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Computer-assisted orthognathic surgery for correction of facial asymmetry: results of a randomised controlled clinical trial

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Abstract

In this randomised controlled clinical trial, 2 homogeneous groups of patients with facial asymmetry ($n = 10$ in each) were treated by either classic or computer-assisted orthognathic corrective surgery. Differences between the 2 groups in the alignment of the lower interincisal point ($p = 0.03$), mandibular sagittal plane ($p = 0.01$), and centring of the dental midlines ($p = 0.03$) were significant, with the digital planning group being more accurate.

Keywords: Computer-assisted orthognathic surgery; Facial asymmetry; Orthognathic planning

Introduction

The correct planning of successful correction of facial asymmetry can be complex. In clinical practice it is often difficult to individualise the midline facial landmarks on a standard frontal cephalogram because of the superimposition of different cranial structures. Midlines can therefore be adopted arbitrarily to assess the asymmetry of the face, which can lead to imprecise evaluation.

Classical surgical simulation using plaster casts on semi-individual articulators is also imprecise. The alignment of the midlines on the articulator is hindered by many errors inherent in the planning of the classic model operation.[1–6]

Planning the correction of asymmetry is more difficult than planning the correction of sagittal deformities because of the complex management of different movements of the plaster casts (roll, yaw, and lateral translation) that affect the position and inclination of the midlines and occlusal planes. Correct model planning of symmetrical maxillomandibular repositioning is also difficult because of the inaccuracy of linear and angular measurements, usually made between pencil marks on the rough surface of the plaster casts.

Surgical planning of the correction of facial asymmetry is therefore challenging, but the difficulties lie mainly in the out-of-date and imprecise tools that we use during the diagnostic and simulation phases, which result in the incorporation of various errors in the intermediate splint. In many cases, despite meticulous planning, residual asymmetry is common.

We wondered if digital planning would give more accurate results.[7,8] Several currently available programmes permit virtual operations with digital control of the 3-dimensional movements of the maxilla, and the computer-aided design

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and machining (CAD/CAM) of intermediate splints.[9] These programmes can overcome the technical problems of management of the spatial positions of the jaws with reference to the soft tissues and craniofacial midlines.

The purpose of this randomised, controlled, clinical study was to evaluate the most accurate procedure for orthognathic correction of facial asymmetry. We compared two different methods of surgical planning: classic and computer-assisted.[10] The specific aims of the study were to measure and compare the rates of alignment and reduction of cant of the dental and facial midlines between the 2 groups.

Patients, material, and methods

Design of the study

We designed a randomised, controlled trial (ClinicalTrials.gov id. NCT01879969) that was conducted according to the Helsinki Declaration of 1975, and approved by the Research Committee (IRB) of the Department of Surgical, Microsurgical and Medical Science, University of Sassari, Italy.

We studied 20 patients who presented to the Maxillofacial Surgery Unit, University Hospital of Sassari, for evaluation and management of facial asymmetry or lateral deviation of the mandible. The randomisation codes were created (Excel, Microsoft, Redmond, WA, USA), by combining a sequence of randomised non-consecutive numbers to match the 2 procedures (classic or digital planning). The codes were assigned by an independent operator who was not involved in the trial, and were placed in envelopes. Data were then collected in sheets (Excel).

All participants provided written informed consent before enrollment, after which they were treated by orthognathic repositioning of the maxilla and mandible with or without genioplasty. All operations were planned and done by the same surgeon between November 2010 and December 2012.

The inclusion criteria were: cant of the occlusal plane of more than 3° or midline discrepancies of more than 2.5 mm, or both; the presence of all central incisors; radiographs and plaster casts taken before and after the operation (classic group), or cranial cone-beam computed tomographic (CT) images (digital group), together with digital photographs taken before and after the operation. Patients were excluded if they had had previous trauma to the hard or soft facial tissues, functional deviation of the mandible, or their records were incomplete (cone-beam CT, radiographs, casts, or digital photographs).

Variables

The primary predictive variable was method of planning treatment. Each eligible patient was randomly selected to have bimaxillary surgery planned with a classic, standard procedure or using computer-assisted orthognathic surgery. The primary outcome variables were linear and angular measures that defined the alignment of the facial midlines, or reduction of maxillary and mandibular cant in the 2 groups.

Technique of classic planning

The deformity for each patient was diagnosed after careful analysis of frontal facial aesthetics,[11–13] compared with the cephalometric findings.[14]

The plaster casts were mounted on an average value, semi-individual articulator (SAM II, SAM Präzisionstechnik GmbH, Munich, Germany). The vertical and mediolateral relations of the teeth were recorded by drawing vertical reference lines on the upper model and horizontal reference lines at a calculated distance. With these reference points, the precise movements of the maxillary segments were calculated in the 3 planes of space with model surgery.[15]

The models were repositioned based on data obtained with the surgical Visual Treatment Objective.[16] Surgical simulation allows the manufacture of the resin occlusal intermediate splint that records the occlusal relations after the upper model has been moved and the mandible is still in the preoperative position, which serves as a guide during the operation. In some cases (such as those with class II, short face, or asymmetric vertical deficiency of the face) we prefer to move the mandible first, and inverted planning is used.

Technique of digital planning

We used cone-beam CT data (KaVo, Biberach, Germany) and the Maxilim software (Medicim, Nobel Biocare Group). The protocol for acquiring CT images involved a first scan of the patient in centric occlusion with relaxed lips, a second scan at low resolution and low-dose biting of a double tray, and a third scan of that tray to record the occlusion at high resolution.[10] The total radiation dose to the patient was ~100 μSv.

Once the CT images had been acquired on to the software, a computer-assisted procedure allowed the development of a virtual 3-dimensional model of the hard and soft tissues of the face, with a better-defined window of the teeth and intercuspation (augmented model). A complete set of 2-dimensional photographs of the face captured with any digital camera was used to add information about the texture of the skin. This process created the patient's face mask.

The relations between the soft and hard tissues of the face were then shown, setting the transparency of the skin texture, and permitting the measurement of the maxillary vertical dimension compared with the length of the upper lip, or definition of deviation of the dental midline from the philtrum (Fig. 1).

Next, we made a 3-dimensional cephalometric analysis. Lateral and frontal cephalograms were developed from the CT data and connected to the surface of the hard and soft tissues of the virtual model. Once all the landmarks had