Effects of orthognathic surgery on cervical vertebras in skeletal class III patients

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Abstract

Background: Pharyngeal airway has been found to be change after orthognathic surgery. Cervical vertebras are skeletal parts that support the patent of pharyngeal airway.

Objectives: The aim of this study was to evaluate the cervical vertebra changes in patients with skeletal class III deformity who underwent orthognathic surgery.

Patients and Methods: Thirty-two patients who underwent orthognathic surgery at Oral and Maxillofacial Surgery Department, Mahidol University, Thailand were included in this study. The subjects were divided in two groups: group 1 underwent mandibular setback (19 patients) and group 2 underwent bimaxillary surgery (13 patients). Lateral cephalogram were taken at 3 times: preoperation (T0), immediate postoperation (T1) and 6 months postoperation (T2).

Results: The mean amount mandibular setback for group 1 and group 2 were 7.3 mm and 6.5 mm respectively. Head posture (OPT/SN) increased immediately after surgery in both group (2.8^0 in mandibular setback grouand 3.1^0 in bimaxillary surgery group). The hyoid bone displaced posteriorly and inferiorly in period T0-T1. C2 in period T0-T1 displaced posteriorly in horizontal plane (1.8 mm in mandibular setback group and 1.9 mm in bimaxillary surgery group). C3 in period T0-T1 displaced posteriorly in horizontal plane (2.9 mm in mandibular setback group and 2.4 mm in bimaxillary surgery group).

Conclusion: After orthognathic surgery in skeletal class III patients, the hyoid displaced posteriorly and inferiorly, the head posture increased, second and third cervical vertebra displaced posteriorly.

Keyword: orthognathic surgery, cervical vertebra, pharyngeal airway space, head posture

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Introduction

Backgound and Rationale

Orthognathic surgery is the method to treat dentofacial deformities. Changes of pharyngeal airway have been observed following orthognathic surgery of the facial skeletons.[1, 2] Since tongue, hyoid bone and soft palate are attached to the mandible and maxilla, mobilization of the jaws by orthognathic surgery affects those tissues, causing changes in the pharyngeal area. Mandibular setback surgery can narrow the pharyngeal airway space (PAS)[3-6] and change the hyoid. After mandibular setback surgery, head posture may also change to adapt normal breathing.[7, 8]

Recently, numerous studies have examined the effects of on the pharyngeal airway size after orthognathic surgery. But to our knowledge, there is not a researc that evaluated the change of cervical vertebras thoroughly including position, head posture and hyoid bone.

The aim of this study was to evaluate the cervical vertebra changes in patients with skeletal class III deformity who underwent orthognathic surgery.

Materials and method

Study design

The authors conducted an observational study to retrospectively evaluate the measurements on cephalometric radiographs of class III deformity patients underwent orthognathic surgery. The cephalometric radiographs were taken at 3 times: before surgery (T0; within 1 year of surgery), immediately after surgery (T1; within 1 week of surgery), and at least 6 months after surgery (T2).

Participants

All the skeletal class III patients who underwent orthognathic surgery at Oral Maxillofacial Surgery Department, Faculty of Dentistry, Mahidol University, Thailand during the period from January 2010 to March 2013 with complete records and good quality cephalometry will be included in the study.

All patients underwent either mandibular setback or bimaxillary surgery. All patients received the same treatment with regard to the surgical technique: Le Fort I osteotomy to allow maxillary movement, bilateral sagittal osteotomy of the mandibular ramus to allow mandibular movement. Operations were performed under general anesthesia with rigid internal fixation using titanium plates and screws.

Inclusion criteria

To be included in the present study, the subjects are required to be healthy, underwent orthognathic surgery to correct skeletal deformities.

Exclusion criteria

Patients will be excluded if they had undergone only genioplasty, surgically assisted rapid palatal expansion alone, or had undergone previous orthognathic surgery, or had a craniofacial congenital anomaly that affected the airway.

Data collection method

Cephalometric radiographs were performed using a standardized technique by Oral and Maxillofacial Radiology Department, Faculty of Dentistry, Mahidol University.

