Journal of Cranio-Maxillo-Facial Surgery 42 (2014) 531–535

Contents lists available at ScienceDirect

Journal of Cranio-Maxillo-Facial Surgery

journal homepage: www.jcmfs.com

Head posture and pharyngeal airway volume changes after bimaxillary surgery for mandibular prognathism

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ARTICLE INFO

Article history:
Paper received 8 November 2012
Accepted 31 July 2013

Keywords:
Orthognathic surgery
CBCT
Head posture
Pharyngeal airway

ABSTRACT

Purpose: The purpose of this study was to evaluate head posture and the pharyngeal airway volume changes using 3D imaging after bimaxillary surgery in mandibular prognathism patients by null hypothesis.
Materials and methods: Cone-beam computed tomography (CBCT) scans were obtained for 25 mandibular prognathism patients before bimaxillary surgery (T1) and 6 months after surgery (T2). The head posture of each patient was assessed by measuring cranio-cervical angle on a midsagittal plane passing through the anterior nasal spine at T1 and T2. Additionally, the volume of each subject's pharyngeal airway was measured using InVivoDental 3D imaging software.
Results: The cranio-cervical angle increased significantly 6 months after bimaxillary surgery ($p < 0.01$). The total volume of the pharyngeal airway slightly decreased ($p > 0.05$) at the same timepoints, while naso- and oro-pharyngeal airway volume decreased significantly ($p < 0.05$, $p < 0.05$). There was significant relationship between the changes of head posture and those of total airway volume ($p < 0.05$).
Conclusion: The null hypothesis was rejected. Bimaxillary surgery resulted in significant head flexion and a slight decrease in total pharyngeal airway volume.

1. Introduction

Facial deformities in patients with skeletal Class III can be surgically corrected with single-jaw or bimaxillary surgery, which combines mandibular setback surgery with posterior maxillary impaction (Chen et al., 2007). Both of these procedures change the mandibular position and remarkably improve the occlusion and aesthetics of the lower facial morphology (Hong et al., 2011). However, bimaxillary surgery is becoming more frequently performed than single-jaw surgery for mandibular prognathism with severe skeletal discrepancies due to the development of general anaesthesia and surgical techniques (Kim and Kim, 2008; Oh et al., 2013).

The relationship between craniofacial skeletal morphology and head posture has been reported in previous studies (Achilleos et al., 2000; Solow and Sandham, 2002; Savjani et al., 2005). Natural head posture is the most balanced and usual position of the head when viewing an object at eye level (Barbera et al., 2009). It can be expressed as the cranio-cervical angle formed by the sella–nasion line and the line through the tangent point at the most superoposterior point and the most inferoposterior point on the body of the second cervical vertebra (Solow and Sandham, 2002). Subjects with large mandibular plane inclination have been found to have extended head posture and increased cranio-cervical angles (Savjani et al., 2005). It has been reported that mandibular prognathism patients tend to have a small cranio-cervical angle, whereas patients with a large cranio-cervical angle have a tendency toward mandibular retrognathism (Solow and Sandham, 2002). Therefore, head posture should theoretically change after orthognathic surgery, including either mandibular setback or advancement (Savjani et al., 2005). Only a few studies have examined the changes of the head posture after bimaxillary surgery (Phillips et al., 1991); therefore, further evaluations of the possible effects of bimaxillary surgery on natural head posture should be performed.

Additionally, it has been reported that orthognathic surgery, which changes the surrounding bony structures and soft tissue may affect the pharyngeal airway (Chen et al., 2007). Previous studies

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http://dx.doi.org/10.1016/j.jcms.2013.07.022

have reported that the volume of the pharyngeal airway was reduced after mandibular setback surgery (Tselnik and Pogrel, 2000; Eggensperger et al., 2005; Kitahara et al., 2010; Hong et al., 2011) because the mandible, base of the tongue, hyoid bone, and pharyngeal airway are intimately associated one to another by surrounding muscles and ligaments (Tselnik and Pogrel, 2000). The effects of bimaxillary surgery on the oro-pharyngeal complex, including the pharyngeal airway space, remain controversial (Athanasiou et al., 1991; Kitahara et al., 2010).

To evaluate the natural head posture and the changes of the pharyngeal airway volume following orthognathic surgery, lateral cephalographs were usually used in previous studies (Tselnik and Pogrel, 2000; Hwang et al., 2010; Kitahara et al., 2010; Marsan et al., 2010). They have a limitation in reflecting the three-dimensional (3D) airway structures due to the differences in left–right magnification, so that it would be difficult to measure airway dimension exactly (Park et al., 2011; Larson, 2012). Cone-beam computed tomography (CBCT) provides multi-planar reformatted views and it is possible to obtain actual size of skeletal structures with lower distortion of the images (Park et al., 2012). It also allows visualization of the internal structures by eliminating external structure images (Baik et al., 2006); thus, it is possible to measure the volumetric and linear dimensions of the airway (Aboudara et al., 2009).

The purpose of this study was to evaluate head posture and the pharyngeal airway volume changes following bimaxillary surgery for mandibular prognathism. In addition possible correlations among skeletal reference points, head posture, and airway volume were evaluated. The null hypothesis was that post-operative head posture and pharyngeal airway volume do not change after bimaxillary surgery in patients with mandibular prognathism.

