be categorized as high condylectomy when the resection is performed within 5 mm from the upper side of the condylar head, and low condylectomy when the condylar neck is preserved. High condylectomy has been reported to be successful with removal of the condyle including the growth cartilage, which can prevent relapse after surgery[16]. In low condylectomy, removal of the growth centre and simultaneous correction of the posterior vertical excess are possible. In this study, an average length of 21.3 mm (SD 3.19) was resected. By removing all of the growth cartilage and correcting the vertical excess, the asymmetry could be improved.

The mean age at the time of diagnosis of the patients with the HE and HH subtypes in this study was similar, at 22.8 years (SD 3.85) and 21.5 years (SD 2.38), respectively, and this differed significantly from the mean age of the patients with the OC type of 47.0 years (SD 8.22). These findings are indicative of the difference in pathogenesis of the OC type, which is neoplastic, compared to the HE and HH types, which develop during growth at puberty.

Patients with the HE type were less likely to require jaw surgery (26.7%) than the patients with the HH type (100%). However, all patients required orthodontic treatment. In the case of HE and HH, maxillary canting and lip canting occurred gradually as a result of the compensatory growth of the dentoalveolar portion of the maxilla during pubertal growth. With the gradual progression of asymmetry, patients often do not recognize the facial asymmetry immediately, but only when it has progressed sufficiently far.

On the other hand, due to the difference in growth rate of older patients, the degree of compensatory growth was at most mild in patients with the OC type. As indicated in the treatment algorithm (Fig. 3), occlusal seating was performed during the 6-month follow-up period after primary condylectomy, and the patients were re-evaluated to determine whether a secondary surgery or additional orthodontic treatment was necessary. Patients with the OC type showed less dental decompensation than those with the HE and HH types, which manifested as a

