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Original research

Evaluation of patient satisfaction with pharyngeal airway changes after orthognathic surgery in patients with Class III skeletal anomalies

Purpose
The aims of our study were to determine the changes in the pharyngeal airway after treating patients with Class III malocclusion who received double jaw surgery, to determine the hard tissue and soft tissue parameters and the hyoid bone and tongue positions after surgery, to determine the changes to compare the pre-treatment and post-treatment measurements of the patients in the double jaw group with the measurements of the control group patients, and to evaluate post-operative patient satisfaction.

Materials and Methods
The study included thirty-two Class III adult patients that received double jaw surgery and twenty-five Class I patients. Cephalometric records were taken before treatment (T1) and after treatment (T2).

Results
After double jaw orthognathic surgery, there were statistically significant changes in all pharyngeal airway linear and areal parameters ($p<0.001$). There were significant superior and posterior movements of the tongue and hyoid bone post-surgery. The post-treatment analysis of the double jaw surgery group and control group were compared, with statistically significant differences in the mandibular dental parameters and pharyngeal airway measurements in patients in the double jaw surgery group.

Conclusion
Despite the narrowings detected, high satisfaction scores were observed in the patient satisfaction questionnaire and the patients did not experience respiratory problems.

Keywords: *Orthognathic surgery, Class III malocclusion, pharyngeal airway, patient satisfaction, cephalometric*

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Introduction

Class III anomalies are the most difficult and complex orthodontic deformities in terms of both diagnosis and treatment planning. These skeletal anomalies can be treated by maxillary advancement or mandibular setback, which can be preferred as a single or double jaw surgical operation (1). Orthognathic surgery aims to give patients a better aesthetic appearance, as well as a healthy occlusion and chewing function. In orthognathic surgical procedures, the movement of skeletal structures significantly affects facial aesthetics and causes changes in soft tissues such as submental and nasolabial areas. Apart from the affected areas such as the nose, lips, and chin tip, changes are also observed in the pharyngeal region (2). This complex structure consists of the soft palate, hyoid bone, tongue, epiglot-

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tis, and a group of muscles associated with them. Especially after mandibular setback procedures, the change of positions in these structures associated with the lower and upper jaws can affect the quality and efficiency of respiration. Changes in the volumes of the oral and nasal cavities cause changes in the pharyngeal airway space (3-6). Volumetric changes in the pharyngeal airway space (PAS) may be a risk factor for respiratory disturbance (6). Some patients develop Obstructive Sleep Apnea syndrome (OSAS) after mandibular setback procedures, drawing attention to the relationship between these operations and airway dimensions, with the number of studies on this issue having increased in recent years (5, 7).

Lateral cephalometric radiography continues to be an important imaging tool in orthognathic surgical. Cephalometric imaging is still used estimate skeletal deformities despite the fact that it provides only 2-dimensional images for the evaluation of the pharyngeal airway (3, 8-10). Easy access, low complexity, low cost, less radiation are among the advantages of cephalometric radiography (9, 10). Many studies examined by lateral cephalometric analysis stated that the most common anatomical changes related to OSAS are the posterior location of the hyoid bone and the base of the tongue, which results in pharyngeal airway narrowing. In these studies, it was aimed to examine the effect of orthognathic surgery on PAS. Conversely, the PAS seems to become narrow after mandibular setback, with a risk of developing OSAS (3, 8, 11).

The purpose of our study is 1) to determine the changes in the posterior pharyngeal airway of patients treated with double jaw orthognathic surgery, 2) to reveal the results of airway measurements on lateral cephalometric films with linear and areal parameters, 3) to determine the changes in hard tissue and soft tissue parameters, hyoid bone, and tongue positions after surgery, and 4) to compare the pre- and post-treatment measurements of the patients in the double jaw surgery group with the measurements of the control group patients and to evaluate post-operative patient satisfaction.

The first null hypothesis of this study was that there was no change in linear and area measurements of the pharyngeal airway space after double jaw surgery when compared to both pre-treatment and control groups.

The second null hypothesis of this study was that there was no change in post-treatment patient satisfaction after double jaw surgery compared to pre-treatment.

Material and Methods

Study design

A retrospective study design was used to address the research subject. The subjects of this study were selected from the patients treated at the Karadeniz Technical University, Faculty of Dentistry, Turkey between 2008 and 2020. Inclusion criteria were nonsyndromic adult patients older than 18 years with skeletal Class III deformities, including mandibular prognathism and maxillary retrognathism, that received orthodontic treatment prior to surgical procedures. Exclusion criteria included previous orthognathic surgery, genioplasty, and craniofacial anomalies. Thirty-two patients (19 women, 13 men) underwent a modified bilateral sagittal split ramus osteotomy (BSSRO) combined with a Le Fort I osteotomy, and twenty-five control group patients (13 women, 12 men) were selected with a Class I malocclusion. In the Le Fort I surgical technique, the maxilla was also positioned upwards. All of the patients were treated surgically with the same examiner and treatment protocol.

