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Comparison of the accuracy of maxillary position between conventional model surgery and virtual surgical planning

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Abstract. The aim of this study was to determine whether virtual surgical planning (VSP) is an accurate method for positioning the maxilla when compared to conventional articulator model surgery (CMS), through the superimposition of computed tomography (CT) images. This retrospective study included the records of 30 adult patients submitted to bimaxillary orthognathic surgery. Two groups were created according to the treatment planning performed: CMS and VSP. The treatment planning protocol was the same for all patients. Pre- and postoperative CT images were superimposed and the linear distances between upper jaw reference points were measured. Measurements were then compared to the treatment planning, and the difference in accuracy between CMS and VSP was determined using the *t*-test for independent samples. The success criterion adopted was a mean linear difference of <2 mm. The mean linear difference between planned and obtained movements for CMS was 1.27 ± 1.05 mm, and for VSP was 1.20 ± 1.08 mm. With CMS, 80% of overlapping reference points had a difference of <2 mm, while for VSP this value was 83.6%. There was no statistically significant difference between the two techniques regarding accuracy ($P > 0.05$).

Key words: orthognathic surgery; virtual surgical planning.

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The success of orthognathic surgery depends not only on the surgical technique, but also on the accuracy of surgical planning. Conventional model surgery (CMS) has been used for over 50 years, and although good and reliable outcomes are obtained, it presents several limitations, especially in the treatment planning for complex dentofacial deformity (DFD) cases[1–3]. Minor errors may accumulate during the various steps of CMS, from model acquisition and mounting on a semi-adjustable articulator to splint construction, which may in the end lead to important inaccuracies. Furthermore, during the different steps of surgical planning, i.e. physical examination, cephalometric tracing, and model surgery, errors may accumulate that, when combined, can lead to an error in maxillary projection of up to 15%[3,4].

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Semi-adjustable articulators were originally developed to aid in dental rehabilitation cases, not for the treatment of DFD. They do not provide a reliable condylar rotational axis, nor are they able to reproduce intrinsic temporomandibular joint (TMJ) deformities. Therefore, these devices should be used with caution when applied to orthognathic surgery planning[5–7].

Virtual surgical planning (VSP) eliminates many of the laboratory steps required in CMS. There is no need to use manual prediction tracing and face-bow transfer to replicate the correct relationship of the patient's skull and the occlusal plane. By eliminating laboratory steps that may lead to errors, it is expected that VSP will produce more accurate results[8].

The advent of three-dimensional imaging has brought a new horizon to the diagnosis and treatment planning of DFD. It is now possible to see the bone movements and their influence on the adjacent tissues. Furthermore, it is fair to conclude that these advances will provide more accurate results for bone repositioning during surgery. However, studies comparing CMS and VSP with the aim of verifying the reliability of VSP are still lacking.

The purpose of this retrospective study was to determine whether VSP is an accurate method for maxillary positioning in patients undergoing orthognathic surgery when compared to conventional articulator model surgery, through the superimposition of computed tomography (CT) images.

Materials and methods

This retrospective study investigated 30 adults patients submitted to bimaxillary orthognathic surgery between March 2011 and September 2015. The study was approved by the institutional review board. All patients were operated on by the same team of surgeons and residents. Inclusion criteria for the study were as follow: (1) bimaxillary orthognathic surgery; (2) availability of pre- and postoperative CT images; (3) availability of surgical planning records. Two groups were created according to the treatment planning performed: CMS and VSP.

The treatment planning protocol was the same for all patients. This was performed after physical examination, photographs in the neutral head position, CT analysis, and study of the plaster model according to Ellis et al.[5]. The preoperative CT image was imported into Dolphin Imaging software (Dolphin Imaging and Management Solutions, Chatsworth, CA, USA) and the head position was oriented with the data from the physical examination and photographs. The following images were created using the software: panoramic radiographs and cephalograms in frontal and lateral views. Digital cephalometric tracing was accomplished over the cephalogram.

