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Influence of setback and advancement osseous genioplasty on facial outcome: A computer-simulated study

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ABSTRACT

The aim of this virtual study was to investigate the influence of angular deviation and displacement distance on the overlying soft tissue during chin genioplasty. Computed tomography data from 21 patients were read using ProPlan CMF software. Twelve simulated genioplasties were performed per patient with variable osteotomy angles and displacement distances. Soft-tissue deformations and cephalometric analysis were compared. Changes in anterior and inferior soft-tissue of the chin along with resultant lower facial third area were determined. Maximum average changes in soft-tissue were obtained anterior after 10-mm advancement about 4.19 SD 0.84 mm and inferior about −1.55 SD 0.96 mm. After 10-mm setback anterior −4.63 SD 0.56 mm and inferior 0.75 SD 1.16 mm were deviations found. The anterior soft tissue showed a statistically significant change with bony displacement in both directions independent of osteotomy angle ($p < 0.001$) and only after a 10-mm advancement with an angle of −5° significant differences at inferior soft-tissue were noted ($p = 0.0055$). The average area of the total lower third of the face was 24,807.80 SD 4,091.72 mm^2 and up to 62.75% was influenced. Advanced genioplasty leads to greater changes in the overlying soft tissue, whereas the affected area is larger after setback displacement. The ratio between soft and hard tissue movements largely depends on the displacement distance.

1. Introduction

The chin plays an important role in the overall harmonization of the facial profile. It has been generally suggested that when evaluating facial aesthetics, the public mostly considers the aesthetics of the lips rather than the other facial structures. Soft tissue deformities of the lower third of the face can be attributed to changes in size, shape, position, or proportion of the lower third facial anatomical landmarks, and this could disturb the overall balance of facial expression (Gonzalez-Ulloa, 1962; McCarthy et al., 1990).

Several studies investigated the predictability of soft and hard tissue changes after surgical correction of the chin skeletal tissue. Most of these investigations dealt with the results of advancement genioplasty, which were close to a 1:1 ratio for the soft tissue pogonion response to surgery (Busquets and Sassouni, 1981; Krekmanov and Kahnberg, 1992; McDonnell et al., 1977; Wittbjer and Rune, 1989). However, it has been shown that the more the chin is moved forward, the less the soft tissue to bone ratio. Furthermore, vertical displacement significantly influences the overall soft tissue surgical outcome. With a more shortened chin, the overlying soft tissue of the chin becomes thicker and vice versa (Van Sickels et al., 1994). Predictive soft tissue response ratios for the lower lip in advancement genioplasty have been highly variable, ranging from 0.26:1 to 0.85:1 (Dermaut and De Smit, 1989; Dolce et al., 2001; Ewing and Ross, 1992; Joss and Thuer, 2008; Keeling et al., 1996; Mobarak et al., 2001; Mommaerts and

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Marxer, 1987; Thuer et al., 1994). Establishment of statistical correlations associated with these ratios is generally difficult because most reported correlation coefficients varied between 0.38 and 0.72.

Recently, most reported studies are based on evaluations of lateral cephalometric tracings. However, advancement in planning methods for orthognathic surgery has lately been optimized by preoperative surgical simulation and digital planning methods. The accuracy of the preoperative diagnosis, surgical planning, and surgical methods has significantly improved because of the progress in three-dimensional (3D) skeletal analysis methods using computer tomography (CT) (Hsu et al., 2013). Based on a patient CT scan, 3D images of the skeletal tissue can be accurately reconstructed and surgical schemes can be simulated in a simple and efficient way. Moreover, the development of virtual planning software can be used for surgical simulation of the necessary osteotomies for genioplasty. Subsequently, the virtually osteotomized bony segment can be freely shifted and proposed movement via virtual planning can be transferred for real-time use during surgery using a surgical guide that is fabricated using the widely available 3D printers. In orthognathic surgery, interest in a simultaneous modelling of the facial soft tissue response during surgical planning has significantly increased. The modelling of the viscoelastic behaviour of soft tissue is of special importance, which is a key element in accurately predicting surgical outcomes (Marchetti et al., 2011). Marchetti et al. validated soft tissue simulation in orthognathic surgical planning, which indicated that soft tissue previewing using a surgical simulation software was of high quality. They concluded that the virtual movement of jaws by using the appropriate software could predict reliable soft tissue responses. In addition, Bianchi et al. suggested that virtual soft tissue simulation is an essential part of surgical planning in orthognathic surgery and the demand for its use as a standard of care is mainly based on its high-quality predictability for different orthognathic surgical procedures (Bianchi et al., 2010). Particularly, the reliability of the overlying soft tissue facial surface outcome is important, which includes accurate colour texture that allows the surgeon to pay more attention to the aesthetic effect of a particular orthognathic surgical procedure on the entire face.