The data collection method was performed in three steps. All cephalometric radiographs were traced manually on acetate paper by the same person and were scanned. Before digitizing, all tracings and landmarks were verified by a senior. The landmarks were digitized, and all variables were measured and analyze by ImageJ computer software (National Institutes of Health, USA). The magnification factor was taken into account for each cephalometric radiograph.

Measurements

The craniofacial landmarks are selected to study the position of maxilla, mandible and related structures to the skull and cervical vertebra as describe in previous studies.[9]

Seven degrees to the Sella-Nasion (SN) plane through Sella point was taken as the horizontal reference plane (HR) and perpendicular to HR through S point was taken as the vertical reference plane (VR) (Figure 1).[10] The magnitude of horizontal and vertical changes were measured according to HR and VR to evaluate the skeletal movement of maxilla (Anterior Nasal Spine (ANS) and A), mandible (B and Pg), hyoid bone (AH) and cervical vertebra (ATA, C2 and C3).[11] Positive values were set to anterior and inferior movements.

The conventional cephalometric measurements were done.

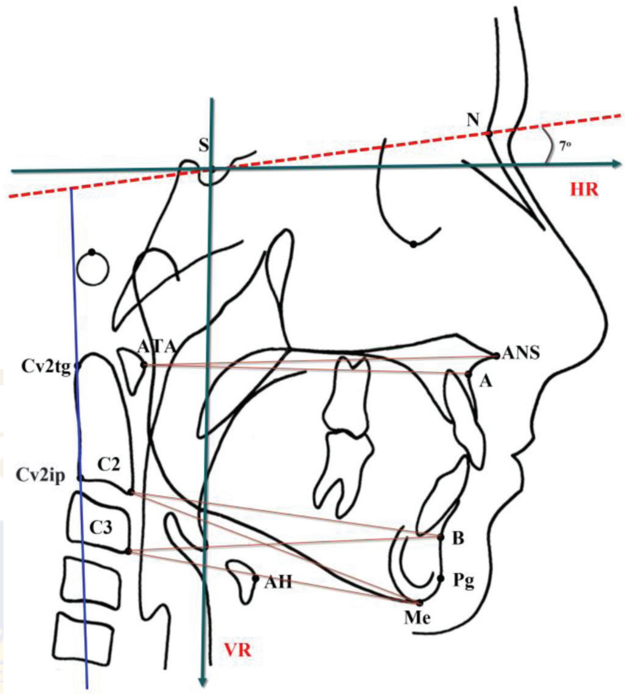

Figure 1 Reference lines and cervical vertebra measurements

Statistical method

Random 15 cephalometric radiographs were retraced and remeasured after 1 month by the same investigators. The error variance was calculated using Dahlberg's formula[12].

The results were calculated using SPSS statistical software version 18.0.

Descriptive statistics including the mean, standard deviation and percentage were computed. The normality of data was test by Kolmogorov-Smirnov test.

Dependent T test was used to evaluate the changes in paired parameters in each group. The correlations between the airway changes and surgical movement were evaluated by Pearson and Spearman's rank test.

Results

Demographic data

32 patients were included in this study. Among them 23 patients are male and 9 patients are female. BSSO set back was done

Table 1 Vertebra references

Abbreviation		Definition
AH	Anterior hyoid	The most anterior and superior point on the body of the hyoid bone
ATA	Atlas	Anterior tubercle of the Atlas
C3	Third cervical vertebra	Inferoanterior point of the third cervical vertebrae
C2	Axis	Inferoanterior point of the second cervical vertebrae
Cv2tg		Tangent point of superoposterior extremity of the second cervical vertebrae
Cv2ip		Infreroposterior point of the second cervical vertebrae
OPT/SN	Head posture	The angle between Cv2tg-Cv2ip and SN

in 19 patients and 2-jaw surgery was done in 13 patients. The mean age of the participants was 26.69±5.15 years old.