A Le Fort I osteotomy was performed in all patients according to the conventional method of Bell et al.[9]. A Kirschner wire inserted at nasion (without an incision) and a surgical splint were used to determine the vertical, anteroposterior, and transverse maxillary positions. After the elimination of bony interferences, the maxilla was fixed with four L-shaped titanium miniplates. The mandible was then osteotomized, using a bilateral sagittal split osteotomy (BSSO).

CT examinations were performed within 1 week before the procedure and at $\geq$10 days after surgery. The intermediate splint was fabricated according to the treatment planning using either CMS or VSP.

Intermediate splint fabrication with CMS

The model surgery was performed according to the technique of Ritto et al.[10] in all cases. For each patient, two maxillas and two mandibles were mounted on a semi-adjustable articulator (Bio Art Equipamentos Odontologicos Ltda, São Carlos, São Paulo, Brazil) with the aid of a face-bow (Bio Art Equipamentos Odontologicos Ltda), simulating the patient's preoperative condition (Fig. 1A). One maxillary and one mandibular cast were identified as original models, not to be cut. The following measurements were recorded on the model surgery sheet for each original maxillary cast: (1) the vertical position of the central incisors, canines, and mesiobuccal cusp tips of the first molars; (2) the anteroposterior position of the central incisors; and (3) the transverse position of the upper midline and the mesiobuccal cusp

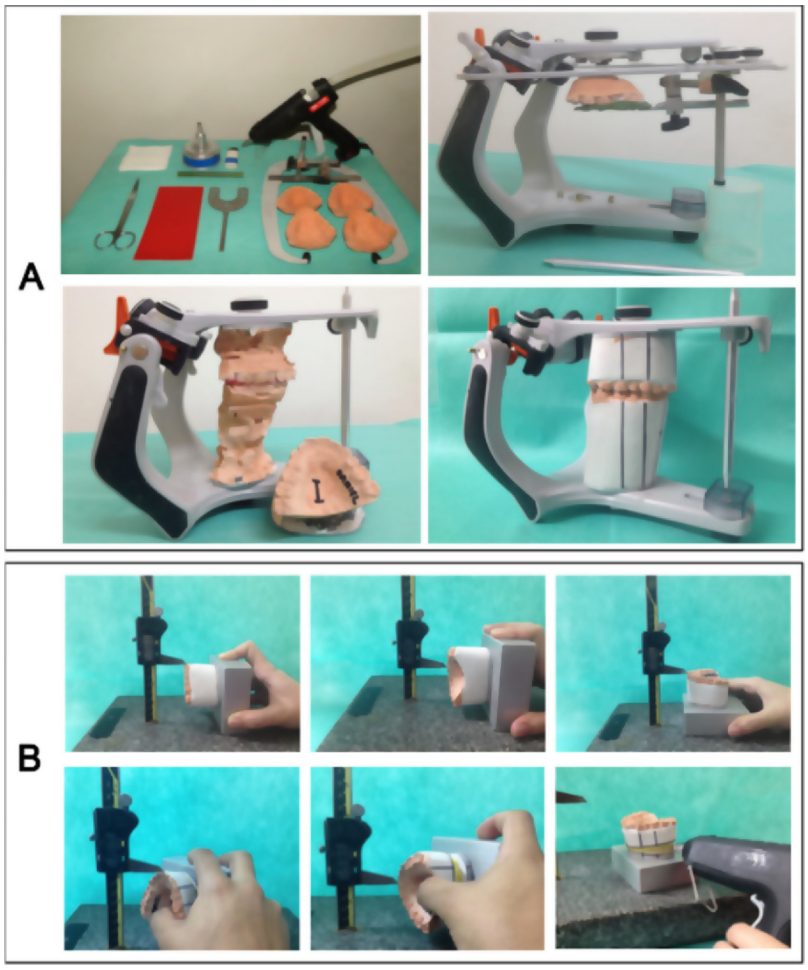

Fig. 1. (A) Maxilla model mounted on a face-bow. (B) Measurements on conventional model surgery using the Erickson platform.