Journal of the Formosan Medical Association (2016) 115, 387–388

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.jfma-online.com

PERSPECTIVES

Three-dimensional simulation of orthognathic surgery—surgeon's perspective

Daniel Lonic, Lun-Jou Lo*

Department of Plastic and Reconstructive Surgery, and Craniofacial Research Center, Chang Gung Memorial Hospital, Chang Gung University, Taoyuan, Taiwan

Received 8 August 2015; accepted 4 September 2015

Orthognathic surgery (OGS) is a powerful procedure used to correct several types of facial deformity. By altering the position of maxillary, mandibular, and chin segments after osteotomy, the facial bony structure and soft-tissue envelope can be harmonized, leading to substantial esthetic and functional improvement of facial appearance and dentoalveolar complex. Because of the meticulous nature of the bone segment movements, accurate surgical planning is imperative.

OGS planning has been subject to dramatic progress. Previously, surgeons relied on two-dimensional (2D) cephalograms, photographic analysis, articulators, and plaster casts to assess the patient's bony and soft-tissue situation.[1] However, these methods have numerous drawbacks. 2D methods assume that every patient has a symmetrical face, which is not reflective of reality, and results in diminished planning accuracy due to bony overprojection in the frontal and lateral cephalograms. The rotational movements around the vertical axis (yaw rotation) cannot be determined in these views. In addition, articulator-mounted plaster models do not provide information about possible bony collisions in the ramus area after the movement of the mandible or the need for genioplasty procedures. With the introduction of three-dimensional (3D) planning methods these problems are now more readily addressed, and the surgeon can virtually plan and conduct the surgery using 3D computed tomography images as a basis for complete patient analysis.

Virtual surgery planning (VSP) has gained substantial popularity in recent years, and increased accuracy is only one of the features that has led to the growth of this technology.[2] Based on cone-beam computed tomography (CBCT), the surgeon is able to assess the osseous morphology and its relationship to the soft tissue, and the position of the inferior alveolar nerve in the mandible in order to avoid nerve injury during the sagittal splitting procedure. Furthermore, the VSP process is carried out like an actual OGS, so that every surgical step can be evaluated before surgeons enter the operating room.[3] Unusual bony deformities, such as weak bony unions in the Le Fort I segment of cleft patients, can be previewed before they result in surgical difficulty. The placement of the maxilla and the proximal and distal segments of the mandible can be precisely adjusted to provide the best possible esthetic and functional result. Patients with facial asymmetry, in particular, warrant 3D planning to address the correct positioning of the bony segments in all three dimensions; in these difficult cases good planning can alleviate surgical morbidity because the surgeon can rely on the result of the simulated surgery during the procedure.[4]

When two-jaw OGS is carried out using a single occlusal splint, the surgeon has six degrees of free movement to position the maxillomandibular complex (MMC) in the

Conflicts of interest: The authors have no conflicts of interest relevant to this article.

* Corresponding author. Department of Plastic and Reconstructive Surgery, Chang Gung Memorial Hospital. 5 Fu-Shin Street, Kwei Shan, Taoyuan, Taiwan.

E-mail address: lunjoulo@cgmh.org.tw (L.-J. Lo).

http://dx.doi.org/10.1016/j.jfma.2015.09.002

position that yields the best esthetic and functional result for the patient, thus providing enormous surgical flexibility.[5] However, this range of freedom also comes with a long learning curve, because the positioning of the MMC can be difficult for the beginner and even the experienced. VSP can shorten the learning process, because the planning procedure already simulates the actual surgery and its result by providing the measurements of maxillary impaction, yaw rotation, and mandibular ramus configuration. The entire process of MMC positioning can be rehearsed in a calm environment without the stress of the operating room, and thus free the surgeon of doubt in his or her result when intraoperative judgement is impaired by swelling, muscle relaxation, and supine positioning.

Controlling the accurate execution of the surgical plan can be achieved by postoperative validation using image superimposition, color mapping, and landmark comparison of simulation and postoperative CBCTs. However, new developments help transfer the virtual surgery plan into the operating room. Intraoperative navigation and individual 3D-printed positioning guides support the surgeon in achieving the desired result by further reducing human error.[6,7] These techniques are now used for OGS by some international centers, and the decreasing prices of planning programs and 3D printers will certainly contribute to the spread of these tools. By implementing augmented reality in this process, the feasibility of this information transfer by projecting the previously planned position of the bony segments into the surgeon's visual field in real-time during surgery can be further increased.[8] Although this method is still in the early stage of development, the concept of merging VSP with the real environment is the next logical step in further improving this process.

We can conclude that VSP is now substantially changing the process of OGS planning. It should be done by the surgeon to anticipate the possible problems of every case, and the additional time spent on VSP is rewarded by increased accuracy, improved outcome, and confidence in the surgical plan. VSP brings us one step closer to the promise we make to our patients that "what you see is what you get".

References

1. Kusnoto B. Two-dimensional cephalometry and computerized orthognathic surgical treatment planning. *Clin Plast Surg* 2007;**34**:417–26.
2. Haas Jr OL, Becker OE, de Oliveira RB. Computer-aided planning in orthognathic surgery-systematic review. *Int J Oral Maxillofac Surg* 2015;**44**:329–42.
3. Cevidanes LH, Tucker S, Styner M, Kin H, Chapuis J, Reyes M, et al. Three-dimensional surgical simulation. *Am J Orthod Dentofacial Orthop* 2010;**138**:361–71.
4. Lin HH, Lo LJ. Three-dimensional computer-assisted surgical simulation and intraoperative navigation in orthognathic surgery: a literature review. *J Formos Med Assoc* 2015;**114**:300–7.
5. Lin HH, Chang HW, Wang CH, Kim SG, Lo LJ. Three-dimensional computer-assisted orthognathic surgery: experience of 37 patients. *Ann Plast Surg* 2015;**74**:S118–26.
6. Chang HW, Lin HH, Chortrakarnkij P, Kim SG, Lo LJ. Intraoperative navigation for single-splint two-jaw orthognathic surgery: from model to actual surgery. *J Craniomaxillofac Surg* 2015;**43**:1119–26.
7. Lin HH, Chang HW, Lo LJ. Development of customized positioning guides using computer aided design and manufacturing technology for orthognathic surgery. *Int J Comput Assist Radiol Surg* 2015 May 16 [Epub ahead of print].
8. Badiali G, Ferrari V, Cutolo F, Freschi C, Caramella D, Bianchi A, et al. Augmented reality as an aid in maxillofacial surgery: validation of a wearable system allowing maxillary repositioning. *J Craniomaxillofac Surg* 2014;**42**:1970–6.