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Original Research

Three-dimensional analysis of facial changes in skeletal Class III patients following mandibular setback surgery

Kazuomi Nishino[a,*], Akihiro Kohara[a], Yuri Yakita[a], Kanako Ochi[a], Takafumi Hayashi[b], Ritsuo Takagi[c], Tadaharu Kobayashi[d], Kazuto Terada[e], Isao Saito[a]

[a] Division of Orthodontics, Niigata University Graduate School of Medical and Dental Sciences, Japan
[b] Division of Oral and Maxillofacial Radiology, Niigata University Graduate School of Medical and Dental Sciences, Japan
[c] Division of Oral and Maxillofacial Surgery, Niigata University Graduate School of Medical and Dental Sciences, Japan
[d] Division of Reconstructive Surgery for Oral and Maxillofacial Region, Niigata University Graduate School of Medical and Dental Sciences, Japan
[e] Orthodontic Dentistry, The Nippon Dental University Niigata Hospital, Japan

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ABSTRACT

Objective: To identify the degree of correlation of various parameters using multiple linear regression analysis with soft tissue changes as the response variable.
Subjects and methods: The subjects comprised 10 skeletal Class III patients who had undergone bilateral sagittal split osteotomy (BSSO). The candidates for the explanatory variables included 10 parameters, such as overjet, overbite, sella–nasion–A point angle (SNA), upper incisor inclination (U1-SN), incisor mandibular plane angle (IMPA), gonial angle, nasolabial angle, menton deviation, soft tissue thickness, and hard tissue changes. These parameters were measured using cephalograms, dental cast models, and a three-dimensional integration model. Finally, 5 parameters were chosen as explanatory variables. A standard regression coefficient (β value) and an adjusted R-square (R^{*2} value) were used to assess correlations between soft tissue changes and to evaluate the regression equation.
Results: In the zygomatic arch and maxillary regions, β values for overjet and SNA were particularly positive and high, whereas those for hard tissue changes were negative and low. In the mandibular central regions, β values for hard tissue changes were positive and high. In the other mandibular regions, β values for menton deviation were higher than those for hard tissue changes. The R^{*2} values in all regions were greater than 0.5.
Conclusion: Overjet and SNA were more strongly associated with soft tissue changes in the zygomatic arch maxillary regions than hard tissue changes. The extent of mandibular retraction and menton deviation was highly correlated with the mandibular central regions and the other mandibular regions, respectively.

1. Introduction

Soft tissue responses following orthognathic correction are influenced by several factors [1–3]. It was necessary to account the degree of overjet and overbite for predicting the final soft tissue appearance after orthognathic surgery [1]. Facial soft tissues are not only influenced by hard tissue changes but also by soft tissue thickness [2,3]. The upper and lower incisors correlated with the soft tissue after reduction of mandibular prognathism, and horizontal changes in lip morphology, respectively [4,5]. Surgical outcomes in mandibular prognathism patients significantly correlated with changes in the sella–nasion–A point angle (SNA), the gonial angle and the extent of mandibular setback [6]. Gulsen et al. revealed that the nasolabial angle was related to the mandibular position using correlation analysis [7]. Deviation of the mandible caused asymmetry in both the lower and upper lips [8]. In addition, the position of the menton was correlated with the form of the lip [9]. From the previous reports, these 10 factors are most likely correlated with soft tissue changes after orthognathic surgery [1–9]. However, the degree of influence of these parameters on soft tissue changes remains unclear.

☆ Asian AOMS: Asian Association of Oral and Maxillofacial Surgeons; ASOMP: Asian Society of Oral and Maxillofacial Pathology; JSOP: Japanese Society of Oral Pathology; JSOMS: Japanese Society of Oral and Maxillofacial Surgeons; JSOM: Japanese Society of Oral Medicine; JAMI: Japanese Academy of Maxillofacial Implants.

* Corresponding author at: 2-5274 Gakkocho-dori, Chuo-ku, Niigata 951-8514, Japan. Tel.: +81 25 227 2905; fax: +81 25 223 5230.
E-mail address: nishino@dent.niigata-u.ac.jp (K. Nishino).

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Although multiple regression analysis has been performed to clarify the degree of their influence, most reports analyzed two-dimensional changes in soft tissue [1,4,10,11]. Recently, three-dimensional analyses of pre- and postoperative changes in orthognathic patients have been carried out using X-ray computed tomography (CT) and dental cone-beam CT (CBCT) instead of conventional two-dimensional analysis [2,3,6,9,12–14,16]. However, since these methods have been used only to determine the actual extent of soft tissue changes [2,3,6,9,13,14], few reports have analyzed postoperative three-dimensional changes using multiple regression analysis [12,16]. In order to predict the soft tissue changes after surgery, it is necessary to elucidate the factors that influence the three-dimensional changes. This study aimed to assess the degree of correlation for the 10 parameters mentioned above with soft tissue changes as the response variable using multiple linear regression analysis.

