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Original Research

Changes of nasal and oronasopharyngeal airway morphologies and nasal respiratory function following orthognathic surgery

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ABSTRACT

Objective: The aim of this study was to determine the effects of maxillomandibular movements by orthognathic surgery on nasal and oronasopharyngeal airway morphologies and nasal respiratory function.
Methods: The subjects were 32 patients in whom jaw deformities were corrected by two jaw surgery. The amount of jaw movements was evaluated on cephalograms taken before surgery and more than six months after surgery, and morphological changes were evaluated using helical computed tomography (CT), and nasal airway resistance (NAR) for the objective evaluation of nasal respiratory function was measured by anterior rhinomanometry. The results showed that the volume of the nasal cavity and NAR was not changed significantly after surgery. However, the change of NAR was negatively correlated with changes of nasopharyngeal volume and the cross-sectional area in the palatal section (P-CSA). The change of NAR correlated with horizontal movement at B-point. Furthermore, the amount of vertical movement of the maxilla at the posterior nasal spine (PNS) was significantly correlated with reductions in the volume of the oropharynx upper region.
Conclusion: There was little association of changes in maxillomandibular position or nasal and oronasopharyngeal airway morphologies with nasal respiratory function. This might be because of compensatory biomedical action to maintain nasal respiratory function.

1. Introduction

Maxillomandibular movements caused by orthognathic surgery can affect nasal and pharyngeal morphologies. While morphological changes of the nasal and pharyngeal airways can improve nasal respiratory function [1–6], nasal obstruction can also occur depending on the direction and amount of maxillary movement [6]. Deterioration of nasal function causes nasal obstruction and mouth breathing [7,8], which might lead to the development of skeletal relapse after orthognathic surgery [8]. Interest has been shown in the effects of maxillomandibular movements on nasal and oronasopharyngeal airway morphologies and nasal respiratory function. Lateral cephalograms have been used widely to evaluate craniofacial and pharyngeal airway morphology, and lateral cephalometric measurements are useful for analyzing the amount of movement of the jaw bone on the sagittal plane after orthognathic surgery. Recently, pharyngeal airway morphology has been evaluated three-dimensionally using 3D-CT, and 3D-CT imaging has been used in recent years for evaluating changes in the pharyngeal airway after orthognathic surgery [9–19]. Nasal airway resistance (NAR) measured by anterior rhinomanometry is a reliable method for assessment of nasal respiratory function and is considered as the standard technique by the International Standards Committee for the Objective Assessment of the Nasal Airway [20]. The aim of this study was to determine the effects of maxillomandibular movements caused by orthognathic surgery on nasal and oronasopharyngeal airway morphologies and nasal respiratory function using NAR and image examinations with lateral cephalograms and 3D-CT images.

2. Materials and methods

2.1. Subjects

This prospective study included 32 patients (10 males and 22 females) with jaw deformities who had been surgically corrected

☆ AsianAOMS: 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.

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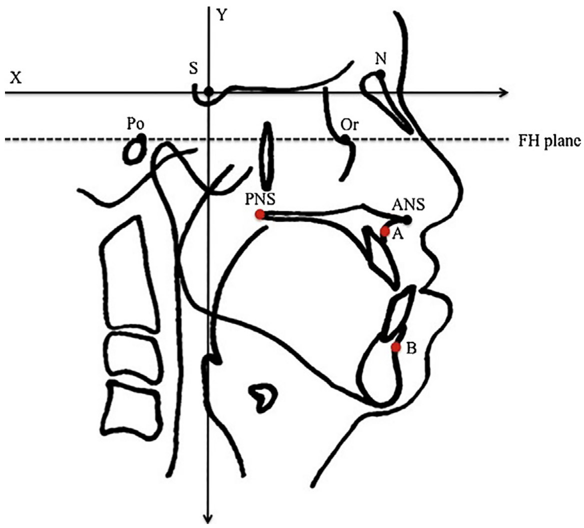

Fig. 1. Cephalometric landmarks of hard and soft tissues.
S: center of the sella torcica. N: most anterior point of the frontonasal suture. Or: lowest point on the average left and right inferior borders of the bony orbit. Po: uppermost point on the bony external auditory meatus. ANS: most anterior point of the nasal spine. PNS: most posterior point of the nasal spine. A: innermost point on the concavity of the maxilla between the incisor tooth and bony chin. B: innermost point on the concavity of the mandible between the incisor tooth and bony chin.

