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Original Research Article

Changes of Adenoid and Pharyngeal Airway Space Following Orthognathic Surgery in Class III Patients with Mandibular Prognathism: A Retrospective Analysis

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Abstract: ***Aim and Background***: This retrospective study evaluated the changes in adenoid and pharyngeal airway spaces associated with surgical mandibular setback in skeletal Class III patients. ***Patients and Methods***: Pre- and one- year-post-operative lateral cephalograms of 25 adult patients with mandibular prognathism who had bilateral sagittal split osteotomy (BSSO) were traced. Cephalometric parameters including SNA, SNB, GoGn to SN, y-axis, SPPS, MPS, IPS, PNS-Eb, at-atp, ppw-Ba were calculated, compared, and then data were analyzed using Paired t-test or Sign test. The role of growth pattern and gender factor was analyzed with Fisher exact test. MannWhitney test was utilized to compare between the groups of male/female as well as the groups of vertical/horizontal grower. The results were considered at a maximum level of significance of 5% ($P < 0.05$). ***Results***: At long-term follow-up, 25 patients (m:8, f:17) with the mean age of 25±4; there was a decrease in MPS value (3.8±6.7) that statistically significant ($P=0.001$). Although an increase was found in PNS-Eb index (3.1±4.4), the changes were not significant ($P=0.03$). No significant change was observed in other parameters. Also, growth pattern and gender didn't affect the mentioned parameters. ***Conclusion***: Mandibular setback surgery causes a long-term effect in some parameters of pharyngeal airway space area. In patients suffering from obstructive sleep apnea or in case of some other risk factors including overweight, short necks, and small pharyngeal airway space, a mandibular setback surgery could possibly predispose to the development of sleep apnea syndrome.

Keywords: Adenoids, Malocclusion, Angle Class III, Mandibular Osteotomy, Prognathism.

INTRODUCTION

Orthognathic surgery to treat skeletal malformation is a procedure to improve facial esthetics, dental occlusion, and maxillomandibular relations.

Previous studies suggested a possible correlation between the orthognathic surgeries and changes in posterior airway space (PAS). The soft palate, tongue, and hyoid bone are attached directly or indirectly to the maxilla and mandible. Therefore, the above-mentioned structures are directly affected by the jaw movement, causing alterations in the pharyngeal area.

Also, the associations between the configuration of the upper airway space and possible respiratory disorders, such as obstructive sleep apnea syndrome (OSAS) could be explained through this way.

Mandibular setback surgery (MSS) with/without maxillary advancement is a common treatment plan in patients with skeletal class III malocclusion.

The majority of previous studies on the effects of orthognathic surgery on PAS were based on two-dimensional measurements using lateral cephalometric analysis [1]. Lateral cephalograms can provide us with

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useful, credible and replicable airway measurements while minimizing patient costs and radiation exposure. Studies have shown that while cephalometric measurements provide two-dimensional data, cephalometry is a reliable method for airway assessment and adenoid size estimation [2, 3].

The purpose of this study was to evaluate the impact of mandibular-only setback on adenoid and PAS changes by using lateral cephalometries in skeletal Class III patients. Our hypothesis was that mandibular-only setback increases PAS parameters.

Patients and Methods

This retrospective study was carried out according to the Declaration of Helsinki. Pre- and one-year-post-operative lateral cephalograms of 25 adult patients with mandibular prognathism who had bilateral sagittal split osteotomy (BSSO) between 2019 to 2021 were traced.

Including Criteria

Skeletal malocclusion class III adult patients undergone mandibular setback surgery with BSSO technique by the same oral and maxillofacial surgeon, cephalometric parameters of 0.76≤SNA≤80, SNB≥80, ANB≤0, reverse overjet, and concave profile, also availability of data from routinely performed lateral cephalograms.

All patients had standard edge wise bracket 02 for arch decompensation before BSSO surgery.