Cephalometric measurements

Lateral cephalograms were obtained using a standardized method by cephalostat on the same orthopantomograph (Sirona Group, Bensheim, Germany). Lateral cephalometric images were obtained pre-treatment (T1) and > 1 years post-treatment (T2) from each subject and traced by the same investigator (an orthodontist). The mean duration of treatment time was 2.8 years in the double jaw surgery group. The pre- and post-surgical cephalograms were digitized by using the Nemoceph software (NemoStudio 2020, Software Nemotec S.L. The horizontal reference plane (HOR) was defined by raising a line 7° from Sella-Nasion (S-N) and the perpendicular line drawn from S point to HOR was used as the vertical reference plane (VER). Seventeen skeletal, nine dental, two hyoidal, six pharyngeal linear, two tongue position, three pharyngeal area, and six soft tissue measurements were used in the study (Figures 1 and 2). Area measurements of the pharyngeal airway were done with an ImageJ version 1.3 software (National Institutes of Health, Bethesda, Md).

Error of the method

All measurements were repeated on 10 randomly selected radiographs. Measurements were compared and correlation coefficients (r^2) were provided. Areal measurements were re-measured three times by the same investigator to eliminate the error rate.

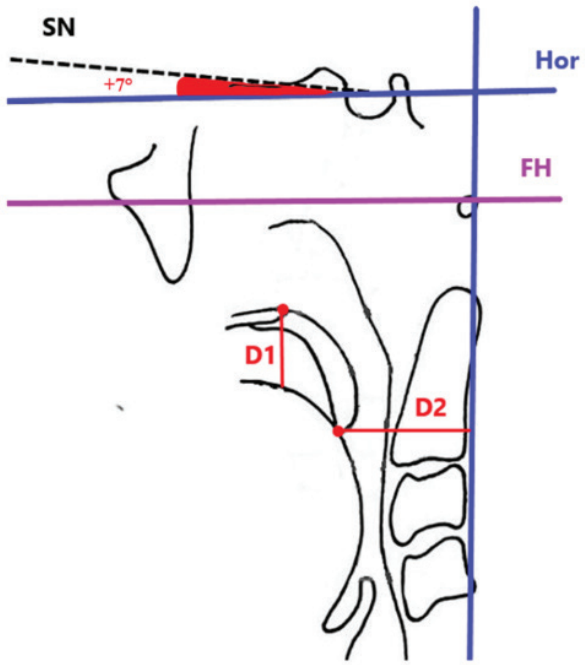

Figure 1. *D1: The line drawn from the PNS point to the dorsum of the tongue parallel to the vertical reference plane (Ver). D2: It is the distance of the point where the dorsum of the tongue cuts the mandibular plane to the line perpendicular to the Frankfort horizontal plane and passing through the Porion.*

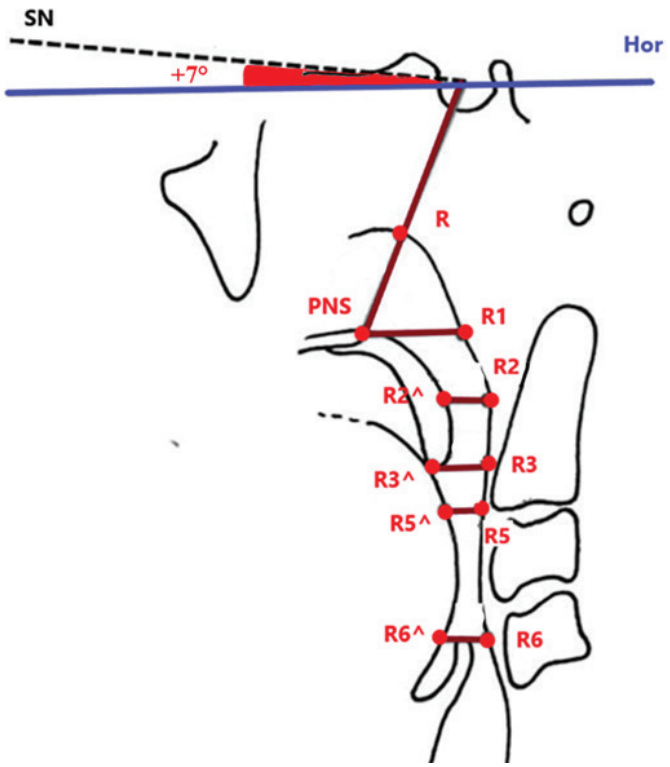

Figure 2. *Pharyngeal Linear Parameters: PNS-R: It is the distance between PNS and R points, PPS (PNS-R1): It is the distance between the PNS and R1 points (Palatal pharyngeal region). SPSS (R2-R2^): Superior posterior pharyngeal region MPS (R3-R3^): Middle pharyngeal region, IPS(R5-R5^): Inferior pharyngeal region, EPS(R6-R6^): Epiglottic pharyngeal region.*

