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Technical Note
Orthognathic Surgery

Minimally invasive intraoral proportional condylectomy with a three-dimensionally printed cutting guide

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Abstract. The aim of this study was to describe the steps of a minimally invasive surgical technique used to perform a proportional intraoral condylectomy with a three-dimensionally (3D) printed cutting guide. The technique consists of two steps: virtual surgical planning and intraoral condylectomy. During virtual surgical planning, the mandibular ramus was measured bilaterally, the height of the proportional condylectomy was planned virtually, and a cutting guide was 3D printed. In the intraoral condylectomy, the mandibular condyle was approached intraorally, the 3D printed cutting guide was positioned in the sigmoid notch, and the proportional condylectomy was performed. The protocol reported in this technical note is the sum of knowledge acquired from a series of studies published previously by the authors, who have jointly developed a surgical technique that is both minimally invasive and accurate for the treatment of condylar hyperplasia.

Key words: temporomandibular joint; condylar hyperplasia; intraoral; computer-assisted; CAD/CAM; minimally invasive surgery.

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Condylar hyperplasia is a condition that causes excessive growth of the mandibular condyle, occurring unilaterally or bilaterally, with consequences that result in deformities and facial asymmetry[1,2]. According to Wolford et al.[2], this hyperplastic growth can be classified into four types (1, 2, 3, and 4), with types 1 and 2 showing a higher prevalence.

Methods for the treatment of condylar hyperplasia have been described widely in the literature, and the following may be indicated: orthognathic surgery alone; high, low, or proportional condylectomy alone; or a combination of these techniques[3,4]. Currently, computer-aided design and computer-aided manufacturing (CAD/CAM) technology is an important tool to assist in the planning of these surgical techniques[5,6].

The aim of this study was to describe the steps of a minimally invasive surgical technique used to perform a proportional intraoral condylectomy with a three-dimensionally (3D) printed cutting guide.

Technique

The surgical protocol described here is indicated mainly for cases of condylar hyperplasia types 1 and 2 (Wolford classification[2]) requiring condylectomy,

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which may be combined or not with orthognathic surgery.

Virtual surgical planning

DICOM data files obtained from full-face cone beam computed tomography scans (CBCT) (i-CAT; Imaging Sciences International, Inc., Hatfield, PA, USA) were imported into Dolphin 3D Imaging software, version 11.95 (Dolphin Imaging and Management Solutions, Chatsworth, CA, USA). The vertical CBCT scans were performed in 'extended field' mode with a field of view (FOV) of 17 cm diameter, 22 cm height; the scan time was 2×20 s, the voxel size was 0.4 mm, and settings were 120 kV and 48 mA.

Proportional condylectomy (3D planning stage)

The difference in vertical size between the side with condylar hyperplasia and the unaffected side was determined by performing bilateral linear measurements from the mandibular angle to the highest point in the condyle region. The vertical difference between the two sides was used as a reference for the height of the proportional condylectomy on the hyperplastic side[1,7,8] (Fig. 1A). An osteotomy was planned in the condylar neck region, extending from the highest point of the condyle towards the sigmoid notch, a distance covering the vertical difference between the two mandibular rami (Fig. 1B).

3D printed cutting guide

The DICOM images of the mandibular ramus with condylar hyperplasia were converted into stereolithography (STL) format in Dolphin 3D Imaging software. The STL file was then imported and opened in the free 3D Builder software (Windows 10; Microsoft Corporation, Redmond, WA, USA) to model a cutting guide that anatomically fits the condylar neck and covers the area from the sigmoid notch to the previously defined osteotomy line of the proportional condylectomy (Fig. 1C).

As the last step of the CAD/CAM protocol, the cutting guide modelled in 3D Builder was fabricated using a 3D printer.

Intraoral condylectomy

Intraoral approach

An electrocautery incision was made in the buccal mucosa region in contact with the ascending mandibular ramus, followed by total mucoperiosteal flap elevation to expose the coronoid process, osteotomy of the coronoid process to better visualize the sigmoid notch, sub-periosteal access to the condylar process to dissect off the lateral pterygoid muscle and articular capsule, and intermaxillary fixation of a locking screw (above the osteotomy region) with braided steel wire[9].

Proportional condylectomy (surgical stage)

After access to the condylar region, the cutting guide was positioned on the anatomical surface corresponding to its surface-best-fit, as delimited during the 3D process of the proportional condylectomy (Fig. 2A). A horizontal osteotomy was performed using a piezoelectric surgery device at the rear end of the cutting guide and the upper portion of the mandibular condyle was separated from the rest of the mandible (Fig. 2B). The steel wire fixed with a locking screw was then pulled to remove the surgical specimen (Fig. 2C). Suture was performed with continuous stitches using absorbable suture material.