Excluding Criteria

Craniofacial anomalies or trauma pharyngeal pathologic symptoms, Previous orthodontic treatment, rhinoplasty, adenoidectomy or tonsillectomy.

Patients were divided into two groups according to the degree of GoGn to SN angle; vertical grower (>32ºC) and horizontal grower (<32ºC). All of the approximately 1month pre- and 1-year-post-operative lateral cephalograms were traced by the same investigator. The following parameters were measured.

- SNA: Sella–nasion–A-point.
- SNB: Sella–nasion–B-point.
- ANB: The angle formed by the planes nasion-point A and nasion-point B y-axis.
- GOGn to SN: The mandibular plane (Go is gonion, and Gn is gnathion, SN is sellanasion).
- SPPS: Superior Pharyngeal Space.

It is the smallest distance between the posterior border of the soft palate to the nearest point on the posterior pharyngeal wall [2] (normal: 15-20 mm [4])

- MPS: Middle Pharyngeal Space.

It is the smallest distance from the intersection of posterior border of tongue and inferior border of the mandible to the closest point on the posterior pharyngeal wall [2], 11–14 mm [4].

- IPS: Inferior Pharyngeal Space.

It is the smallest distance between the posterior borders of the tongue to the nearest point on the posterior pharyngeal wall, through the tip of the soft palate [2], 11–14 mm [4].

- PNS-Eb: Elongated pharynx.
- ppw-Ba: Posterior Pharyngeal Wall- Basion.

Statistical Analysis

Data were analyzed with paired t-test and in case of no normal distribution of pre- and post-operative cephalograms, Sign test was carried out. The role of growth pattern and gender factor was analyzed with Fisher exact test. MannWhitney test was utilized to compare between the groups of male/female as well as the groups of vertical/horizontal grower.

Results

The study group comprised of 25 patients (m: 8, f: 17) with the mean age of 25±4 years old. All patients had BSSRO setback under general anesthesia. There was a decrease in MPS value (3.8±6.7) that statistically significant (P=0.001). Although an increase was found in PNS-Eb index (3.1±4.4), the changes were significant (P=0.03). No significant change was observed in other parameters. Data obtained from lateral cephalogram tracing related to changes in hard tissue, adenoid, and pharyngeal space is summarized in Table 1.

A. In the vertical grower group, there was a 4 mm decrease in MPS parameter which was statistically significant (P=0.03). However, changes of this parameter in the horizontal grower group were not significant (P=0.2).

PNS-Eb parameter increased significantly in vertical group (2.5 mm increase, P=0.03) but no significant changes were found in horizontal group (P=0.08). Mann Whitney test showed no significant difference between the two groups of vertical and horizontal growers. Data specified in vertical and horizontal groups are summarized in Table 2.

B. MPS parameter decrease 4 mm in male patients which was significant (P=0.02), however, the changes of this parameter were not significant in female group (P=0.1).

Although the changes of PNS-Eb were significant in female patients (3 mm, P=0.02), this parameter didn’t show significant changes in male patients (P=0.06).

Mann Whitney test revealed no significant difference between the two groups of males and females. Data specified in gender of patients are summarized in Table 3.

C. Decreased MPS was observed more in males rather than females, as well as in horizontal growers in comparison with vertical ones. Fisher test showed that these differences were not statistically significant.

D. PNS-Eb increased more in males when compared to females, also, in vertical growers than that of horizontal growers. However, these changes were not significant according to the Fisher test.