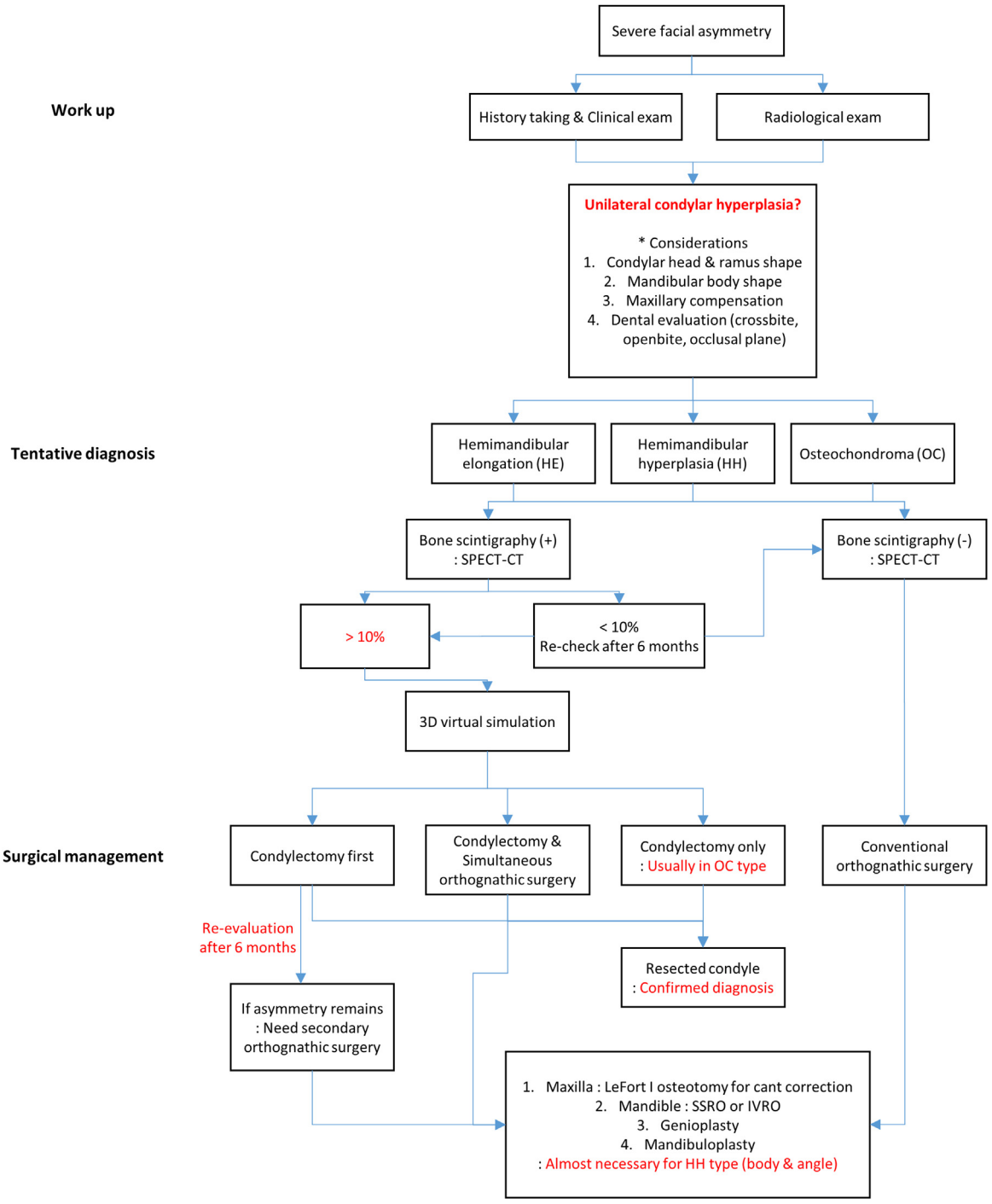

Fig. 3. Proposed algorithm for the treatment of unilateral condylar hyperplasia of the mandible. (Abbreviations: SPECT-CT, single photon emission computed tomography–computed tomography; SSRO, sagittal split ramus osteotomy; IVRO, intraoral vertical ramus osteotomy.)

mild malocclusion. In most OC type cases, orthodontic treatment was either omitted or minimal. These results suggest that favourable treatment outcomes can be obtained with condylectomy alone in the OC type.

In some cases, asymmetry was treated with condylectomy alone, while in other cases a secondary orthognathic surgery was needed. This depended on various factors including the anteroposterior relationship of the maxilla and mandible, the degree of compensatory growth, the shape of the jaw, and the presence of dental problems. In addition, genioplasty or mandibuloplasty with border shaving were performed according to the genial profile or mandibular contour; these are almost a requirement for the HH type[17]. Following condylectomy alone, asymmetry may persist in the HH type due to hyperplasia of the mandibular angle and body region, and additional surgery for these regions was necessary in the HH-type patients included in this study. However, since the mandibular canal was also displaced, it was important to consider this during surgery.

Nine of the 27 study patients (33.3%) required secondary orthognathic surgery. Interestingly, in the OC type, facial asymmetry was resolved just with the removal of the hyperplastic condyle in all eight patients, and additional post-surgical orthodontics for occlusal stabilization was needed in only three cases (37.5%).

A Le Fort I osteotomy for the correction of maxillary canting was performed in eight patients, and one additional patient underwent SARPE to treat a maxillary transverse deficiency and crowding of the maxillary teeth. Four patients underwent a sagittal split ramus osteotomy (SSRO) for mandibular advancement, and an intraoral vertical ramus osteotomy (IVRO) was performed in two patients with a skeletal class III tendency. In patient 18, an IVRO was performed on the unaffected side at the same time as the condylectomy on the affected side. This simultaneous surgery was a good way to achieve optimal jaw function and facial balance at the same time, without the burden of a second surgery, which greatly improved the patient's quality of life. Genioplasty or mandibular border shaving was performed depending on the pattern of asymmetry and genial profile of the patient. A mandibuloplasty was performed in all patients with the HH type; the mandibular border was shaved due to the difference in size of the mandibular body.

Before the development of 3D surgical simulation using a computer, a staged approach was performed at the study institution (condylectomy + secondary orthognathic surgery), as mentioned above. This traditional treatment method is useful for obtaining good postoperative results considering relapse, but requires a secondary operation and a longer treatment period. In recent years, 3D simulation surgery has become possible and condylectomy and orthognathic surgery have been performed simultaneously to obtain good results[18,19].

