Int. J. Oral Maxillofac. Surg. 2016; 45: 1065–1069
http://dx.doi.org/10.1016/j.ijom.2016.03.012, available online at http://www.sciencedirect.com

International Journal of Oral & Maxillofacial Surgery

Clinical Paper
Orthognathic Surgery

Comparison of time required for traditional versus virtual orthognathic surgery treatment planning☆

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Abstract. Virtual surgical planning (VSP) is a tool for predicting complex surgical movements in three dimensions and it may reduce preoperative laboratory time. A prospective study to compare the time required for standard preoperative planning versus VSP was conducted at Massachusetts General Hospital from January 2014 through January 2015. Workflow data for bimaxillary cases planned by both standard techniques and VSP were recorded in real time. Time spent was divided into three parts: (1) obtaining impressions, face-bow mounting, and model preparation; (2) occlusal analysis and modification, model surgery, and splint fabrication; (3) online VSP session. Average times were compared between standard treatment planning (sum of parts 1 and 2) and VSP (sum of parts 1 and 3). Of 41 bimaxillary cases included, 20 were simple (symmetric) and 21 were complex (asymmetry and segmental osteotomies). Average times for parts 1, 2, and 3 were 4.43, 3.01, and 0.67 h, respectively. The average time required for standard treatment planning was 7.45 h and for VSP was 5.10 h, a 31% time reduction ($P < 0.001$). By eliminating all or some components of part 1, time savings may increase to as much as 91%. This study indicates that in an academic setting, VSP reduces the time required for treatment planning of bimaxillary orthognathic surgery cases.

Key words: model surgery; splint construction; virtual surgical planning; orthognathic surgery; resident work-hours.

Accepted for publication 15 March 2016
Available online 18 April 2016

☆ This study was presented at the 2015 American Association of Oral and Maxillofacial Surgeons Annual Meeting, Washington, DC.

During the last decade, in parallel with technological advances, societal pressure has pushed surgical disciplines to increase efficiency and focus on performance and cost metrics while maintaining quality. Transformative advances such as three-dimensional (3D) computer-aided treatment planning and surgical navigation have had a significant impact on the specialty of oral and maxillofacial surgery

0901-5027/0901065 + 05

(OMS) in general and on orthognathic surgery in particular. At the same time, mandated limits on resident work-hours have resulted in a similar drive to improve efficiency in education and eliminate tasks, which provide decreasing educational value after a period of time.

In an effort to reduce medical errors, state laws and regulations of the American Council on Graduate Medical Education (ACGME) have limited resident work-hours to 80 per week and have mandated 1 day off per week for all residents in addition to 8 h free of duty per day for PGY-1s (post-graduate year 1 residents).[1–4] Although the Committee on Dental Accreditation (CODA), which governs accreditation of OMS programs in the USA, has not enacted these regulations, many OMS training programs are required to comply by their sponsoring institutions.[1,2] Programs are thus under pressure to limit resident tasks and service-related duties, while maximizing clinical education in the allotted time. Studies across various surgical specialties have demonstrated the difficulty of balancing reduced work-hours with providing the clinical experience required to adequately train residents.[4–8]

Traditional orthognathic surgery analysis, treatment planning, model surgery, and construction of surgical occlusal splints represents a significant time commitment for trainees. It is recognized that virtual surgical planning (VSP), when utilized properly, provides very detailed analysis of anatomic deformities and aids the surgeon in accurately planning operative corrections of dentofacial deformities.[9–18] The limitations of traditional model surgery and availability of cone beam computed tomography (CBCT) scanners has established VSP as a viable tool for the analysis and planning of complex orthognathic surgery cases.[9–18] Furthermore, 3D printing of occlusal splints can potentially save surgeons/residents additional time.