Postoperative patient satisfaction questionnaire

In our study, all individuals were interviewed face-to-face, and they were asked to answer a 14-question questionnaire evaluating post-surgical quality of life and patient satisfaction. In our questionnaire, a 3-point Likert scale was used and the patients were asked to mark the answers as "Never", "Moderate", or "Very".

The first 4 questions were included in the questionnaire in order to evaluate the patients who had respiratory distress and related problems before orthognathic surgery.Patients who did not experience the problems mentioned before the operation were asked to pass these questions. In the 6-10th questions in the questionnaire, the existence and severity of functional problems that patients may experience after orthognathic surgery were questioned. In the 10-14th questions, awareness related to the changes in the external appearance of the patients after surgery was questioned. The views of the patients about their appearance and the people in their social circles, changes in self-confidence and social adaptation, and general satisfaction after the operation were evaluated.

Sample size calculation

In calculating the sample size, based on the Cakarne D. (12) study, alpha error=0.05, beta error=0.20, effect size 0.65, it was concluded that 22 patients for each group would be sufficient. However, considering possible data losses, it was planned to retrospectively include at least 50 patients (at least 25 in each group) in the study.

Statistical analysis

Statistical analyses were performed with SPSS for Windows 17.0 (SPSS Inc., Chicago, IL, USA). Wilcoxon Signed Ranks Test was used to evaluate the differences between skeletal, dental, pharyngeal airway parameters and area measurements performed on cephalometric radiographs between the treatment periods of the double jaw group. Mann Whitney U Test was used for comparisons between groups. Intra-class correlation coefficient (ICC) was applied to evaluate the intra-observer agreement between pre-treatment and post-treatment measurements. The p value below than 0.05 was considered as significant.

Results

The method's reliability was high, with the correlation coefficients ranging between 0.758 and 0.996. The demographic and clinical characteristics of the groups are presented in Table 1.The cephalometric outcomes for 32 patients who underwent bimaxillary orthognathic surgery were compared with 25 patients who had Class I skeletal malocclusion. The results are presented in Tables 2 and 3. There was a significant post-surgery posterosuperior movement of hyoid bone (H-Ver and H-Hor: $p<0.001$). The D1 value showed significant decreases, describing the movement of the tongue in the vertical direction, and the D2 value, which describes the movement in the sagittal direction (D1 and D2: $p<0.001$). An increase in the nasopharyngeal airway area (AREA 1) was observed ($p<0.001$). Decreases in the oropharyngeal (AREA 2), hypopharyngeal airway area (AREA 3), and dimensional measurements ($p<0.001$) were found (Table 2).

When the sagittal direction analyzes were evaluated in the comparison of the pre- jaw orthognathic surgery group and the control group, statistically significant differences were found (SNA, SNB, ANB: $p<0.001$). When pharyngeal airway linear measurements were compared, statistically significant differences were found in all parameters except the PNS-R value and in parameters expressing tongue position (D1 and D2) (PNS-R1: and SPSS: $p<0.05$ MPS, IPS and EPS: $p<0.001$, D1 and D2: $p<0.01$). Statistically significant differences were observed in the AREA 3 value from the pharyngeal airway areal parameters ($p<0.05$). While the PNS-P value was 19.74 mm in the double jaw group post-treatment, this value was 17.73 mm in the control group, and the difference between them was statistically significant ($p<0.001$). While the AREA

Table 1. *Demographic and clinical characteristics of the groups.*

Groups	Age (years)			Gender	
	Mean	Min	Max	Male	Female
Double Jaw (n=32)	21.50	18	32	13	19
Control (n=25)	19.88	18	23	12	13

Min:Minimum, Max: Maksimum

Table 2. *Comparison of Skeletal, Dental, Soft Tissue, Hyoid Bone, Tongue and Pharyngeal Airway Measurements Before and After Treatment of the Double Jaw Surgery Group.*

