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Short communication

Augmented reality guided condylectomy

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Abstract

An accurate transfer of a 3D virtual planned proportional condylectomy to the patient is challenging due to the limited surgical access. A new clinical workflow that uses augmented reality to assist a condylectomy is presented step-by-step. This AR-based approach has the potential to be implemented in the clinical setting routinely.

Keywords: 3D planning; Augmented reality; Condylectomy; Guided surgery; High condylectomy; Hololens

Introduction

Proportional condylectomy is increasingly being used as an initial treatment in unilateral condylar hyperplasia.[1] The key in proportional condylectomy is able to place the osteotomy plane at the desired location to reduce the vertical ramal asymmetry. Clinically, it remains challenging to transfer a virtually planned condylectomy plane to the patient during surgery. The limited surgical access, the axial location of the condylar head, and the seating of condyle in the fossa often restricts a complete overview of the condylar head and hampers the use of surgical guides. The implementation of augmented reality (AR) can aid surgical interventions by presenting images of 3D virtual surgical planning on the operation field.[2] We present a novel AR-guided work-flow for condylectomy.

Material & method

A 38-year-old female presented at our department with a progressive chin point deviation to the right based on an unilateral condylar hyperplasia. A proportional condylectomy of the left condyle was proposed.

A threshold-based segmentation in IPS CaseDesigner (KLS Martin Group, Tuttlingen Germany) was used to create a 3D model of the mandible from an extended-height CBCT scan (FOV 16 × 22 cm; scanning time 2 × 20 s; voxel size, 0.4 mm; 3D Imaging System, Imaging Sciences International Inc, Hatfield, PA, USA). The osteotomy plane was virtually planned to resolve the discrepancy between the left and right ramal height.

Surgery was performed under general anesthesia with nasotracheal intubation. The left condyle was approached through a post-tragal incision with a limited superior preauricular extension. After gaining access to the condylar head, the surgeon identified the plane of condylectomy visually. Three marking points were place on the lateral condylar surface with a round burr.

By wearing Microsoft Hololens2 (Microsoft, Washington, USA), the position of three markings was checked using the following steps:

1. A sterile quick response (QR) marker was attached to the lower dentition to allow tracking of the mandibular position through Hololens2.
2. A stainless-steel pointer, equipped with a second QR marker, was used to check the location of the planned osteotomy line (Fig. 1).

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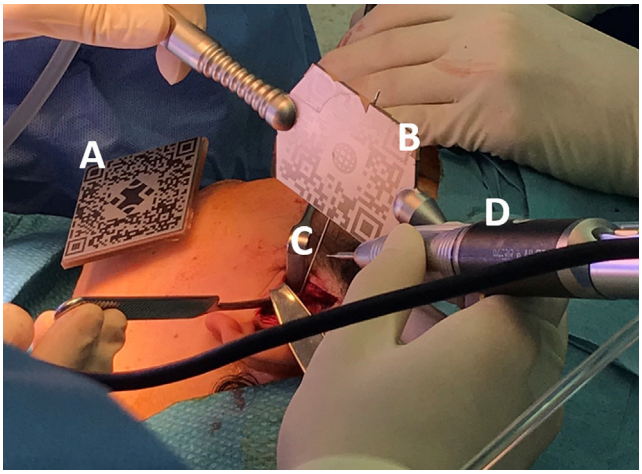

Fig. 1. The mandible was tracked by the QR marker fixated on the lower dentition (A). The position of the pointer with laser engraved QR-marker (B) was tracked by the HoloLens and the tip of the pointer (C) was visualized by the surgeon in the HoloLens. The surgical burr (D) was used to perform the condylectomy.

3. An Unity-based inhouse-developed Hololens application, enabled the surgeon to visualize the planned position of the osteotomy line and the three markings. The HoloLens displayed a virtual arrow at the location of the pointer to direct the surgeon to move the pointer to the planned position (Fig. 2).

Next, the actual condylectomy was performed with a round burr based on the markings. The cranial part of the condylar head was removed.

Five days following surgery, a postoperative check-up CBCT was acquired. The planned and actual location of the condylectomy planes were compared.

Results and discussion

The 3D registration of planned and postoperative mandibular models (Fig. 3) showed that on the lateral, anterior and medial side of the condyle, the condylectomy was performed almost exactly as was planned (error 1 mm). However, the postoperative posterior border of the left condyle was located more caudally compared to the planning. This discrepancy could be a result of the fact that only the lateral position of the osteotomy was verified by HoloLens2.