Reliability

Interclass Correlation Coefficient revealed that the repeatability for lateral cephalometric measurements is on average 97.0% (range 86.1% - 99.0%). This result indicated excellent repeatability of measurements (excellent >90%; good >80%).

The error analyses found no significant differences between any paired measurements. Dahlberg's formula calculation showed that all horizontal and vertical coordinates had random errors smaller than 1.0 mm.

Skeletal landmark measurements

Skeletal landmark were measured to evaluate the skeletal change after orthognathic surgery in 2 groups (Table 2, 3). Point ANS and point A were used to evaluate the maxilla position. Point B and point Pg were used to evaluate the mandible position. In bimaxillary surgery group, the advancement of maxilla was showed by the significant increase in horizontal plane of point ANS and point A (1.9 mm and 2 mm respectively, p<0.01) between T0 and T1.

Table 2 Skeletal measurements evaluated at T0, T1, and T2 and changes during movement from T0 to T1, T0 to T2, and T1 to T2 for mandibular setback group (n=19)

	T0		T1		T2		T0-T1		T0-T2		T1-T2	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
ANS-HR	63.9	3.4	64.1	3.4	63.7	3.3	-0.1	0.6	0.3	0.5	0.4	0.6
ANS-VR	42.9	3.6	42.7	3.9	42.9	3.5	0.2	1.1	0.0	0.9	-0.2	0.7
A-HR	61.0	3.2	60.9	3.3	60.5	3.1	0.1	1.0	0.5	0.9	0.4	0.9
A-VR	49.2	4.7	49.0	4.6	49.1	4.1	0.2	0.9	0.1	1.1	-0.1	0.9
B-HR	66.0	5.1	58.7	5.6	59.4	5.7	**7.3‡**	3.4	6.6‡	3.1	**-0.7***	1.3
B-VR	89.8	8.1	89.9	7.1	88.0	7.2	-0.1	2.3	**1.8‡**	1.6	**1.9‡**	1.7
Pg-HR	68.4	6.0	61.7	6.8	62.9	6.5	**6.7‡**	3.4	**5.5‡**	3.1	**-1.2†**	1.7
Pg-VR	103.0	9.4	102.6	8.7	101.2	8.2	0.4	2.6	**1.8†**	1.9	**1.4†**	2.0

*p< .05, †p <.01, ‡p < .001, significant differences

HR: horizontal coordinate, VR: vertical coordinate

Table 3 Skeletal measurements evaluated at T0, T1, and T2 and changes during movement from T0 to T1, T0 to T2, and T1 to T2 for bimaxillary surgery group (n=13)

	T0		T1		T2		T0-T1		T0-T2		T1-T2	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
ANS-HR	67.0	3.7	68.8	4.1	68.7	4.3	**-1.9†**	2.0	**-1.7†**	1.9	0.2	1.3
ANS-VR	42.6	4.4	41.8	3.2	42.4	2.9	0.8	2.4	0.2	2.3	-0.6	2.3
A-HR	64.5	3.7	66.4	4.2	66.3	4.1	**-2.0***	2.4	**-1.8***	2.2	0.2	0.8
A-VR	49.1	5.2	48.1	4.0	48.0	4.2	1.0	2.5	1.1	2.6	0.0	1.6
B-HR	71.9	7.5	65.4	7.3	66.5	7.2	6.5‡	3.7	**5.4‡**	3.0	**-1.1†**	1.3
B-VR	88.7	8.7	88.1	8.2	86.1	7.9	0.7	3.0	**2.6†**	2.6	**2.0†**	1.7
Pg-HR	74.3	9.2	67.5	9.1	69.4	9.1	6.8‡	4.0	**4.9‡**	3.4	**-1.9‡**	1.2
Pg-VR	101.0	10.3	101.1	10.0	98.5	9.5	-0.1	2.6	**2.5†**	2.2	**2.6‡**	1.7