PARAMETERS	2-jaw surgery group (n=32)		T2-T1	p value
	T1	T2		
	X ± Sx	X ± Sx		
Skeletal Parameters				
SNA	77.72± 4.25	81.81±3.81	4.71	***
Nperp-A	-4.92± 3.12	-0.85±1.89	5.77	***
A-Ver	43.97± 4.27	47.84±4.00	3.87	***
Co-A	59.32±4.12	62.44±3.72	3.12	***
A-Hor	36.83±3.61	35.15±4.60	0.68	*
SNB	83.96±4.38	79.62±4.11	3.34	***
Nperp-B	1.66±4.99	-3.47±3.30	5.13	***
B-Ver	48.24±5.04	43.48±5.07	4.76	***
Pg-Ver	50.14±5.47	45.59±5.14	4.55	***
Me-Ver	44.65±5.58	39.88±5.02	4.77	***
Cd-Gn	89.54±5.38	86.27±5.50	3.27	***
Cd-Go	41.85±4.52	40.03±4.92	1.55	**
Go-Gn	57.51±3.66	54.80±3.71	2.71	***
ANB	49.89±4.43	45.78±3.99	7.36	***
SN-GoGn	79.12±7.48	79.43±5.43	1.56	***
OP-SN	52.36±4.29	50.02±4.73	1.53	*
N-Me	49.89±4.43	45.78±3.99	2.08	***
Dental Parameters				
U1i-Ver	47.31±4.65	51.34±5.52	4.03	***
U6t-Ver	29.53±3.51	33.18±4.46	3.65	***
U1i-Hor	51.70±4.02	50.36±4.91	1.34	*
U6t-Hor	48.23±3.70	47.47±4.63	0.76	*
L1i- Ver	49.89±4.43	45.78±3.99	4.11	***
IMPA	79.12±7.48	79.43±5.43	0.31	
L1i-Hor	52.36±4.29	50.02±4.73	2.34	***
Overjet	-2.83±2.05	2.39±0.64	5.22	***
Overbite	-0.19±1.77	1.01±0.34	1.40	***
Soft Tissue Parameters				
Pn-Ver	69.35±4.15	71.60±4.41	2.25	***
Nazolabial Angle	101.78±11.71	102.65±12.98	0.87	
ULA-Ver	57.35±4.20	59.90±4.27	2.55	**
LLA-Ver	59.64±4.63	55.92±3.81	3.72	***
B'-Ver	55.52±5.77	50.90±4.54	4.62	***
Pg'-Ver	57.95±6.11	53.21±4.82	2.34	***
Hyoid Bone Position				
H-Ver	13.10±4.54	10.73±4.54	2.34	***
H-Hor	76.36±4.06	74.23±3.64	2.13	***
Tongue Position				
D1	11.05±2.89	8.96±2.11	2.09	***
D2	21.10±3.70	18.74±3.67	2.36	***
Pharyngeal Airway Linear Parameters				
PNS-R	1.66±4.99	-3.47±3.30	1.84	***
PNS-R1	48.24±5.04	43.48±5.07	1.84	***
SPSS	50.14±5.47	45.59±5.14	0.78	***
MPS	44.65±5.58	39.88±5.02	1.38	***
IPS	89.54±5.38	86.27±5.50	1.17	***
EPS	41.85±4.52	40.03±4.92	1.27	***
Pharyngeal Airway Areal Parameters				
Nasopharynx, mm2	183.50±33.87	224.71±46.93	41.21	***
Oropharynx, mm2	212.59±34.51	191.81±32.83	20.78	***
Hypopharynx, mm2	178.87±48.35	155.00±42.12	23.87	***

Note: Data presented as mean±standard deviation, p<0.05*,p<0.01**, p<0.001*** Wilcoxon Signed Ranks Test; Abbreviations: Ver: Vertical Referance Plane, Hor: Horizontal Reference Plane, Nperp: Nasion perpendicular, Co; Condylion OP-SN: Occlusial Plane- Sella-Nasion, U1i: Upper 1. incisor, U6t: Upper 1. molar, L1i: Lower 1. incisor, ULA: Upper Lip Anterior, LLA: Lower Lip Anterior, H: Hyoidale, PNS: Posterior Nasal Spina, PPS: Palatal pharyngeal region, SPSS : Superior posterior pharyngeal region, MPS: Middle pharyngeal region, IPS: Inferior pharyngeal region, EPS: Epiglottic pharyngeal region, D1: The line drawn from the PNS point to the dorsum of the tongue parallel to the vertical reference plane (Ver). D2:It is the distance of the point where the dorsum of the tongue cuts the mandibular plane to the line perpendicular to the Frankfort horizontal plane and passing through the Porion.

