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Computer-assisted surgical planning and intraoperative navigation in the treatment of condylar osteochondroma

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Abstract. Mandibular condylar osteochondroma (OC) results in asymmetric prognathism with facial morphology and functional disturbances. The aim of this study was to explore the feasibility of computer-assisted surgical planning combined with intraoperative navigation in the treatment of condylar OC. Five patients with mandibular condylar OC were enrolled in this study. Surgical planning and simulation was performed based on a computed tomography reconstruction model using SurgiCase software. Under the guidance of navigation, a condylar OC resection and conservative condylectomy was carried out via intraoral approach. Simultaneous orthognathic surgery was used to correct the facial asymmetry and malocclusion. All patients healed uneventfully. No facial nerve injury or salivary fistula occurred. Facial symmetry and morphology were greatly improved and stable occlusion was obtained in all cases. Good matching between preoperative planning and postoperative results was achieved. Patients showed no signs of recurrence or temporomandibular joint ankylosis during follow-up of 12–30 months. Computer-assisted surgical planning and intraoperative navigation is a valuable option in the treatment of mandibular condylar OC.

Key words: surgical planning; navigation; osteochondroma; registration; tumour resection.

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Osteochondroma (OC), also known as osteocartilaginous exostosis, is one of the most common benign tumours of the long bones, but is rarely found in the facial skeleton. Mandibular condylar OC can result in morphological and functional disturbances, including facial asymmetry, malocclusion, and temporomandibular joint (TMJ) dysfunction.[1,2] Clinical features of condylar OC include progressively increasing facial asymmetry, vertical elongation of the face on the affected side, prognathic deviation of the chin, crossbite on the contralateral side, and lateral open bite on the affected side.[3,4] The presentation varies with the size of the tumour and its main vector of growth. In some cases, asymmetric prognathism may occur along with bowing of the lower border of the mandible on the ipsilateral side, while compensatory down-growth of the maxilla due to open bite may give rise to a cant of the maxillary occlusal plane.[5] Therefore, the treatment of condylar OC

Table 1. Patient characteristics.

Case no.	Age, years	Gender	Affected side	History of facial asymmetry, years	Occlusion canting	Concomitant orthognathic surgery	Follow-up, months
1	22	M	L	5	Y	Le Fort I osteotomy, R SSRO, genioplasty, mandibular contouring	12
2	28	F	R	4	Y	Le Fort I osteotomy, L SSRO	16
3	24	F	R	10	Y	Le Fort I osteotomy, L SSRO, mandibular contouring	18
4	32	F	L	3	Y	Le Fort I osteotomy, R SSRO, mandibular contouring	27
5	21	M	L	3	Y	Le Fort I osteotomy, R SSRO, mandibular contouring	30
Mean	25.4			5			20.6

M, male; F, female; L, left; R, right; SSRO, sagittal split ramus osteotomy.

should include not only surgical excision of the lesion, but also the correction of dento-maxillofacial deformities.[6,7] Currently, condylar OC resection and condylectomy combined with orthognathic surgery is a proposed option for the treatment of condylar OC.[1,3] However, the achievement of accurate OC resection and the simultaneous rehabilitation of facial symmetry are great challenges for the surgeon.

As secondary deformities are complex and variable, individualized preoperative surgical planning is indispensable for the correction of maxillofacial deformities and to achieve facial symmetry.[5] Using virtual surgical planning and simulation, surgeons can try out different surgical approaches to identify the optimal method. In recent years, computer-assisted surgery (CAS) has been used extensively in craniomaxillofacial and dental surgery and has shown great benefits and potential.[8–12] As we all know, even with the best preoperative planning, without accurate intraoperative implementation, the results may be compromised. With real-time instrument positioning and clear anatomical identification, computer-assisted navigation systems (CANS) provide us with an ideal option for the intraoperative application of three-dimensional (3D) image data and allow the surgical planning to be realized.[13] However, due to mandibular mobility, the application of CANS in the mandible is limited. Sun et al. attempted the use of endoscopic navigation in a case of condylar OC resection and obtained satisfactory results.[14] In this study, computer-assisted surgical planning and combined intraoperative navigation was attempted in the treatment of CO.

Patients and methods

Patients

Five patients with mandibular condylar OC were treated in the department of oral and craniomaxillofacial science between January 2011 and December 2012. For inclusion in the study, patients had to have been diagnosed with condylar OC combined with secondary facial asymmetry and malocclusion. According to the growth pattern, OC can be divided into two types: the exostosis type and the diffuse type. The exostosis type of OC grows from the condylar head with a narrow stalk connecting it to the condyle. The diffuse type affects the whole condyle and often causes overgrowth and hypertrophy of the mandible. A clinical diagnosis was made on the basis of combined computed tomography (CT) scan characteristics and clinical symptoms; the diagnosis was confirmed by postoperative pathological diagnosis. As a result, some cases were excluded from this study after histological examination.

The study patients (three women and two men) had a median age of 25.4 years (range 21–32 years). The first symptom noticed was a gradual facial asymmetry and chin deviation over the course of years; the mean history of facial asymmetry before treatment was 5 years. Occlusal canting and disorders were noted in all patients preoperatively. All patients had an open bite or locked occlusion on the affected side and a crossbite on the other side (Table 1). Preoperative orthodontic treatment was carried out for alignment and decompensation of dentition before surgery. This study was approved by the institutional review board of the hospital and informed consent was obtained.

Preoperative planning and simulation

Five position screws were implanted in the mandibular alveolar bone as navigation markers. A preoperative thin-cut (1.25 mm), spiral CT scan (Light speed 16; GE, Gloucestershire, UK) was obtained for all patients. Each patient's individual anatomy and OC was assessed using SurgiCase software, version 5.0 (Materialise, Leuven, Belgium), in multiplanar (axial, coronal, and sagittal) and 3D views. The boundary of the tumour and the osteotomy line were delineated on a 3D reconstruction model based on the CT scan. Orthognathic surgical planning was designed based on cephalometric analysis and evaluation of the 3D reconstruction model. A virtual condylectomy and orthognathic surgery was performed on the model. To correct the remaining facial asymmetry, the median sagittal plane was used as the reference plane. The normal anatomical structures were mirrored from the contralateral side so that the desired contour of the affected side could be visualized. Using side-by-side comparison, the asymmetric regions to be revised were defined and displayed on the 3D reconstruction images in different colours (Fig. 1). After simulation, virtual wafers and guides for intraoperative use were manufactured by rapid prototyping technology. A virtual guide was used to define the osteotomy line for mandibular recontouring in the operation.

Surgery and intraoperative navigation

Surgeries were performed under general anaesthesia through nasoendotracheal intubation. In accordance with the preoperative surgical plan, a maxillary Le Fort I osteotomy was performed for treatment of the cant and/or advancement. A navigation-guided OC resection and condylectomy was carried out via intraoral approach. A buccal maxillary incision was made from the level of the mandibular second molar to the level of the maxillary teeth. A subperiosteal dissection along the condylar neck and head was carried out until the mandibular condyle was fully exposed. The coronoid process was osteotomized at the level of the mandibular notch using a reciprocating saw and osteotome, and was then removed to expose the condyle.

Intraoperative navigation was performed using frameless stereotaxy, with infrared cameras tracking the navigation pointer and trackers. The position of the