*p< .05, †p <.01, ‡p < .001, significant differences

About the mandible movement, Point B and Pg were significantly setback in horizontal plane in both groups between T0 and T1 (7.3 mm and 6.7 mm in mandibular setback group, P<0.001; 6.5 mm and 6.8 mm in bimaxillary surgery group, p<0.001). The horizontal relapse of point B and Pg showed significant anterior movement in both groups between T1 and T2 (0.7 mm and 1.2 mm in mandibular setback group, P<0.01; 1.1 mm and 1.9 mm in bimaxillary surgery group, p<0.01). There were no significant vertical movements of point B and Pg between T0 and T1. On the other hands, B and Pg showed significant upward displacement between T1 and T2 in both group (1.9 mm and 1.4 mm in mandibular setback group, p<0.01; 2.0 mm and 2.6 mm in bimaxillary surgery group, p<0.01).

Cervical vertebra measurements

Table 4 and table 5 showed the changes in head posture, position of hyoid bone and cervical vertebra. Head posture (OPT/SN) increased immediately after surgery in period T0-T1 in both group (2.8^0 in mandibular setback group, p<0.05 and 3.1^0 in bimaxillary surgery group, p<0.01). The hyoid bone displaced posteriorly (3.6 mm

Table 4 Cervical vertebra measurements evaluated at T0, T1, and T2 and changes during movement from T0 to T1, T0 to T2, and T1 to T2 for mandibular setback group (n=19)

	T0		T1		T2		T0-T1		T0-T2		T1-T2	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
OPT/SN (deg)	94.6	8.2	97.4	10.7	95.2	7.8	**-2.8**[*]	6.1	-0.6	3.8	2.2	5.1
AH-HR	19.7	5.5	16.1	7.0	17.3	5.1	**3.6**[†]	5.1	**2.3†**	2.6	-1.3	4.8
AH-VR	95	6.5	99.6	6.7	97.1	7.2	**-4.6**[‡]	4.3	**-2.1**[*]	3.5	2.5	4.7
ATA-HR	-10.8	3.4	-11.1	3.4	-10.9	3.4	0.3	1.1	0.1	0.9	-0.2	0.9
ATA-VR	43.4	4.0	44.1	4.3	43.5	3.7	-0.7	0.3	-0.1	0.2	0.6	1.4
C2-HR	-13.6	5.0	-15.4	5.8	-14.2	4.4	**1.8**[*]	3.7	0.6	2.2	-1.2	3.4
C2-VR	74.4	4.8	75.1	5.0	74.6	4.2	-0.7	1.5	-0.2	1.3	0.5	1.5
C3-HR	-14.1	7.0	-17.0	8.1	-15.1	5.8	**2.9**[*]	5.3	1.0	3.0	-1.9	4.9
C3-VR	89.9	5.6	90.7	5.5	90.2	4.7	-0.8	2.0	-0.3	1.6	0.6	1.8

*p< .05, †p <.01, ‡p < .001, significant differences

Table 5 Cervical vertebra measurements evaluated at T0, T1, and T2 and changes during movement from T0 to T1, T0 to T2, and T1 to T2 for bimaxillary surgery group (n=13)

	T0		T1		T2		T0-T1		T0-T2		T1-T2	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
OPT/SN (deg)	94.0	7.3	97.1	7.0	94.7	6.8	**-3.1**[†]	3.2	-0.7	4.1	2.4	4.7
AH-HR	23.0	7.8	20.2	6.7	21.5	8.2	**2.8**[*]	1.0	1.6	5.7	-1.2	4.2
AH-VR	98.7	8.8	102.0	9.9	97.7	7.8	**-3.3**[†]	4.0	1.0	0.7	**4.3**[*]	1.0
ATA-HR	-9.0	3.7	-8.6	3.2	-8.6	3.2	-0.5	2.0	-0.4	1.5	0.0	0.7
ATA-VR	46.0	4.7	46.4	4.4	45.8	4.8	-0.5	0.9	0.2	1.6	0.7	1.4
C2-HR	-11.3	4.4	-13.2	4.5	-12.2	5.5	**1.9**[*]	2.2	0.9	3.0	-1.0	2.8
C2-VR	78.7	6.4	78.8	6.8	78.4	7.4	-0.2	1.1	0.3	1.8	0.5	1.36
C3-HR	-12.0	6.0	-14.4	6.0	-11.2	7.0	**2.4**[*]	3.5	-0.9	0.2	-3.2	6.3
C3-VR	94.9	7.8	95.3	8.4	94.7	9.1	-0.4	1.1	0.2	2.0	0.6	1.1