1 value expressing the nasopharyngeal area post-treatment was 224.71 mm^2 in the double jaw group. This value was measured as 192.20 mm^2 in the control group, and the difference between them was statistically significant (p<0.05). While the AREA 2 value expressing the oropharyngeal area at post-treatment was 191.81 mm2 in the double jaw group,

Table 3. *Evaluation of Skeletal, Dental, Soft Tissue, Hyoid Bone, Tongue and Pharyngeal Airway Measurements in Double Jaw Surgery and Control Group.*

PARAMETERS	Non-Surgical (Control) Group (n=25)	2-jaw surgery group (n=32)			
		Pre-Treatment (T1) X±Sx	P value	Post-treatment(T2) X±Sx	P value
Skeletal Parameters					
SNA	81.88±1.98	77.72± 4.25	***	81.81±3.81	
Nperp-A	-0.82±1.19	-4.92± 3.12	***	-0.85±1.89	
A-Ver	49.80±3.93	43.97± 4.27	***	47.84±4.00	
Co-A	62.63±3.95	59.32±4.12	**	62.44±3.72	
A-Hor	35.93±3.95	36.83±3.61		35.15±4.60	
SNB	79.36±1.80	83.96±4.38	***	79.62±4.11	
Nperp-B	-4.79±1.01	1.66±4.99	***	-3.47±3.30	
B-Ver	46.41±4.25	48.24±5.04		43.48±5.07	
Pg-Ver	47.86±4.45	50.14±5.47		45.59±5.14	
Me-Ver	41.94±4.84	44.65±5.58		39.88±5.02	
Cd-Gn	84.19±4.55	89.54±5.38	***	86.27±5.50	
Cd-Go	40.75±3.94	41.85±4.52		40.03±4.92	
Go-Gn	56.74±3.22	57.51±3.66		54.80±3.71	
Dental Parameters					
U1i-Ver	52.48±3.77	47.31±4.65	***	51.34±5.52	
U6t-Ver	32.35±4.17	29.53±3.51	**	33.18±4.46	
U1i-Hor	51.64±4.32	51.70±4.02		50.36±4.91	
U6t-Hor	47.63±4.17	48.23±3.70		47.47±4.63	
L1i- Ver	50.04±3.86	49.89±4.43	***	45.78±3.99	***
IMPA	93.12±4.41	79.12±7.48	***	79.43±5.43	***
L1i-Hor	49.94±4.36	52.36±4.29	*	50.02±4.73	
Maxillo-Mandibular Skeletal Parameters					
ANB	2.44±1.00	-5.18±2.53	***	2.18±1.35	
SN-GoGn	33.12±2.35	37.90±8.30	**	36.34±6.66	*
OD-SN	13.72±4.03	15.83±6.57		17.34±6.51	*
N-Me	83.87±4.91	86.93±5.52		84.85±4.97	
Maxillo-Mandibular Dental Parameters					
Overjet	2.63±0.71	-2.83±2.05	***	2.39±0.64	
Overbite	1.51±0.45	-0.19±1.77	***	1.21±0.34	
Soft-Tissue Parameters					
Pn-Ver	73.43±4.60	69.35±4.15	***	71.60±4.41	
Nazolabial Angle	99.64±3.32	101.78±11.71		102.65±12.98	
ULA-Ver	61.68±4.47	57.35±4.20	***	59.90±4.27	
LLA-Ver	58.70±4.53	59.64±4.63		55.92±3.81	
B'-Ver	53.16±4.40	55.52±5.77		50.90±4.54	
Pg'-Ver	56.22±4.84	57.95±6.11		53.21±4.82	
Hyoid Bone Parameters					
Hi-Ver	11.67±6.06	13.10±4.54		10.73±4.54	
Hi-Hor	77.75±6.23	76.36±4.06		74.23±3.64	
Tongue Position Parameters					
D1	9.13± 2.22	11.05±2.89	**	8.96±2.11	
D2	17.60±3.88	21.10±3.70	**	18.74±3.67	
Pharyngeal Airway Linear Parameters					
PNS-R	17.73±1.69	17.91±1.66		19.74±1.92	***
PNS-R1	18.66±2.13	17.51±1.91	*	19.35±2.22	
SPSS	9.10±1.37	10.01±1.75	*	9.18±1.84	
MPS	9.40±2.03	11.39±2.18	***	10.01±2.32	
IPS	8.13±1.55	9.98±2.28	***	8.81±2.20	
EPS	8.11±1.70	9.80±2.25	***	8.53±2.11	
Pharyngeal Airway Areal Parameters					
Nasopharynx, mm2	192.20±40.67	183.50±33.87		224.71±46.93	*
Oropharynx, mm2	222.80±35.39	212.59±34.51		191.81±32.83	**
Hypopharynx, mm2	149.20±40.23	178.87±48.35	*	155.00±42.12	

