Int. J. Oral Maxillofac. Surg. 2017; 46: 586–589
http://dx.doi.org/10.1016/j.ijom.2017.01.020, available online at http://www.sciencedirect.com

International Journal of Oral & Maxillofacial Surgery

Technical Note
Cosmetic Surgery

Three-dimensional surgical planning and simulation to improve surgical accuracy and reduce invasiveness of cranioplasties

A. Valls-Ontañón[1,2], C. Mezquida-Fernández[1], R. Guijarro-Martínez[1,2], F. Hernández-Alfaro[1,2]

[1]Institute of Maxillofacial Surgery, Teknon Medical Centre, Barcelona, Spain; [2]Department of Oral and Maxillofacial Surgery, Universitat Internacional de Catalunya, Sant Cugat del Vallès, Barcelona, Spain

A. Valls-Ontañón, C. Mezquida-Fernández, R. Guijarro-Martínez, F. Hernández-Alfaro: Three-dimensional surgical planning and simulation to improve surgical accuracy and reduce invasiveness of cranioplasties. Int. J. Oral Maxillofac. Surg. 2017; 46: 586–589.

Abstract. Patients with too large a frontal prominence may suffer discomfort and subsequent self-esteem problems. The case of a 29-year-old male with a prominent forehead is presented. After three-dimensional (3D) virtual simulation of the procedure, a stereolithographic model of the skull and a surgical cutting guide were fabricated. The forehead recontouring and reconstruction procedure was performed under general anaesthesia and the postoperative course was uneventful. At the 12-month postoperative follow-up, clinical and radiographic documentation confirmed softening of the frontal prominence from 14.48 mm to 8.56 mm, a nasofrontal angle increase of 22°, and overall high patient satisfaction. The proposed workflow results in greater surgical precision, shorter reconstruction times, reduced patient morbidity due to a reduced risk of dural exposure and postoperative infection, and overall higher predictability and patient satisfaction.

Key words: frontal sinus; frontal bone; forehead; cone beam computed tomography; surgical planning software; surgical cutting guide; cranioplasty; aesthetic surgery; feminization.

Available online 21 February 2017

Comprehensive aesthetic analysis of the upper facial third entails consideration of three key-areas: the frontal sinus prominence, the superciliary and supraorbital ridge, and the nasoglabellar angle. In particular, a prominent frontal vault is an inherent masculine characteristic that may be due to large frontal sinuses and/or thick supraorbital ridges.[1] Consequently, the nasofrontal angle is often acute in men, while it is much more obtuse in women in response to very little — if any — brow fullness.[2]

The frontal sinuses are the last facial sinuses to achieve complete development. After slow progressive growth, they become pneumatized and reach their full size at puberty.[3] Lee et al. described frontal sinus anatomy and sex variations from computed tomography (CT) scan images and concluded that males have greater dimensions in most frontal sinus measurements: male foreheads were characterized by a more acute nasofrontal angle (119.9°

0901-5027/050586 + 04

vs. 133.5°), a steeper posterior forehead inclination (−7.2° vs. −3.5°), and a wider glabella (44.4 mm vs. 33.9 mm), frequently protruding beyond the ideal forehead slope line (51% vs. 30%).[4]

According to the classification of Urken et al., an abnormally large frontal sinus may be due to three different conditions: hypersinus, pneumosinus dilatans, and pneumocele.[5] A hypersinus is an enlarged frontal sinus that does not extend beyond the normal limits of the frontal bone and has normal wall thickness. Pneumosinus dilatans is a situation where the sinus expands abnormally beyond the normal limits of the frontal bone, yet the bony walls of the sinus are of normal thickness. Finally, an aerated sinus with variable thinning of its walls characterizes a pneumocele. This condition differs from the two previous ones in that it is considered a pathological status secondary to a sinus drainage disturbance.[3]

While the chief patient complaint is an annoying prominent forehead, related symptoms include local painful pressure, nasal bleeding, anosmia, diplopia, and headache. In women with bossing foreheads, substantial aesthetic disharmony and facial masculinization may result.[1–3] Likewise, men with too large a frontal prominence may refer to discomfort and self-esteem problems. Surgical reshaping of the upper facial third is an effective solution to the aforementioned clinical and psychological symptoms.