Table 1: Data obtained from lateral cephalogram tracing related to changes in hard tissue, adenoid, and pharyngeal space

Cephalometric Parameters	GOGN to SN	Y Axis	SNA	SNB	ANB	SPPS	MPS	IPS	PNS-Eb	at-atp	ppw-Ba
T1	35.7 (6.2)	66.6 (4.4)	79.3 (2)	82.7 (3.9)	-3.3 (3.1)	12.1 (3.7)	17.7 (5.5)	14 (5.6)	68.8 (7.8)	13.5 (4)	23.8 (4.5)
T2	38.7 (6.8)	70.2 (4.5)	79.4 (2.2)	78 (3.5)	1.5 (2.8)	11 (4.2)	13.9 (5.3)	11.3 (5.2)	71.9 (8)	12.8 (3.3)	22.6 (3.9)
Changes	3 (4.5)	3.6 (2.1)	0.2 (0.5)	-4.7 (1.7)	4.8 (1.9)	-1.1 (2.9)	-3.8 (6.7)	-2.7 (5.7)	3.1 (4.4)	-0.76 (3.3)	-1.2 (4.6)
Changes in percentage	8.4	5.4	0.2	5.7	145	9	21.5	19.3	4.5	5.6	5
P value	0.01	0.01	0.3	0.001	0.001	0.1	0.001	0.06	0.03	0.9	0.2
Paired t-test, P<0.05 is appropriate.											

Table 2: Data specified in vertical and horizontal growers

	SPPS		MPS		IPS		PNS-Eb		At-atp		ppw-Ba	
	H	V	H	V	H	V	H	V	H	V	H	V
T1	12.1 (3.8)	12.2 (3.6)	18.3 (5.9)	15.6 (3)	14.6 (5.5)	12.3 (5.9)	69.3 (7.9)	69.4 (9.9)	14 (4.2)	12.3 (4.8)	24.1 (4.8)	23 (3.7)
T2	11.1 (4.1)	10.6 (4.9)	14.3 (5.4)	12.4 (4.9)	11.9 (5.2)	9.3 (5.3)	70.9 (8)	74.1 (3.2)	12.9 (3.2)	12.3 (3.7)	23 (4.3)	21.7 (2.8)
Changes	-0.9 (2.7)	-1.6(2.8)	-4 (7.1)	-3.2 (4.7)	-2.7 (6)	-3 (5.5)	2.5 (4.1)	4.7 (5.1)	-1.06 (3.7)	-0.001 (1.4)	-1.1 (5.1)	-1.3 (3.1)
Changes in Percentage	7.4	13.1	21.8	20.5	18.5	24.4	3.6	6.8	7.6	0.008	4.6	5.6
P Value Intra Group	0.2	0.3	0.03	0.2	0.1	0.2	0.03	0.08	0.3	1	0.6	0.2
P Value Inter Group	0.7		0.6		0.8		0.5		0.6		0.6	
Paired t-test and Mann Whitney tests, P<0.05 is appropriate.												

Table 3

	SPPS		MPS		IPS		PNS- Eb		At-atp		ppw-Ba	
	m	f	m	f	m	f	m	f	m	f	m	f
T1	11.3 (2.9)	12.5 (4)	17.1 (5.1)	18 (5.8)	15.1 (5.8)	13.5 (5.6)	77.5 (7.2)	65.5 (5.5)	12.7 (3.1)	13.9 (4.3)	23.6 (3.7)	23.9 (4.9)
T2	9.9 (3.5)	11.6 (4.5)	13.1 (5)	14.2 (5.5)	11.5 (4.9)	11.1 (5.5)	79.5 (9)	68.7 (4.9)	13.2 (2.8)	12.5 (3.5)	23.5 (3.4)	22.2 (3.9)
Changes	-1.5 (3.2)	-0.87 (2.4)	-4 (4.3)	-3.7 (7.7)	-3.6 (5.4)	-2.3 (6)	3 (3.5)	3.18 (4.8)	0.5 (2.5)	-1.35 (3.5)	-0.13 (4.2)	-1.6 (4.8)
Changes in Percentage	13.2	6.9	23.3	20.5	23.8	17	3.8	4.8	3.9	9.7	0.5	6.7
P Value Intra Group	0.2	0.2	0.02	0.1	0.1	0.7	0.06	0.02	0.3	0.1	0.9	0.3
P Value Inter Group	0.7		0.7		0.5		0.9		0.08		0.8	
Paired t-test and Mann Whitney tests												

DISCUSSION

We observed a significant decrease in MPS particularly in males and in horizontal growers.