*p< .05, †p <.01, ‡p < .001, significant differences in mandibular setback group, p<0.01 and 2.8 mm in bimaxillary surgery group, p<0.05) and inferiorly (4.6 mm in mandibular setback group, p<0.001 and 3.3mm in bimaxillary surgery group, p<0.01) in period T0-T1. There was a superior displacement of hyoid bone in vertical plane between T1 and T2 in bimaxillary surgery group (4.3 mm, p<0.01).

The ATA showed no displacement in both vertical and horizontal plane in both groups. C2 in period T0-T1 displaced posteriorly in horizontal plane (1.8 mm in mandibular setback group and 1.9 mm in bimaxillary surgery group, p<0.05) but did not displace in vertical plane significantly. C3 in period T0-T1 displaced posteriorly in horizontal plane (2.9 mm in mandibular setback group and 2.4 mm in bimaxillary surgery group, p<0.05) but did not displace in vertical plane significantly.

Correlation

Table 6 and table 7 demonstrated the correlation coefficients between the changes in cervical vertebra measurements in period T0-T1 and the changes in measurements of skeletal landmarks in period T0-T1. The horizontal

Table 6 Correlation between changes in period T0-T1 of skeletal measurements and cervical vertebra measurements for mandibular setback group (n=19)

Changes between T0 and T1	ATA-HR	ATA-VR	C2-HR	C2-VR	C3-HR	C3-VR	AH-HR	AH-VR	OPT-SN
ANS-HR	0.216	0.324	-0.104	0.228	-0.133	0.212	-0.091	0.032	0.200
ANS-VR	-0.442	-0.051	-0.145	0.076	-0.091	-0.043	-0.098	-0.339	0.010
A-HR	0.402	0.145	0.203	-0.171	0.161	-0.170	0.247	0.372	-0.124
A-VR	-0.111	-0.235	0.066	-0.140	0.071	-0.047	0.159	0.185	-0.121
B-HR	0.267	-0.126	0.311	-0.182	0.302	-0.192	**0.526***	0.309	-0.325
B-VR	-0.256	0.204	-0.209	0.346	-0.202	0.472	-0.227	-0.134	0.117
Pg-HR	0.409	-0.306	0.325	-0.297	0.317	-0.298	**0.548***	0.138	-0.325
Pg-VR	-0.116	0.148	-0.114	0.285	-0.101	0.394	0.077	0.023	-0.198

*p< .05, †p <.01, significant correlation

Table 7 Correlation between changes in period T0-T1 of skeletal measurements and cervical vertebra measurements for bimaxillary surgery group (n=12)

Changes between T0 and T1	ATA-HR	ATA-VR	C2-HR	C2-VR	C3-HR	C3-VR	AH-HR	AH-VR	OPT-SN
ANS-HR	-0.174	0.287	0.061	0.362	0.119	0.051	0.058	-0.140	0.034
ANS-VR	0.475	-0.006	0.377	-0.178	0.400	-0.205	0.446	0.054	-0.481
A-HR	-0.246	0.294	-0.042	**0.574***	0.013	0.298	-0.012	-0.001	0.122
A-VR	0.351	0.187	0.235	0.035	0.259	-0.038	0.295	0.026	-0.420
B-HR	0.248	0.173	**0.695†**	-0.311	**0.729†**	-0.263	**0.820†**	0.044	**-0.586***
B-VR	0.137	-0.112	0.392	-0.463	0.390	-0.174	0.412	-0.254	-0.530
Pg-HR	0.179	0.202	**0.645***	-0.275	**0.671***	-0.224	**0.766†**	-0.027	-0.526
Pg-VR	0.217	-0.273	0.206	-0.310	0.126	-0.018	0.101	0.078	-0.342

*p< .05, †p <.01, significant correlation movement of hypoid bone was significantly correlated with the horizontal movement of point B and Pg in both groups. In mandibular setback group no correlation was found between movement of cervical vertebra and movement of skeletal landmark. In bimaxillary surgery group, the horizontal movements of point B and Pg were significantly correlated with the horizontal movements of second and third vertebras.