The aim of this article is to describe a specific workflow for three-dimensional (3D) planning and execution of forehead recontouring and reconstruction, to analyze its advantages and limitations, and to discuss potential possibilities for future improvement.

Methods

A 29-year-old male was referred to the department of oral and maxillofacial surgery of a tertiary hospital complaining of a prominent forehead and self-esteem problems related to his facial appearance (Fig. 1). The patient was otherwise asymptomatic and denied any symptoms consistent with sinus disease. The remainder of his medical history was unremarkable, with no history of trauma, infectious rhinitis, or allergies.

Physical examination revealed a prominent frontal vault and an acute nasofrontal angle. Otorhinolaryngological, ophthalmological, hormonal, and neurological examinations were normal.

A cone beam computed tomography (CBCT) examination was performed (i-CAT scanner; Imaging Sciences International, Inc., Hatfield, PA, USA) and showed diffuse enlargement of both frontal sinuses. No signs of intracranial or orbital involvement were detected. Similarly, a sinus pathology was ruled out. Metric analysis was performed at the facial midline. The frontal sinus height, width, and depth measured 36.47 mm, 58.84 mm, and 14.58 mm, respectively. The thickness of the anterior table was 2.24 mm. Despite mild thinning of the anterior cortical wall, the anatomical deformity was categorized as a pneumosinus dilatans owing to frontal sinus expansion beyond the normal limits of the frontal bone with signs or symptoms of sinus drainage disturbance.

Fig. 1. Preoperative and postoperative pictures illustrating the successful result.

Primary DICOM files (digital imaging and communications in medicine) from the CBCT analysis were imported into specific treatment planning software (SimPlant O&O version 13.0; Dentsply, Leuven, Belgium). After careful manual segmentation of the raw dataset, the 3D skull model of the patient was exported in .stl (stereolithography file) format in order to fabricate a stereolithographic model. The complete forehead recontouring and reconstruction procedure was simulated virtually. The virtual plan was reproduced in the stereolithographic skull model, and a surgical cutting template was fabricated.

Under general anaesthesia, the frontal bossing was reached through a coronal approach. The incision was performed in an oblique fashion in order to preserve the maximum amount of hair follicles. Once the frontal bone, glabella, and superior orbital rim were exposed, both supraorbital neurovascular bundles were dissected carefully. The limits of the frontal sinus were marked on the anterior cortical wall with the help of the prefabricated surgical cutting guide (Fig. 2). Then, the anterior wall was removed integrally using a piezoelectric device (Implant Center 2; Satelec-Acteon Group, Tuttlingen, Germany) (Fig. 3). The tip of the piezoelectric saw was inclined obliquely at an angle greater than 45° to the bone surface, taking care to avoid any perforations and subsequent dural exposure. The mucosa of the sinus was removed, and both frontonasal ducts and frontal sinuses were obliterated with fibre-reinforced calcium phosphate (Norian CRS; Synthes Inc., West Chester, PA, USA). The previously removed anterior wall fragment was meticulously sculpted and flattened with a surgical burr (round cutting, 6-mm diameter head) and then repositioned. The sharp edges of the repo-

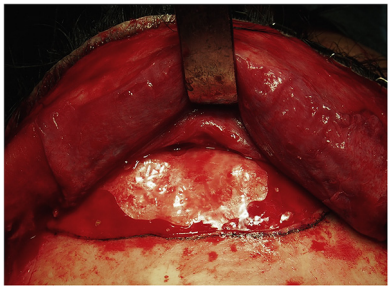

Fig. 2. Intraoperative picture: limits of the frontal sinus marked on the anterior cortical wall with the help of the prefabricated surgical cutting guide.