There are various reports on the total treatment duration including the period of orthodontic treatment[20,21]. In the present study, the HE and HH types, which developed during adolescence, required a total treatment period of about 22.4 months and 27.5 months, respectively. For patients who underwent orthognathic surgery after condylectomy, the treatment period – with preoperative and postoperative orthodontics – was longer. With regard to the OC type, three patients (37.5%) required postoperative orthodontic treatment, and the average treatment duration for this group of eight patients was 15.6 months. The patients showed various patterns of asymmetry and individual differences due to canting and dental problems. Thus, the subtypes and various factors such as the degree of maxilla and lip canting, as well as crowding of the teeth, should be taken into consideration when estimating the duration of treatment.

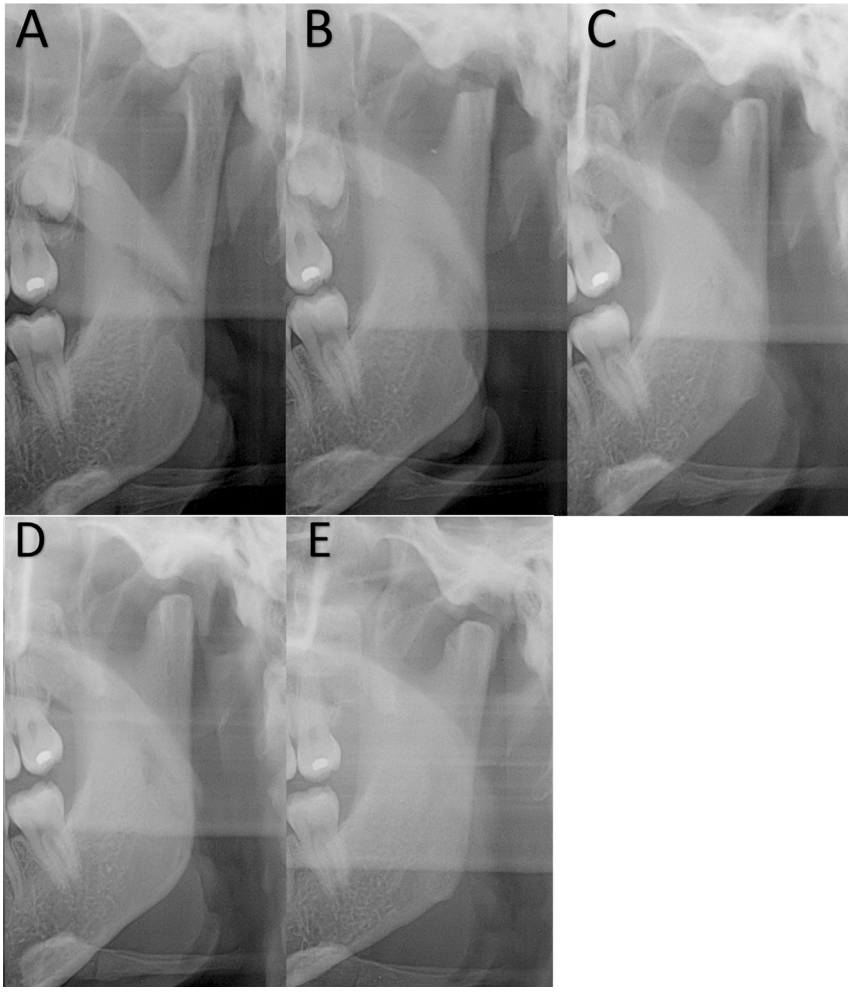

Fig. 4. Serial panoramic X-rays after condylectomy showing condyle remodelling to form a neocondyle, which has adapted to the condylar fossa (patient 19): (A) preoperative; (B) immediately postoperative; (C) 2 years postoperative; (D) 4 years postoperative; (E) 6 years postoperative.

Miyamoto et al., in a study of beagle dogs, reported that the pattern of condyle regeneration at 3 months after surgery showed greater regeneration in the medial region compared to the lateral region[22]. Displacement of the condyle increased the load on the lateral part, resulting in increased damage to this region compared to the medial part during surgery. In addition, histologically it was observed that the bone around the glenoid fossa was maintained, while the cartilage regenerated in an irregular manner and was thickened in compensation.