2. Materials and methods

2.1. Subjects

Twenty-five consecutive skeletal Class III patients (14 men, 11 women; mean age, 30.04 ± 13.08 years; range, 17.2–48.1 years) who had undergone bimaxillary surgery at Kangdong Sacred Heart Hospital were included in this study. This study protocol was approved by the Ethics Review Committee at the Kangdong Sacred Heart Hospital, Hallym University Medical Center (IRB12-1-012), and informed consent was obtained from all patients in this study.

All twenty-five subjects underwent pre- and post-operative orthodontic treatment. In each case, the surgical procedure consisted of a LeFort I osteotomy with a bilateral sagittal split osteotomy (BSSRO) and rigid fixation with or without genioplasty. After the LeFort I osteotomy, the posterior maxilla was impacted and rotated in a clockwise direction with a centre of rotation at either the anterior nasal spine (ANS) or upper incisal tip. The mandible was set back with BSSRO, and the proximal segment was stabilized by intermaxillary rigid fixation for approximately 1 week after the surgery. Nine of the patients had advancement genioplasty as an adjunctive procedure. Surgical wafers were placed for 3–4 weeks after surgery and interarch elastics were used in order to stabilize the interarch relationship after removal of the surgical wafers.

No subjects included in the present study had any craniofacial anomalies, cleft lip or palate, or pharyngeal pathologic symptoms. Patients with a history of adenoidectomy or tonsillectomy were excluded.

2.2. CBCT image acquisition

CBCT scans were acquired 2 weeks (range, 0–3 weeks) before surgery (T1) and 6 months (range, 5–8 months) after surgery (T2)

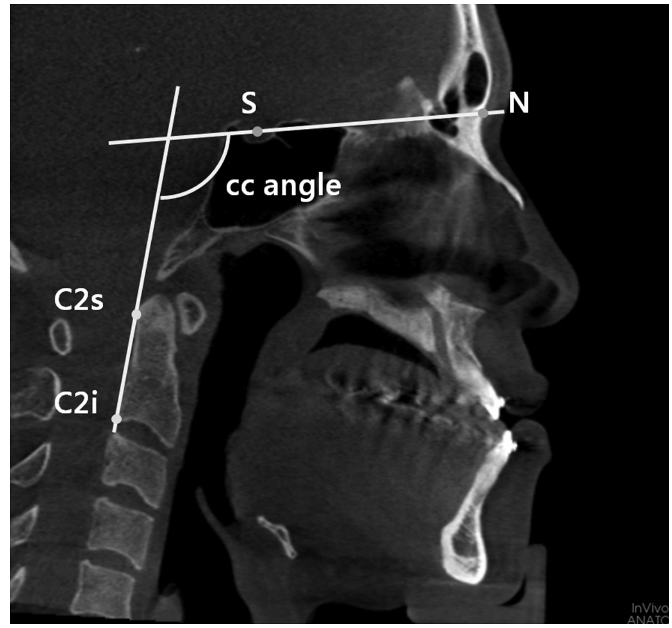

Fig. 1. Natural head posture. Cranio-cervical angle (cc angle) formed by the sella–nasion (SN) line and the line through the tangent point at the most superoposterior point (C2s) of the odontoid process and the most inferoposterior point (C2i) on the body of the second cervical vertebra on the reoriented midsagittal plane.

on average. CBCT volume scans of all subjects at Kangdong Sacred Heart Hospital were obtained using the Master 3D dental-imaging system (Vatech Inc., Seoul, Korea) with the following imaging protocol; 90 kV, 3.6 mA, 15-second scan time, and 20 cm × 19 cm field of view to include the entirety of the craniofacial anatomy. The axial slice thickness was 0.3 mm, and the voxels were isotropic. All patients were seated in a chair with the head in its natural head position (mirror position), and the jaws were at maximum intercuspation with the lips and tongue in a resting position, but not to swallow or breathe, and not to move their heads or tongues (Solow and Sandham, 2002).

2.3. Head posture and airway parameters

The digital image files were exported using the Digital Imaging and Communications in Medicine (DICOM) format and imported into the InVivoDental 3D imaging software (Anatomage, San Jose, CA). Each 3D-rendered image was reoriented using the Frankfort Horizontal (FH) plane as its horizontal reference plane, which was constructed from the right and left porions that are located in the most laterosuperior point of the external auditory meatus, and the right orbitale, the most inferior point of the lower margin of the bony orbit.

In order to assess the head posture, we measured the cranio-cervical angle on a midsagittal plane. The midsagittal plane was constructed through anterior nasal spine (ANS), crista galli and opisthion, and was perpendicular to the horizontal plane. The cranio-cervical angle is defined as the angle formed by the sella–nasion (SN) line and the line through the tangent point at the most superoposterior point (C2s) of the odontoid process and the most inferoposterior point (C2i) on the body of the second cervical vertebra (Fig. 1; Solow and Sandham, 2002).

Volumetric analysis of the airway was performed by inverting the 3D-rendered image to isolate the upper pharyngeal airway. The inverting process facilitates the removal of the hard and soft tissues around the airway and highlights the airway spaces of the