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Splintless surgery: does patient-specific CAD-CAM osteosynthesis improve accuracy of Le Fort I osteotomy?

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Abstract

To analyse the accuracy of maxillary positioning after Le Fort I osteotomy, we retrospectively assessed the outcome in three patients (mean (range) age 40 (21 – 60) years) who had been treated with patient-specific CAD-CAM osteosynthesis plates as part of a bimaxillary osteotomy. Virtual surgical planning in each case was based on cone-beam computed tomography (CT) (Simplant® O&O, Dentsply Implants NV, Kessel-Lo, Belgium), and patient-specific CAD-CAM drilling guides and osteosynthesis plates were produced for maxillary positioning and fixation. We evaluated the accuracy of the placement by virtual comparison of the preoperative and postoperative images. In the upper dentition, postoperative analysis showed a mean (SD) deviation of 1.3 (1.4) mm from the preoperative plan. The method enables accurate placement of the maxilla, independent of the condyle or mandible, without the need for extraoral reference points.

Keywords: CAD-CAM; splintless; osteosynthesis; CBCT; orthognathic surgery; 3D planning

Introduction

Three-dimensional planning of orthognathic surgery is already widely applied, particularly for the treatment of patients with asymmetrical maxillofacial deformities, and good outcomes depend on careful planning being translated to the actual operation.[1] Correct positioning of the maxilla after Le Fort I osteotomy in the transverse and sagittal planes is usually guided by an intermediate splint,[2,3] and the vertical dimension is generally measured using intraoral or extraoral reference points.[4] Intraoral reference points are usually marked on the bone above and below the osteotomy line. The most commonly used extraoral reference point is a nasion screw or glabella pin. These variables, however, can cause inaccurate positioning of the maxilla, as can the splint, errors in vertical positioning, intraoperative condylar sag, and posterior pressure from the condyle.[5] Reported alternatives are intraoperative 3-dimensional printed guides, and tooth or bone-borne guides, [2] which can be used with prebent plates.[6]

We aimed to develop and evaluate a new method of positioning the maxilla that was independent of the amount of condylar sag. To realise this, patient-specific osteosynthesis plates were used. Patient-specific osteosynthesis or splintless maxillary repositioning has previously been reported,[7,8] but our method enables the postoperative analysis of accuracy, and does not require the removal of additional tissue or a change in the surgical approach. The primary outcome measure was the position of the maxilla evaluated on cone-beam computed tomography (CT).

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Patients and methods

The Medical Ethics Committee of the University Medical Centre, Groningen, approved the use of patient-specific osteosynthesis, and the study conformed to the principles of the Declaration of Helsinki.

We retrospectively studied three patients (2 women and 1 man, mean (range) age 40 (21-60) years) who were treated with patient-specific CAD-CAM osteosynthesis plates at the Department of Oral and Maxillofacial Surgery at the University Medical Centre, Groningen. All patients received Le Fort I osteotomy as part of combined orthodontic and surgical treatment; they had not had previous operations on the maxilla or mandible, and had no craniofacial anomalies or syndromes.

Data acquisition

Three-dimensional scans of the craniofacial area were done using cone-beam CT (i-CAT, Imaging Sciences International, Hatfield, USA), and all output files were generated in digital imaging and communications in medicine (DICOM) format. We used the Lava™ Chairside Oral Scanner (3 M ESPE, St Paul, USA) to produce stereolithographic output files to obtain a virtual model of the dentition. This was projected and superimposed on the cone-beam CT using Simplant® O&O (Dentsply Implants NV, Kessel-Lo, Belgium) and the contours aligned.

Virtual planning

After segmentation of the anatomical structures on the augmented model, we made virtual osteotomies using the custom planar application and repositioning tool in the software. The position of the maxilla was based on the predetermined clinical data and virtual analysis. The completed virtual plan indicated the preferred locations for the plates and screws on the zygomatic and paranasal buttresses, which were guided by the thickness of the bone as interpreted from the cone-beam images.[9]

CAD-CAM osteosynthesis

The generation of stereolithographic files in virtual planning enables the design and fabrication of medical-grade titanium miniplates using CAD-CAM (Createch Medical SL, Mendaro, Spain). Our plates were based on the size and shape of the conventional titanium L-plates used in Le Fort I osteotomies (Figs. 1 and 2). They followed the contour of the maxillary bone, and the design was based on the sites of the screws, which aided in their translocation to the final position. A drill and cutting guide (Fig. 1) enabled accurate placement. The guides were made on a 3-dimensional printer using stereolithographic techniques (polymerisation of liquid resin in layers) and the plates manufactured using a five-axis milling machine. An intermediate 3-dimensional splint was also made (Simplant®, Kessel-Lo, Belgium) to enable the surgeon to switch to conventional methods if the position of the maxilla was questioned after use of the CAD-CAM plates. The splint was based on the surgical plan and therefore permitted the same degree of translocation as was planned with the CAD-CAM plates. All guides and osteosynthesis plates were sterilised using standard methods.

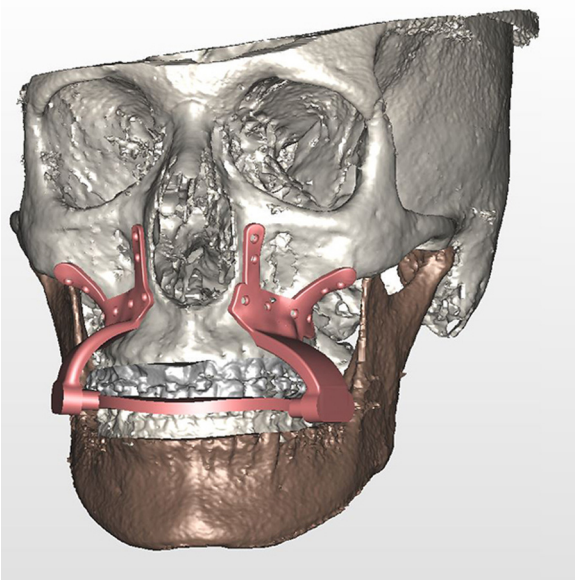

Fig. 1. Dentition-supported drill and osteotomy guide.

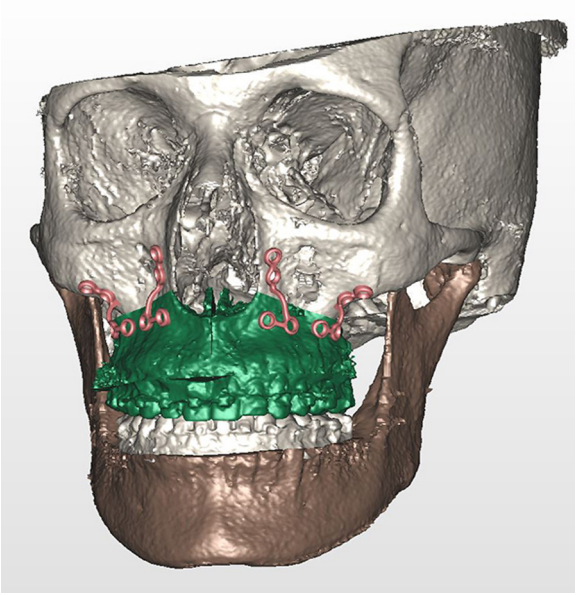

Fig. 2. Surgical 3-dimensional customised CAD-CAM osteosynthesis plates.

Surgery

The surgery included a conventional Le Fort I approach through a vestibular incision in the maxilla to expose the

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