Note: Data presented as mean±standard deviation, p<0.05*,p<0.01**, p<0.001*** Mann Whitney U Test; Abbreviations: Ver: Vertical Referance Plane, Hor: Horizontal Reference Plane, Nperp: Nasion perpendicular, Co; Condylion, OP-SN: Occlusial Plane- Sella-Nasion, U1i: Upper 1. incisor, U6t: Upper 1. molar, L1i: Lower 1. incisor, ULA: Upper Lip Anterior, LLA: Lower Lip Anterior, H: Hyoidale, PNS: Posterior Nasal Spina, PPS: Palatal pharyngeal region, SPSS : Superior posterior pharyngeal region, MPS: Middle pharyngeal region, IPS: Inferior pharyngeal region, EPS: Epiglottic pharyngeal region, D1: The line drawn from the PNS point to the dorsum of the tongue parallel to the vertical reference plane (Ver). D2: It is the distance of the point where the dorsum of the tongue cuts the mandibular plane to the line perpendicular to the Frankfort horizontal plane and passing through the Porion.

this value was measured as 222.80 mm^2 in the control group, and the difference between them was statistically significant (p<0.01) (Table 3). The questionnaire data we obtained from the same dpatients in the patient group with the skeletal Class III malocclusion who underwent double jaw orthognathic surgery are shown in Table 4.

Discussion

Skeletal Class III malocclusions are clinically defined as mandibular prognathia, maxillary retrognathia, or a combination of both. Orthognathic surgery aims to provide patients with a healthy occlusion and chewing function as well as a better aesthetic appearance (2).

Current literature shows that mandibular setback surgery narrows the upper airway by posterior positioning of associated structures such as the soft palate, tongue, and hyoid bone. The total pharyngeal volume decreased considerably between its preoperative level and one year postoperatively (7, 13). The decrease in airway volume after the operation may cause respiratory distress and decrease the patients' quality of life.

Ho *et al.* (14) reported that the hyoid bone moved upwards and backwards one week after the double jaw surgery in the

Table 4. *Evaluation Of Pre- and Post-Treatment Measurements with Intraclass Correlation Coefficient*

Parameters	Pre-Treatment (T1)		Post-Treatment (T2)	
	Intraclass Correlation Coefficient	P value	Intraclass Correlation Coefficient	P value
Maxillary Skeletal Measurements				
SNA	0.997	***	0.981	***
Nperp-A	0.998	***	0.947	***
A-Ver	0.998	***	0.958	***
Co-A	0.775	**	0.997	***
A-Hor	0,967	***	0.977	***
Maxillary Dental Measurements				
U1i-Ver	0.998	***	0.947	***
U6t-Ver	0.954	***	0.979	***
U1i-Hor	0.997	***	0.948	***
U6t-Hor	0.978	***	0.964	***
Mandibular Skeletal Measurements				
SNB	0.998	***	0.987	***
Nperp-Pg	0.964	***	0.979	***
B-Ver	0.997	***	0.986	***
Pg-Ver	0.967	***	0.977	***
Me-Ver	0.949	***	0.939	***
Cd-Gn	0.919	***	0.989	***
Cd-Go	0.889	***	0.964	***
Go-Gn	0.964	***	0.898	***
Mandibular Dental Measurements				
L1i-Ver	0.939	***	0.949	***
IMPA	0.944	***	0.979	***
L1i-Hor	0.889	***	0.974	***
Maxillo-Mandibular Skeletal Parameters				
ANB	0.919	***	0.989	***
SN-GoGn	0.934	***	0.979	***
OD-SN	0.889	***	0.934	***
N-Me	0.997	***	0.986	***
Maxillo-Mandibular Dental Parameters				
Overjet	0.888	***	0.937	***
Overbite	0.919	***	0.989	***
Soft-Tissue Parameters				
Pn-Ver	0.889	***	0.976	***
Nazolabial Angle	0.997	***	0.981	***
ULA-Ver	0.998	***	0.958	***
LLA-Ver	0.949	***	0.939	***
B'-Ver	0.934	***	0.979	***
Pg'-Ver	0.998	***	0.997	***
Hyoid Bone Parameters				
Hi-Ver	0.954	***	0.979	***
Hi-Hor	0.998	***	0.996	***
Tongue Position Parameters				
D1	0.947	***	0.981	***
D2	0.956	***	0.758	**
Pharyngeal Airway Linear Parameters				
PNS-R	0.939	***	0.949	***
PNS-R1	0.888	***	0.937	***
SPSS	0.889	***	0.776	**
MPS	0.949	***	0.739	***
IPS	0.862	**	0.973	***
EPS	0.788	**	0.937	***
Pharyngeal Airway Areal Parameters				
Nasopharynx, mm^2	0.913	***	0.916	***
Oropharynx, mm^2	0.785	**	0.978	***
Hypopharynx, mm^2	0.889	***	0.776	**