The accuracy of the presented method should be further investigated in future research. Besides, the software can be improved to make the AR application more intuitive. To eliminate the use of the pointer, the surgical handpiece (and thus the burr) can be equipped with a QR-code so that the position of the burr can be tracked and corrected throughout surgery. The magnitude of the registration error, perception error[3] and surgical error in AR-guided surgery should be investigated thoroughly.

Although conventional surgical navigation systems can be used to guide to user during surgery, the combination of the Hololens with sterilizable QR markers is an easy and low-cost alternative. This AR solution allows the user to stay focused on the surgical field while attaining feedback from the planning. The surgeon is not forced to switch his/her view to an external monitor as in conventional navigation.[4]

We believe that AR guidance is an adequate method to transfer a virtual planning for various CMF procedures. Especially during proportional condylectomy, where surgical guides are impractical, AR guidance is an effective method to assist the surgeon.

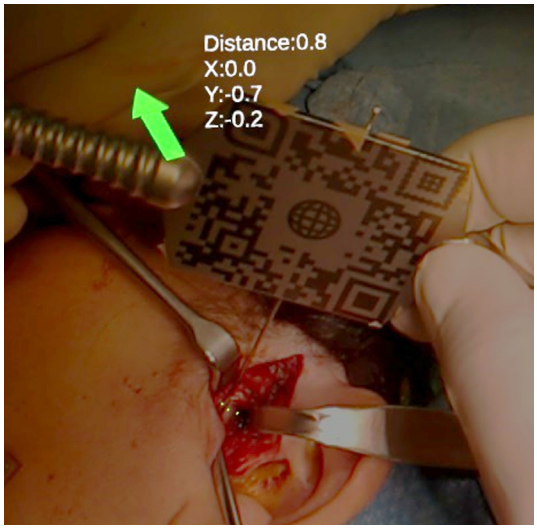

Fig. 2. Visualization in the HoloLens: the green arrow indicates how the tip of the pointer should be manipulated to target the planned osteotomy position. The red color of the virtual arrow turned green in case the offset between the planned position of guidance points and the real-time position of the tip of the pointer was below 2 mm. The absolute distance between the pointer and the planned osteotomy point was indicated on the top left.

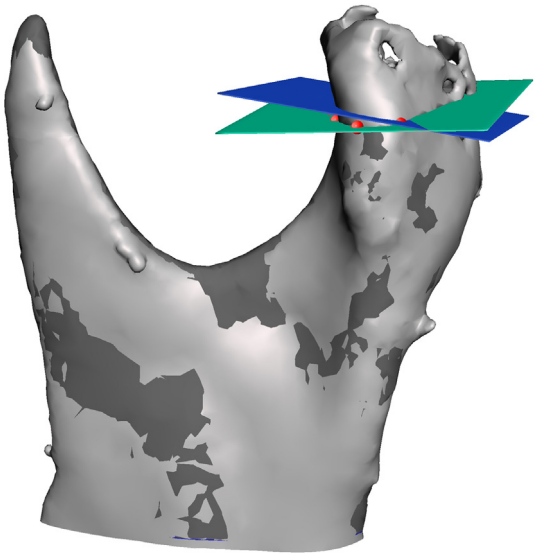

Fig. 3. Lateral view of the preoperative (light gray) and postoperative (dark gray) condyle with the planned (green) and the achieved (blue) osteotomy planes. The three points (red) were projected by the HoloLens and indicated the osteotomy plane. The posterior point was concordant with the planning and the middle point deviated by 1 mm.

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Conflict of Interest

No.

Ethics statement

Ethical approval was obtained from the institutional ethics review board (#2019-5986). The ethics committee has passed a positive judgment on the study. Radboud University Nijmegen Medical Centre confirm the study doesn't fall within the remit of the Medical Research Involving Human Subjects Act (WMO). Patients permission obtained

Sources of support

None.

References

1. Fariña R, Olate S, Raposo A, et al. High condylectomy versus proportional condylectomy: is secondary orthognathic surgery necessary? *Int J Oral Maxillofac Surg.* 2016;**45**(1):72–77. https://doi.org/10.1016/j.ijom.2015.07.016.
2. Kubben P, Sinlae R. Feasibility of using a low-cost head-mounted augmented reality device in the operating room. *Surg Neurol Int.* 2019;**10**(1). https://doi.org/10.4103/sni.sni_228_18.
3. Condino S, Carbone M, Piazza R, Ferrari M, Ferrari V. Perceptual limits of optical see-through visors for augmented reality guidance of manual tasks. *IEEE Trans Biomed Eng.* 2020 Feb;**67**(2):411–419.
4. Meulstee JW, Nijsink J, Schreurs R, et al. Toward holographic-guided surgery. *Surg Innov.* 2019;**26**(1):86–94. https://doi.org/10.1177/1553350618799552.