In the patients included in the present study, long-term follow-up of TMJ function showed satisfactory results without relapse. There was a decrease in the amount of the maximum mouth opening, but the degree was not severe (about 2.2 mm), and there was an improvement in terms of joint pain and sounds. Previous studies have examined mandibular movements after condylectomy. Villanueva-Alcojol et al. reported no significant changes in maximum mouth opening before and after condylectomy in 36 patients[15]. Additionally, Lippold et al. reported no significant changes after condylectomy in six patients[21]. Wolford et al. reported an decrease of 2.3 mm in maximum mouth opening in 37 patients with condylar osteochondroma after low condylectomy, which is similar to the result found in the present study[23]. However, Brusati et al. studied articular function after high condylectomy and found that 40% of the patients showed suboptimal function, with deviation or decreased movement[2]. Shen and Darendeliler described the concept of a neocondyle as remodelling of the condylar stump to form a new condyle. In fact, long-term follow-up in the present study showed that remodelling of the condylar head was achieved, and the TMJ adapted to the situation without functional problems[24] (Fig. 4). Routine panoramic X-ray and cephalograms are considered good diagnostic methods to examine remodelling of the condyle[25].

It is important for clinicians to consider potential complications that can occur after condylectomy. In the absence of complete resection, regrowth of the mandibular condyle may occur. Conversely, the newly adapted condyle can be resorbed or dislocated in the process of remodelling or loading, which may lead to a loss of vertical dimension. Wolford et al. reported that facial asymmetry could recur if the osteochondroma is not completely removed[23]. In addition, the articular space between the new condyle and the mandibular fossa may change with the passage of time.

In the present study, there was no case of condylar regrowth after condylectomy. The ramus height was slightly decreased (within 1 mm on average) by remodelling. Various factors such as changes in the articular space and adaptation of the surrounding muscles may affect the occlusal dimension in a complex manner. Therefore, it is important for clinicians to monitor the occlusal state of the patient and the position of the maxilla and mandible over long-term follow-up. Studies on the long-term stability after surgery may further justify this approach as the treatment of choice for UCH.

This study involved a retrospective analysis of patients who underwent condylectomy for the treatment of active UCH, as confirmed by bone scans. The overall sample size and the sample sizes for each subtype were limited. However, the clinical features, response to treatment, and outcomes were described for each subtype, which will be helpful for the treatment of patients. Using this information, an algorithm for the treatment of UCH of the mandible is proposed. As indicated in the treatment algorithm, condylar regrowth and the need for a secondary surgery or orthodontic treatment were assessed in this study during the 6-month follow-up period after condylectomy. This follow-up period has usually been adequate to confirm regrowth and has the advantage of allowing a secondary surgery in severely affected patients. However, with the development of 3D virtual surgical planning, simultaneous surgeries can be performed with an established surgical plan, thereby eliminating asymmetry and obtaining a good jaw relationship at the same time. In this study, as a sufficient amount of condyle including the growth centre was removed, relapse did not occur. Our observations suggest a potential shift in the trend towards simultaneous surgeries, which requires further study.

Additional research to identify the cause of UCH and well-designed prospective studies are necessary, since findings could be valuable in the treatment of patients with UCH and facial asymmetry. In the future, patient-specific treatment should be provided to ensure a favourable occlusion and oral health. In addition, technological advancements in diagnosis and treatment planning through 3D simulation can ensure the stability and predictability of simultaneous surgery. Consequently, this is an important step towards achieving better treatment results for patients with active UCH.

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Competing interests

None declared.

Ethical approval

The study was conducted according to the dictates of the Declaration of Helsinki and was approved by the Ethics Review Board of Yonsei University Dental Hospital Institutional Review Board (IRB No. 2-2018-0037). The need for informed consent was waived due to the retrospective nature of the study.

Patient consent

Not required.

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Address:
Young-Soo Jung
Department of Oral and Maxillofacial Surgery
Yonsei University College of Dentistry
50-1 Yonsei-ro
Seodaemun-gu
Seoul
03722
Republic of Korea
Tel.: +82 2 2228 3139
Fax: +82 2 2227 7825
jyomfs@yuhs.ac,
htaewook@yuhs.ac,
wlsgnek@yuhs.ac,
cancer7@yuhs.ac,
yjsoms@yuhs.ac