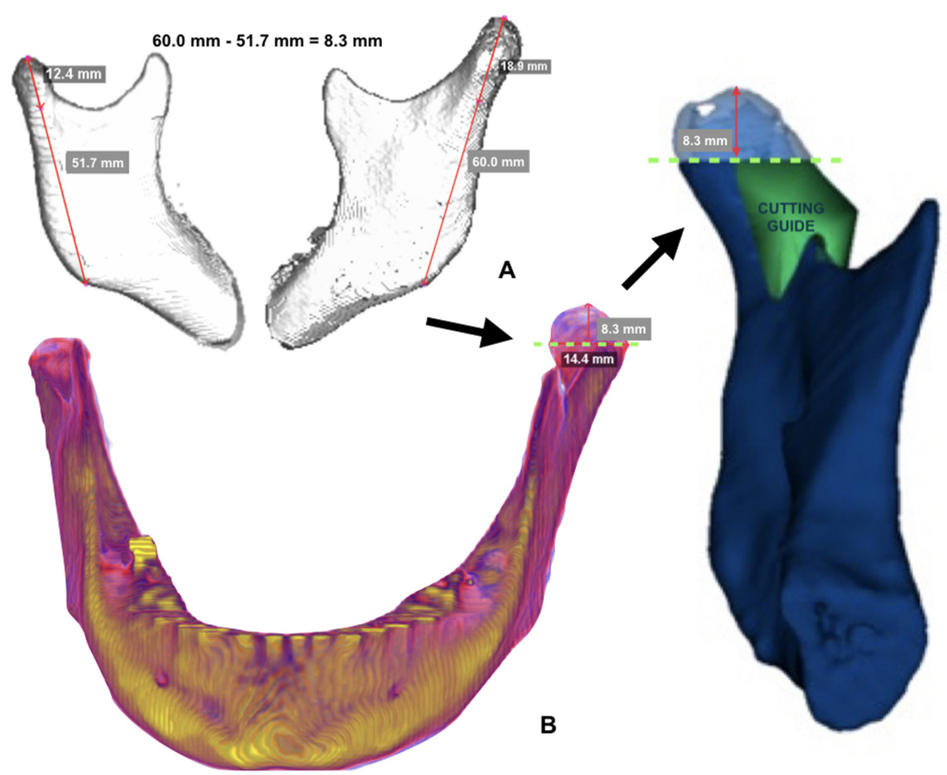

Fig. 1. (A) Proportional condylectomy virtual planning. (B) Confirming that the entire diseased area will be removed. (C) Proportional condylectomy cutting guide.

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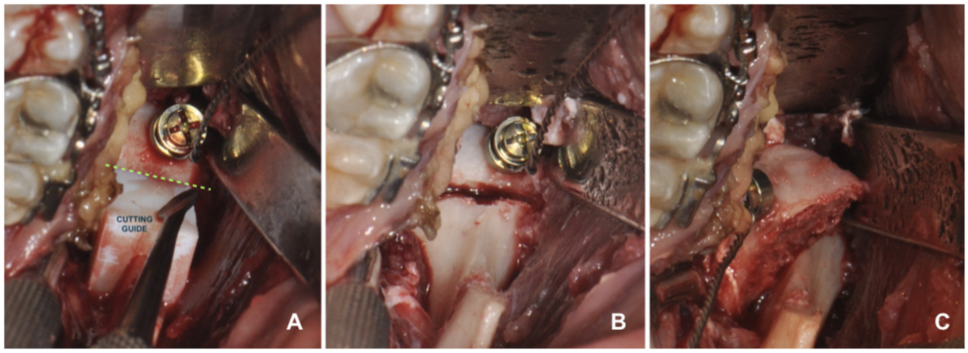

Fig. 2. (A) Cutting guide in surgical position. (B) Osteotomy. (C) Proportional condylectomy with intraoral approach.

Discussion

The combination of techniques, such as intraoral access to the condyle[9] and proportional condylectomy[1,7,8], helps further develop the concept of a minimally invasive surgical procedure. This provides an approach that results in less damage to the articular soft tissue region and an osteotomy technique that allows removal of the diseased condylar bone as early as possible, in order to maintain the vertical balance of the mandibular rami and avoid a more invasive surgical intervention in the future in the case of dentofacial deformities, such as asymmetry, as a sequela of condylar hyperplasia.

To improve the minimally invasive concept and give more precision to the surgical procedure of proportional condylectomy with an intraoral approach, a cutting guide was fabricated using CAD/CAM technology. The cutting guide has reduced dimensions compatible with a limited surgical approach and no prominent structures for its fixation, and it can be anatomically fitted using the surface-best-fit method. This tool fits the sigmoid notch and extends to the area where the osteotomy must be performed using a piezoelectric surgery device, thus providing safety and accuracy in removing the diseased tissue and ensuring the vertical balance of the mandibular rami. The condylar height where the osteotomy must be performed is always determined using a Hounsfield unit colour scale[10], to ensure that the region of proportional condylectomy will cover the entire pathological area or the hyperplastic area. After this step, the cutting guide can easily be modelled virtually in a free software that does not require specialized 3D modelling skills, avoiding the need to use specialized software.

Given the reliability of this combination of techniques, it can also be used in cases where both a condylectomy and orthognathic surgery are performed in the same surgical session. The cutting guide provides precision with respect to the height of the mandibular rami[6], increasing the ability to reproduce the virtual planning of orthognathic surgery to correct facial asymmetry, which is known to be accurate[5]. When only a condylectomy is performed, the technique described here takes no longer than 25 minutes, as it allows a rapid and direct approach to the hyperplastic region[9]. Therefore, when performed in combination with orthognathic surgery, this short period of time is added to the total intervention time. Also, this combination reduces the chance of infection, because both procedures are performed through the same intraoral access, avoiding communication between the intraoral and extraoral environment, as reported previously with similar techniques[6].

The technique described here has already been used by the authors in condylar hyperplasia types 1 and 2[2], either combined or not with orthognathic surgery. Whenever both interventions are performed at the same time, the same surgical sequence is followed to ensure reliability between the virtual planning and surgical stage. The following surgical steps are performed: condylectomy, mandible first with bilateral sagittal split ramus osteotomy (to have the maxilla as a fixed reference point), and maxilla last.

Several studies were published previously by the authors of this article[1,5,7,8,9,10], before the collaborative development of this surgical technique for the treatment of condylar hyperplasia, which is both minimally invasive and accurate. Thus, we believe that by combining knowledge we managed to develop a technically simple protocol to be shared and reproduced in the clinical setting.

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Competing interests

There are no conflicts of interest.

Ethical approval

Not required.

Patient consent

Written patient consent was obtained to publish the surgical photographs.

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