Tselnik and Pogrel [5] reported a long-term decrease in pharyngeal airway space following to surgical mandibular setback in 14 adult patients. The mean reduction in pharyngeal airway space was 1.52 cm2, which corresponded to a 12.8% reduction.

Kitahara *et al.*, [6] reported that the Class III subjects had a significantly wider PAS than did the control subjects. Significant decreases in the lower PAS were observed after orthognathic surgery. Upward movement of the lower border of the PAS during the postsurgical stage was reported in the bilateral sagittal split ramus osteotomy (SSRO) group. In contrast, the anterior border of the PAS and the hyoid bone showed considerable backward movement in the bilateral intraoral vertical ramus osteotomy (IVRO) group. The IVRO group showed a reduction in the airway dimensions, especially during the postsurgical period, which occurred during surgery in the SSRO group.

A systematic review by Fernández-Ferrer *et al.*, [7], reported persistent and significant decreases in the area, horizontal linear dimensions, and volume of these spaces (oropharynx, hypopharynx, and nasopharyngeal space) are encountered after mandibular setback alone. This study found no evidence to confirm that bimaxillary or mandibular orthognathic surgery predisposes to obstructive sleep apnea development.

In Becker *et al.*, [8] study, five measurements of the pharyngeal airway space (nasopharynx; upper, middle, and lower oropharynges; hypopharynx) were evaluated and correlated with the skeletal movement of the jaws (lines perpendicular to the Frankfurt horizontal plane passing through the nasion point to points A and B). A correlation for pharyngeal airway measurements was found between those located anatomically near each other, showing the importance of the pharyngeal muscles in this relation.

Rückschloß *et al.*, [9] reported that CBCT scans were analyzed for several airway parameters (volume, mean cross-sectional area, and diameter) and the three dimensional extent of mandibular movement. In Class III patients there were only significant postoperative increases in the volumetric, and partially in diametric and spherical, variables ($p < 0.05$) of the upper PAS segment.

Saitoh [10] claimed that 10 women who were diagnosed as having skeletal mandibular prognathism and underwent mandibular setback surgery by bilateral sagittal split ramus osteotomy (SSRO) and orthodontic multi-bracket treatment. The subjects were assessed before treatment (T1), 3-6 months after SSRO (T2), and 2 or more years after SSRO (T3). From T1 to T2, the pharyngeal airway constricted significantly. On the other hand, from T2 to T3, the lower facial morphology showed no significant changes. The pharyngeal airway morphology showed significant changes in soft-palate length and posterior reference line to point of posterior tongue, indicating a tendency for relapse. These results suggest that, although the lower facial morphology and the pharyngeal airway morphology showed marked changes after SSRO, the pharyngeal airway morphology exhibited gradual physiologic readaptation.

The finding that mandibular setback surgery leads to a narrowing of the upper airway has led to the conclusion that this volumetric change may impair sleep quality and possibly cause OSAS [11, 12].

In Class III patients there were only significant postoperative increases in the volumetric, and partially in diametric and spherical, variables ($p < 0.05$) of the upper PAS segment [9].

LIMITATION

Although cephalometric analysis remains the "work horse" for the evaluation of craniofacial development, Lateral cephalometry has a fundamental limitation in describing the three-dimensional (3D) structure of the airway, which makes it difficult to characterize the dimensions of the airway accurately.

However, despite its effectiveness in computing the size of the airways in the sagittal plane, it lacked accuracy in depicting the anatomy in three dimensions. Moreover, the most crucial information lies in the axial images perpendicular to the airflow pathway, and lateral cephalometric images fail to illustrate this.

CONCLUSION

Mandibular setback surgery causes a long-term effect in some parameters of pharyngeal airway space area. In patients suffering from obstructive sleep apnea or in case of some other risk factors including overweight, short necks, and small pharyngeal airway space, a mandibular setback surgery could possibly predispose to the development of sleep apnea syndrome.

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