Discussion

Although the fact that lateral cephalometric radiograph provides only two-dimensional information of the pharyngeal airway, it is still a popular method in the assessment of craniofacial structures.[13] The advantages of cephalometry consist of its availability, simplicity, low cost, easily comparison with other studies. Moreover, cephalometry is a routine diagnosis tool for orthodontic and orthognathic surgery treatment.

The pharyngeal airway has been concerned after orthognathic surgery in skeletal class III patient because of potential adverse effects on the airway.[14] Moreover, mandibular setback surgery has been reported to be a risk to induce obstructive sleep apnea (OSA) in some patients.[4, 5] Obstructive sleep apnea is defined as the soft tissue of the airway collapsed but the skeletons of the airway also have important roles. The skeletons support the soft tissue to keep airway patent. Many studies have evaluated the airway soft tissue by measuring the dimension, area or volume of the airway. However, up to our knowledge, there has been not any paper that focuses on the evaluation of the cervical vertebras or the airway skeletal after orthognathic surgery. The cervical vertebras measurement in this study included the position of three first cervical vertebras, the head posture, and the position of the hyoid bone.

The hyoid displaced posteriorly (3.6 mm in mandibular setback group and 2.8 mm in bimaxillary surgery group) and inferiorly (4.6 mm in mandibular setback group and 3.3 mm in bimaxillary surgery group) immediately after surgery. These findings were similar to other studies that the movement of hyoid is a compensatory mechanism that allowed airway maintenance.(9, 15) Moreover, the horizontal movement of hyoid bone showed a significant correlation with the horizontal movement of point B and point Pg. After that, the hyoid often gradually returned to its original position after long-term follow-up.(16) However, in this study the return of hyoid was not seen in mandibular setback group but only in upward movement in bimaxillary surgery group. It was found that the upward repositioning of the hyoid bone occurred late postoperatively and was related to the narrowed airway space at the tongue base, which explains the subsequent physiological adaptation of the dentofacial structures following surgery.[17]

Head posture (OPT/SN) increased about 3^0 immediately after surgery in both group. This finding about the adaptive increased craniocervical inclination was similar to other studies.[6, 7] The extension of the head serves as a compensatory mechanism by pulling the hyoid bone, tongue and soft palate away from interfering with posterior pharyngeal wall.[18] Muto et al[7] reported that 10° rise in the inclination of head posture will result in an increase in PAS about 4 mm.

Cervical vertebras are important in maintain the airway. The head posture change after orthognathic surgery was studied well in the literature but the change in the position of cervical vertebra has not noticed much in previous research. In our study, the positions of first three cervical vertebras were studied in horizontal and vertical plane and their changes were noted. The significant posterior movements of C2 and C3 (from 2 to 3 mm) immediately post-operation were found and the changes were maintained in the follow up.

The posterior movements of cervical vertebras showed a significant correlation with amount of surgical setback at point B and point Pg in bimaxillary group. However there is no such correlation in mandibular setback group. The prediction of cervical vertebras movement seem to be need a more complicated model other than simple surgical movement of skeletal landmarks such as point B and point Pg. The displacement of cervical vertebras was important because they are connected to the soft tissue of posterior pharyngeal wall. The posterior displacement of cervical vertebra maybe worked as a compensatory mechanism for the reduced airway after surgical setback.

In conclusion: in this study, after orthognathic surgery in skeletal class III patients, the hyoid displaced posteriorly and inferiorly, the head posture increased, second and third cervical vertebra displaced posteriorly. Those movements of the skeletons had important role in adaptation and patent of the airway.

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