p<0.05*,p<0.01**, p<0.001*** Intraclass Correlation Coefficient (ICC)

maxillary impaction group. The computed tomography (CT) study of Park *et al*.(15) noted that the hyoid bone moved backward, but there was no significant change in its vertical position. However, these results we found in our study are similar to those of Marşan *et al*. (8).

Statistically significant decreases occurred in the tongue position (p<0.001). Kawakami et al. (3) evaluated the posterior airway, tongue position, and post-operative patient satisfaction in cases with skeletal Class III malocclusion, and reported that none of the existing patients had any OSA symptoms before or after orthognathic surgery, despite the tongue being positioned more posteriorly and superiorly after surgery. Their studies it was reported reported that the mean of the D2 parameter, which expresses the movement of the tongue in the sagittal direction, was more than 10.0 mm, which was larger than previously reported in OSA patients. Some of the changes seen in the oropharyngeal region after surgery are quite similar to the changes in OSA patients. The previously published studies show that OSA developed after mandibular retrieval surgery in two patients (5, 16). Both patients reported worsening of snoring and narrowing of the airway in the first 18 months after surgery. We could say that this result was equivalent to the movement of the mandible as a result of double jaw surgery.

Statistically significant changes were observed in all pharyngeal dimensional and areal parameters in the pre- and post-operative analyses of the group undergoing bimaxillary surgery (p<0.001) (16).

The PNS-R and PNS-R1 values, which express the dimensional measurement of the nasopharynx, increased and the value of AREA 1, which expresses the areal measurement,

Table 5: *Postoperative Patient Satisfaction Questionnaire Results*

Postoperative Patient Satisfaction Questionnaire	
Questions	**Average Scores**
1. How satisfied are you with your current loud snoring?	4.20
2. How satisfied are you with your fatigue complaint when you wake up in the current morning?	4.30
3. How satisfied are you with your current shortness of breath during sleep?	4.50
4. How satisfied are you with your complaint of shortness of breath during current physical activity?	4.50
5. How satisfied are you with your current breathing?	3.70
6. How satisfied are you with your current speech?	4.20
7. How satisfied are you with the side view of your current face?	4.45
8. How satisfied are you with the current closure and stance of your lips?	4.20
9. How aesthetically pleasing are you with the appearance of your current teeth?	4.70
10. How satisfied are you with your current chewing and biting function?	4.20
11. How satisfied are your family, relatives or friends about the outcome of your surgical operation?	4.60
12. Has your self-confidence increased after orthognathic surgery?	4.50
13 .If you were to decide again, would you want to have the same surgical operation again?	4.50
14. Would you recommend the same surgical operation to other people who have similar problems as you?	4.50

increased. The change in PNS-R measurement is associated with the prominence of the PNS point after maxillary advancement operation. Depending on the increase in PNS-R length, an increase in AREA 1 value is expected. The significant increase we obtained in our double jaw group coincides with Chen *et al.*'s findings. In this study, in which 31 cases with skeletal Class III malocclusion were evaluated, a significant increase was found in the nasopharynx three to six months after the double jaw group's operation (17). In our study, there was an increase in the nasopharynx with a change SNA and SNB. Likewise, Marşan *et al.* (8) observed a significant increase in the nasopharyngeal measurement after 1.3 years with SNA and SNB change in 53 female patients who underwent double jaw surgery.

If we talk about the changes in the oropharynx region, a decrease and expresses the dimensional measurement of the oropharynx, and a decrease in the AREA 2 value expresses the areal measurement. The literature states that the oropharynx is the region most affected and there is narrowing with the mandible's retraction (15, 18-20). However, our study reveals that the hypopharynx is also seriously affected by the narrowing. IPS and EPS values, which express the dimensional measurement of the hypopharynx, decreased and 1.27 mm and AREA 3, which expresses the areal measurement, decreased ($p<0.001$). If we support the results of our study with the literature, in the CT study of Değerliyurt *et al.*(21), 35% narrowing of the oropharynx and 29% narrowing occurred in the hypopharynx as a cross-sectional area in the mandibular retraction group, where the mandible was retracted 7 mm, while these values were observed in the double jaw group in which the 7.3 mm mandible was retracted, respectively. 15% and 8%.