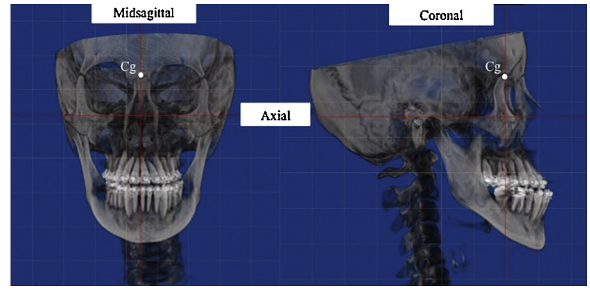

Fig. 2. Image orientations with Dolphin imaging software: frontal and sagittal views.
The axial plane was adjusted to show the Frankfort horizontal (FH) plane passing through the right and left Po and the right Or, and the midsagittal plane was adjusted on the skeletal midline of the face including the crista galli (Cg) and was perpendicular to the FH plane. The coronal plane passes through Cg and is perpendicular to the FH plane.

in the clinic of Oral and Maxillofacial Surgery, Niigata University Medical and Dental Hospital between April 2014 and February 2016. No cases of cleft palate or craniofacial syndrome or cases with a history of head and neck trauma were included. A combination of Le Fort I osteotomy and bilateral sagittal split osteotomy was performed. The mean age of the subjects at surgery was 24 years (range: 15–43 years) and mean body mass index(BMI) values preoperatively and more than 6 months postoperatively were 20.8 kg/m2 (range: 16.3–25.2 kg/m2) and 20.8 k g/m2 (range: 16.4–25.1 kg/m2), and there was no obesity in this study. All of the subjects received preoperative and postoperative orthodontic treatment, and osteosynthesis was achieved using a titanium miniplate or resorbable fixation devices. An alar cinch suture was used in all of the patients. Maxillomandibular fixation was performed one day after surgery and was maintained for 14 days. The study protocol was approved by the Ethics Committee of Niigata University, and informed consent was obtained from the subjects.

2.2. Cephalometric analyses

Changes in maxillary and mandibular positions following orthognathic surgery were evaluated on lateral cephalograms that were taken preoperatively (T0) and more than 6 months postoperatively (T1) with the Frankfort horizontal (FH) plane parallel to the floor and with the patient in centric occlusion. The lateral cephalograms were traced to identify each landmark. The measuring points were defined on each cephalogram. Cephalograms taken at T0 and T1 were superimposed using the sella (S) and nasion (N) as fixed cephalometric landmarks. These points were digitized as 2-dimensional coordinate values to determine the direction and amount of movement of the jaw bones using cephalometric analysis software (CephaloMetrics AtoZ; Yasunaga Computer System Co., LTD, Fukui, Japan). The amount of movement in the jaw bones was determined by measuring the parallel and perpendicular movements of A-point, B-point and the posterior nasal spine (PNS) to the FH plane (Fig. 1). Anterior and inferior movements were taken as positive values.

2.3. Measurements of nasal and oronasopharyngeal airway morphologies

All of the patients underwent CT examinations for assessment of nasopharyngeal airway morphology preoperatively (T0) and more than 6 months postoperatively (T1).

CT data of the maxillofacial regions were obtained in the supine position with centric occlusion, and at the end of the exhalation period when the patient was not swallowing. Each scan was obtained at a tube voltage of 120 kVp, average tube current of 125 mA, 500 msec scan time and thickness of 1 mm by a multidetector CT scanner (AquilionONE Global Edition; Toshiba Medical Systems Co. Ltd., Japan) [21]. Tree-dimensional images of the maxillofacial region were reconstructed by using software (Dolphin Imaging version 11.7; Dolphin Imaging & Management Solutions, Chatsworth, USA). The 3D images were corrected and re-aligned using the Frankfort horizontal (FH) plane, coronal plane, and midsagittal plane as references. The FH plane was defined by the bilateral uppermost point on the bony external auditory meatus (porion: Po) and lowest point on the right inferior borders of the bony orbit (orbitale: Or). The midsagittal plane was adjusted on the skeletal midline of the face including the crista galli (Cg) and perpendicular to the FH plane and coronal plane. The coronal plane was defined as a plane passing through Cg and perpendicular to the FH plane (Fig. 2). To assess nasal and oronasopharyngeal airway morphologies, four regions, nasal inferior meatus (S1), nasopharynx (S2), oropharynx upper region (S3) and oropharyngeal lower region (S4), were defined by delineating the compartment borders in the sagittal, axial, and coronal planes in a 2-dimensional view (Fig. 3). The airway volumes of the selected regions were automatically calculated under the condition that the threshold number was 73 according to a previous study [22] by using image processing software. The narrowest cross-sectional area of the oropharynx (O-NCSA) and the cross-sectional area in the palatal section (P-CSA) were also automatically calculated (Fig. 4).

2.4. Nasal airway resistance (NAR)

To assess nasal airflow of each patient and to provide an objective quantification of NAR, anterior active mask rhinomanometry was performed using a rhinomanometer (KOC-8900 or HI-801, CHEST M.I., INC., Japan). It was taken in a while time, for 30 s, after taking a sitting position. A minimum of 3–5 breaths were recorded at a fixed transnasal pressure of 100 Pa during quiet breathing with the mouth closed. The total nasal airflow and total NAR of both nasal cavities were measured preoperatively (T0) and more than six months postoperatively (T1).