Concerns exist that the use of VSP may deprive trainees of learning to perform model surgery. Nevertheless, the use of VSP can potentially save resident work-hours in academic training centers. At the Massachusetts General Hospital (MGH), traditional treatment planning and model surgery are performed for all orthognathic cases to allow for discussion and review during formal orthognathic surgery conferences and presentation to the patient. Recently, VSP has been used for bimaxillary orthognathic cases and segmental Le Fort I osteotomies.

The purpose of this study was to compare the time required for MGH resident and attending/consultant surgeons to perform standard preoperative planning and model surgery versus VSP. The hypothesis was that VSP would result in a significant reduction in laboratory and overall planning time. The aims were to quantify the time spent at each step in surgical planning for both methods and to determine areas of potential time-savings.

Materials and methods

Study design and sample

This was a prospective study of surgical planning done for orthognathic surgery cases performed at MGH from January 2014 through January 2015. Bimaxillary surgery cases (Le Fort I osteotomy and bilateral sagittal split osteotomy), in which both standard planning (i.e., two-dimensional (2D) cephalometric analysis and treatment planning, model surgery, and fabrication of intermediate and final splints) and VSP (with 3D printing of intermediate and final occlusal splints) to the same surgical plan were performed, were analyzed. Cases that only involved a single jaw, had incomplete data recorded, and those that required other types of osteotomy (e.g., inverted L or vertical ramus), reconstruction of the condyle–ramus unit, or distraction osteogenesis were excluded.

Time recordings

The duration of each step in diagnosis and treatment planning for each case was recorded in real time. The majority of standard preparation work was done by the residents with faculty input. PGY-1 (intern) and PGY-4 (chief) residents logged the time recorded for each step of the planning process in an Excel spreadsheet (Microsoft, Redmond, WA, USA).

Part 1 was recorded by the PGY-1 resident and consisted of the following: alginate impressions, patient occlusal and face-bow records, pouring, preparing and mounting models on a semi-adjustable articulator (SAM 3; SAM-Dental, Munich, Germany), fabricating a jig for maxillary movements, and surveying and cutting the models in preparation for model surgery. In cases with a segmental maxillary osteotomy, the time required for the additional step of duplicating the segmented, hand-articulated model and remounting it using the jig was recorded.

Part 2 was performed by the PGY-4 resident with attending guidance. The time was recorded by the PGY-4 resident and consisted of the following: occlusal analysis with adjustment as necessary to establish the planned occlusion, traditional model surgery on face-bow mounted models, and fabrication of two acrylic splints (i.e., intermediate and final). The intermediate splint was made on the articulated models simulating the intermediate occlusal position and the final splint on a standard Galetti articulator (Kerr Dental, Orange, CA, USA). In cases with segmental osteotomies, a wire-reinforced palatal strap was added to the final splint to be left in place in the postoperative period. The intermediate splint was made to 'piggy-back' on the final splint, as described previously.[19]

Part 3 was the VSP session done via online conference between clinicians (attending and PGY-4) and engineers at Materialise (Materialise, Plymouth, MI USA). The VSP session required one set of final models articulated by the surgeon in the planned occlusion. This set of models was scanned and incorporated into the 3D model created by the engineers at Materialise. Virtual occlusion or optical imaging of occlusion was not used.

Study variables—predictors

The primary predictor variable was the type of planning used: standard or VSP. The sum of times spent on parts 1 and 2 corresponded to standard treatment planning. For the purposes of this study, VSP time was calculated as part 1 plus part 3.

Secondary predictor variables included the complexity of the case. Cases were classified as 'simple' if the maxilla was a single segment and if there was no correction of an asymmetry. 'Complex' cases involved cant correction, asymmetric rotation, and/or segmental osteotomies of the maxilla. A genioplasty did not alter the categorization of a case between simple and complex, since it was not simulated in model surgeries.

Study variables—outcomes

The outcome of interest was the time recorded to the nearest minute for each step in planning.

Statistical analysis

The statistical analysis was performed using GraphPad Prism 5.0 (GraphPad, La Jolla, CA, USA). Data are presented as the mean ± standard deviation. Descriptive and bivariate statistics were computed to compare study variables between