Various techniques for genioplasty have been described in the literature. Distinct features of sliding, jumping, interpositional, wedge, oblique, stepladder/two-tiered, and centring genioplasty have also been identified (Ward et al., 2007). The sliding technique is most common, although the direction of osteotomy can also influence the overall result. Seifeldin et al. demonstrated differences in soft to hard tissue ratios, the labiomental fold depth, and the position of the lips among different genioplasty techniques (Seifeldin et al., 2014).

The present study investigated the virtual soft tissue response of the lower third of the face and corresponding cephalometric measurements after virtually performing sliding osseous genioplasty with variations in osteotomy angle relative to the Frankfort plane with a bone segment shift of 5 mm and 10 mm in the anterior and posterior directions, respectively. The aim of the present study was to determine whether angular deviation and displacement distance have a statistically significant influence on facial aesthetics outcomes.

2. Materials and methods

The present study complies with the principles laid down in the Declaration of Helsinki. After institutional approval head and neck CT scans of 21 patients (8 females and 13 males, mean age: 28 years, range: 18–39 years) were obtained from the radiology server of our department from patients aged between 20 and 40 years. Exclusion criteria were history of any surgery, signs of facial fractures, tumours or other deformities of the hard and soft tissues, missing teeth, non-occlusion, as well as compromising artifacts.

CT scans of the facial skeleton were performed using the 128-row multi-slice CT scanner Somatom Definition Flash (Siemens, Erlangen, Germany). Slice thickness was 0.5 mm. The resulting CT data in digital imaging and communications in medicine (DICOM) format were read in a ProPlan CMF 2.0 software (Materialise, Leuven, Belgium), which has been well established in the field of computer-assisted jaw surgery because of its high accuracy (Modabber et al., 2014; Möhlhenrich et al., 2015a, 2015b). The appropriate voxels were grouped based on Hounsfield units (HU) between 250 and 3000 to achieve a bone mask, as well as −700 and 200 to generate a soft tissue mask. This mask was processed by segmentation with the ProPlan CMF 2.0 software and finally, the virtual models of the head and neck skeleton as well as the corresponding soft tissue profile were constructed. With aid of the orthognathic surgical tool provided in the ProPlan CMF 2.0 software, landmarks on the soft tissues were set according to the recommendations in the literature, with a special consideration of the chin (Cavalcanti et al., 2004; Hwang et al., 2012; Kim et al., 2013) (Fig. 1).

Soft tissue landmarks were set as follows: pronasale (Pn), subnasale (Sn), labrale superior (Ls), upper lip point (ULP) right and left, stomion (Stm), cheilion (Ch) right and left, labrale inferior (Li), soft tissue B-Point (B*), soft tissue pogonion (Pog*), soft tissue menton (Me*), and soft tissue gonion (Go*) right and left. In addition, landmarks on the hard tissue were set as follows: nasion (N), sella turcica (S), anterior nasal spine (ANS), porus acusticus externus (Po) right and left, orbicularis oculi inferior (Or) right and left. Reference planes were as follows: Frankfort plane (defined by points PoL, PoR, OrL, and OrR), sagittal plane (defined by points N, S, and ANS), and aesthetic-line (defined through points Ns and Pog* and the sagittal plane). The resulting cephalometric measurements are presented in Table 1. Landmark identification was performed by a single investigator.

The issues in our case could only be studied in virtual reality because virtual reality makes different chin operations possible for

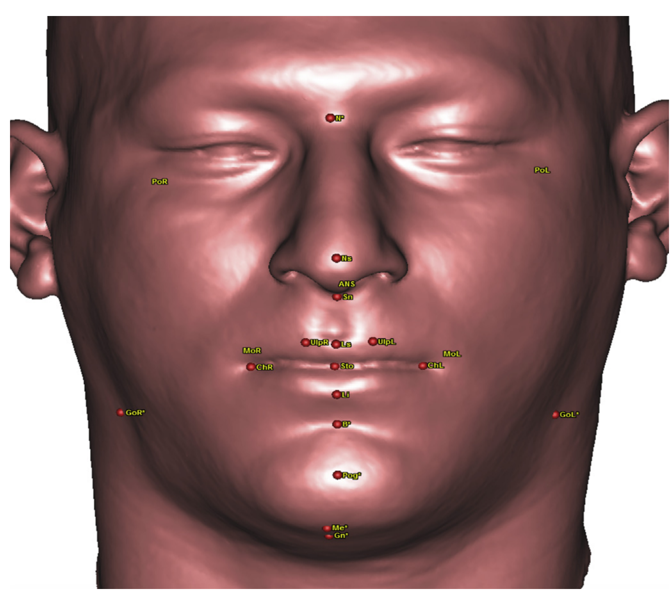

Fig. 1. Landmarks on soft tissue: Pn (pronasale), Sn (subnasale), Ls (labrale superior), ULP (upper lip point) right and left, Stm (stomion), Ch (cheilion) right and left, Li (labrale inferior), B* (soft tissue B-Point), Pog* (soft tissue pogonion), Me* (soft tissue menton), and Go* (soft tissue gonion) right and left.