2. Subjects

Subjects comprised 10 skeletal Class III patients (3 males and 7 females; mean age 21 years 8 months at the time of orthognathic surgery) who had undergone bilateral sagittal split osteotomy (BSSO) at the Department of Oral Surgery, Niigata University Medical and Dental Hospital (Table 1). Patient selection was based on the following criteria: (1) no history of trauma, (2) no recognized syndromes, (3) no bimaxillary orthognathic surgery, (4) no additional surgery such as genioplasty, and (5) no facial growth at the time of orthognathic surgery. All subjects had menton deviation from 1.0 mm or more to less than 5.0 mm. Presurgical orthodontic treatment was performed on every patient to obtain suitable occlusal interdigitation immediately after surgery. Postsurgical orthodontic treatment was also completed for all patients. Informed consent was obtained from all patients before participation in the study.

Table 1
Summary of subjects' characteristics.

	Sex	Age at surgery	Overjet (mm)	Overbite (mm)	Menton deviation (mm)
1	Female	17 y 10 m	−3.5	0.0	3.0
2	Female	18 y 8 m	−1.0	0.5	1.0
3	Female	18 y 9 m	−2.5	−0.5	3.0
4	Female	19 y 0 m	−1.0	1.0	1.0
5	Female	20 y 1 m	−6.0	1.0	4.5
6	Female	21 y 3 m	−3.5	0.5	3.0
7	Male	23 y 1 m	−6.0	0.0	2.0
8	Male	25 y 3 m	−1.0	1.0	4.0
9	Male	25 y 8 m	−1.0	0.5	4.5
10	Female	27 y 0 m	0.0	−1.0	1.0

3. Methods

3.1. Three sets of data for the integrated model

We constructed an integrated model in accordance with the method described by Kohara et al. [15]. The three types of three-dimensional data included craniofacial CBCT data, scanned facial surface data and scanned dental cast data. The details of those data construction are described in Sections 3.1.1–3.1.4.

3.1.1. Craniofacial CBCT data (Fig. 1A)

The CBCT data were taken with a CB MercuRay® (Ver.1.22, Hitachi Medical Corporation, Tokyo, Japan) for inspecting airway changes just before and 6 months after BSSO. All patients sat in a chair with a headrest, and their Frankfurt horizontal plane (FH plane) was oriented parallel with the floor. The X-ray of CBCT was performed for each patient immediately after swallowing saliva and in the state of the lips closure. CBCT imaging conditions were as follows: 0.3 mm slice thickness, 120 kV tube voltage, 15 mA tube current, and 9.6 s of exposure time. Three-dimensional craniofacial hard and soft tissue geometries were exported from these CBCT data into DICOM format. Then, the three-dimensional surface data were constructed from the DICOM data using image processing software (OsiriX, ver.5.0, OsiriX Foundation, Geneva, Switzerland). The data were from the soft and hard tissues set at 500 and −500 values and were exported as geometric data in the standard triangulated language (STL) format.

3.1.2. Scanned facial surface data (Fig. 1B)

Facial surface data comprised the data scanned with an optical laser scanner (VIVID 910®, KONICA MINOLTA, Inc., Tokyo, Japan) just prior to orthognathic surgery. Facial scanning data were acquired with the dentition and gingiva exposed with a lip retractor by the individual operating the scanner. After the head was set with

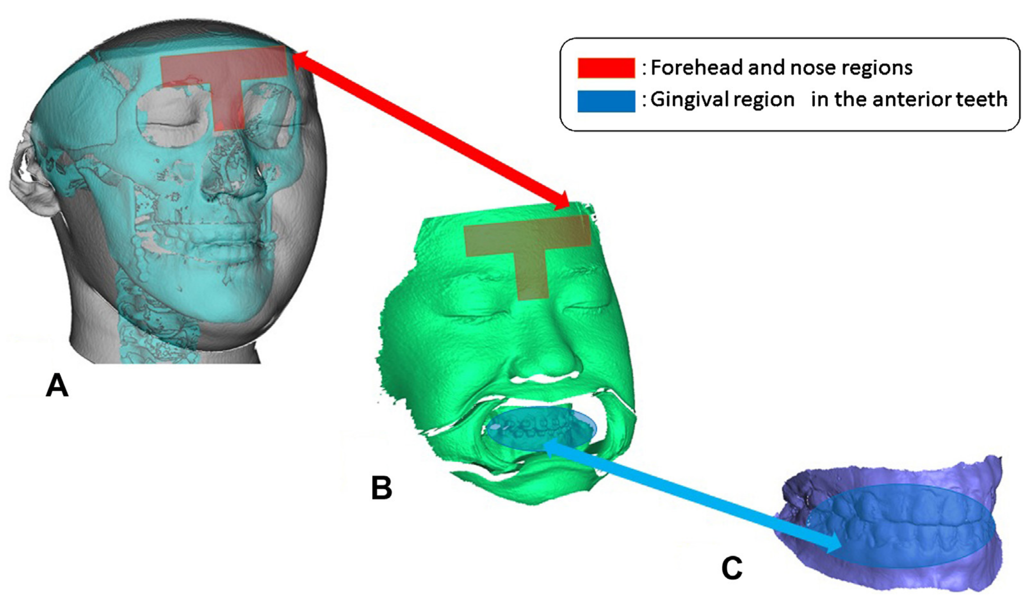

Fig. 1. Integration steps of craniofacial CBCT and scanned dental cast data [15]. (A) Craniofacial CBCT data. (B) Scanned facial data at gingival exposure. (C) Scanned dental cast data.

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