Soft Tissue Changes Measured With Three-Dimensional Software Provides New Insights for Surgical Predictions

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Purpose: Although computer-aided craniofacial reconstructions allows for simulation of hard tissue changes, the prediction of the final soft tissue facial changes remains a challenge. The purpose of the present study was to evaluate the 3-dimensional (3D) soft tissue changes in patients undergoing 2-jaw orthognathic surgery.

Patients and Methods: For the present retrospective cohort study, 40 consecutive patients (11 men and 29 women; mean age 23.5 ± 4.9 years) who had undergone 2-jaw orthognathic surgery were selected. We obtained the medical and dental records from 3 weeks before surgery to 6 months after surgery. We used image processing software to segment, superimpose, and quantify the hard and soft tissue displacements in 3 dimensions before and after surgery at 15 paired locations. The soft tissue and hard tissue changes were determined through quantification of homologous landmark displacements between the preoperative and postoperative computed tomography data. We measured the 3D soft and hard tissue changes and the anteroposterior, inferosuperior, and transverse components of the changes. We quantified the ratios between the soft and hard tissue changes, tested Pearson's correlation between these changes, and developed a predictive regression equation for the observations at each location.

Results: We found that soft tissue movement followed the hard tissue movement, with a correlation nearly equal to 0.9 (range 0.85 to 0.98), suggesting that the soft tissues of the maxillary and mandibular landmarks are affected similarly by the skeletal movements. The anteroposterior component of the soft tissue 3D displacements followed the hard tissue movement with a ratio greater than 0.9 and with high correlation ($r > 0.9$) in the mandible.

Conclusion: The results of the present study provide surgeons with a ratio of hard to soft tissue change and the strength of the correlations, which will allow for more accurate 3D predictions for both midline and lateral structures in bimaxillary orthognathic surgical cases. In addition, predictive equations for various landmarks were developed and can be used in computer-based prediction programs to aid in treatment planning of soft tissue changes.

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Craniofacial surgery allows for the correction of occlusion and jaw alignment using combined orthodontic and surgical approaches with the goal of improving dentoskeletal harmony and esthetics. The conventional approach for orthognathic surgery planning includes a comprehensive clinical examination, focusing on the face and its underlying skeletal and dental components. In this conventional approach, lateral and posteroanterior cephalometric analysis, supplemented with study model analysis, is routinely undertaken. For surgical planning, the conventional 2-dimensional (2D) approach will not necessarily reveal sufficient information about the causes of the asymmetry, which can compromise the final treatment plan and outcome.[1] The major limitation of 2D cephalometry is the application of 2D data sets to treat a 3-dimensional (3D) problem. Conventional radiographic images can be misleading when complex 3D structures are projected and mapped on 2D surfaces. Additionally, fabrication of the surgical splints introduces a degree of imprecision, because this approach relies on the experience and skill of the practitioner.

Advances in imaging and computer modeling have granted unprecedented clarity regarding the complex 3D anatomy of dentofacial structures and the corresponding soft tissues. This 3D assessment and corresponding surgical prediction provides the surgical team with unique insight to correct severe dentoskeletal issues.[2] The primary motivation of patients with severe deformities is the need to improve their appearance. Patients will be more concerned with improving their facial features than with the underlying skeletal bone changes.[3] In contrast, the surgeon manipulates the skeletal bony segments with the intent of bringing the skeletal, dental, and soft tissue components into harmony.[4] The diagnostic and treatment planning focus continues to be on the skeletal components, and the resulting soft tissue changes are assumed to follow the skeletal changes. However, our knowledge of the precise changes in the soft tissue in response to 2-jaw orthognathic surgeries is limited. However, with 3D imaging and planning, we are able to exploit data sets to precisely quantify the 3D soft tissue changes that occur in response to orthognathic surgery.[5]

The purpose of the present study was to analyze quantitatively the 3D soft tissue changes that occur after bimaxillary surgery. Specifically, we quantified and determined the relationship between the soft tissue responses to repositioning of the osseous structures in bimaxillary surgery in 3 dimensions. We hypothesized that 3D osseous repositioning would have no effect on the soft tissue response.

Patients and Methods

For the present retrospective cohort study, 40 consecutive adult patients (11 men and 29 women; mean age 23.5 ± 4.9 years) who had undergone 2-jaw orthognathic surgery (maxillary Le Fort I osteotomy and mandibular bilateral sagittal split osteotomy) from 2012 to 2014 were selected retrospectively after excluding those with craniofacial syndromes (Table 1). The entire data set was analyzed for changes associated with the hard tissue and the ensuing soft tissue response. The CT data at 3 weeks preoperatively and 6 months postoperatively were available for all 40 patients. The predictor variables were the 3D changes in the hard tissues, and the outcome variable was the ensuing 3D soft tissue changes.

SUBJECTS

All experimental procedures were performed in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) with the requisite institutional review board approval (approval no. 104-0373C). The study population included all consecutive patients who had undergone bimaxillary orthognathic surgery, with CT scans taken 3 weeks before surgery and 6 months after surgery at 1 institution. To be included in the study sample, the patients were required to have undergone maxillary Le Fort I osteotomy and mandibular bilateral sagittal split osteotomy. Patients were excluded as study subjects if they had craniofacial syndromes.

Table 1. DEMOGRAPHIC PATIENT DATA AND MALOCCLUSION TYPES

Variable	Value
Patients	40
Gender	
Male	11
Female	29
Skeletal pattern	
Skeletal Class I	5
Skeletal Class II	8
Skeletal Class III	27
Age (yr)	
Mean ± SD	23.5 ± 4.9
Range	18 yr, 1 mo to 40 yr, 2 mo

Patient selection criteria retrospectively selected in 40 consecutive adult patients (excluding those with craniofacial syndromes) who had undergone 2-jaw orthognathic surgery at Kaohsiung Chang Gung Memorial Hospital, Taiwan.

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