When the pre-treatment values of the double jaw group and the maxillary skeletal values of the control group were compared, statistically significant differences were found in the SNA, Nperp-A, and A-Ver parameters, thereby giving information in the sagittal direction, and in the Co-A parameter (SNA: $p<0.001$, Nperp-A: $p<0.001$, A-Ver: $p<0.001$, Co-A: $p<0.01$). Mouakeh et al. (22) compared a total of 138 cases (69 Class I patients and 69 Class III patients) with Class I and Class III malocclusions, and found that there were statistically significant differences in SNA, Nperp-A, and Co-A parameters, similar to our findings. They emphasized that the maxillary length (Co-A) of Class III patients is shorter than that of normal individuals and that the maxilla is located further back. When the pre-treatment values of the double jaw group were compared with the data of the control group on the mandibular skeletal values, statistically significant differences were found in the SNB and Nperp-Pg parameters, which gave information in the sagittal direction, and in the Cd-Gn parameter (SNB: $p<0.001$, Nperp-Pg: $p<0.001$, A-Ver: $p<0.001$, Cd-Gn: $p<0.001$). Studies comparing Class I and Class III cases showed that there were significant differences in SNB and Nperp-Pg parameters, similar to the findings in our study (22, 23).

The D2 value, which shows the horizontal movement of the tongue position in the pre-treatment double jaw group, was 21.10 mm, while this value was 17.60 mm in the control group, and the difference between them was statistically significant ($p<0.01$). Cheng et al., in their study in which they examined the posterior airway and tongue position of Class I, Class II, and Class III patients, stated that the tongue was located more anteriorly in Class III patients (24).

Statistically significant differences were found in PNS-R1, SPSS, MPS, IPS, and EPS parameters when the pre-treatment values of the double jaw group were compared with the pharyngeal airway dimensional measurements of the control (PNS-R1: $p<0.05$; SPSS: $p<0.05$; MPS, IPS, and EPS: $p<0.001$). Statistically significant difference was observed in the AREA 3 value from the pharyngeal airway areal parameters (AREA 3: $p<0.05$). A study examining the posterior airway of the non-surgery group (Class I and Class II) and Class III patients stated that nasopharyngeal dimensional measurements of Class III patients were less and the difference was statistically significant at the $p<0.05$ level. In the same study, when the dimensional measurements of the hypopharynx were examined, it was found that this length was greater in the Class III patient group and was statistically significant at the $p<0.001$ level. Researchers stated that the anterior positioning of the mandible in Class III patients caused this difference (24). In our study, the results are similar to this study when evaluated in terms of dimensional measurements.

In most studies evaluating the posterior airway, the post-treatment measurements of Class III patients who underwent orthognathic surgery and those of the control group individuals with Class I malocclusion were not compared (25). Kitahara *et al*. (25) evaluated 46 female Japanese

patients with skeletal Class III malocclusion and control group patients with Class I malocclusion who had undergone different orthognathic surgical procedures.

When the post-treatment mandibular dental values of the double jaw group are compared to the mandibular dental values of the control group with skeletal Class I malocclusion in the L1i-Ver parameter—which gives information in the sagittal direction—and in the IMPA angle—which indicates the position of the lower incisor relative to the mandibular plane—there were statistically significant differences, respectively (L1i-Ver: $p<0.001$, IMPA: $p<0.001$). The L1i-Ver and IMPA values were lower in the double jaw surgery group than in the control group after treatment. If we support the findings of our study with the literature; Troy *et al*. evaluated two groups of patients with skeletal Class III malocclusion treated as orthognathic surgery and orthodontic camouflage, and stated that the mandibular incisors were retroclined after treatment in the orthognathic surgery group (26). Similar to our study, An et al. evaluated long-term patients with skeletal Class III malocclusion, whose treatment was carried out as orthognathic surgery (27).

The PNS-R1 value, one of the dimensional measurements of the nasopharynx, was higher in the double jaw group at the end of the treatment when compared to the control group. Likewise, when the AREA 1 parameter, which expresses the nasopharyngeal area, was evaluated, it was larger than the control group at the end of the treatment. Chen et al.(17), Marşan et al.(8), and Cakarne et al. (12) with the effect of maxillary advancement/impaction operation, an increase in nasopharyngeal dimensional and spatial measurements was a finding that we expected after surgery. Contrary to our study, Kitahara et al. (25) reported that posterior airway dimensional measurements were similar in their study comparing Class III patients who had undergone orthognathic surgery and Class I patients.

There are many studies in the literature evaluating patient satisfaction after surgery (28-30). The most frequently used questionnaires in these studies; Orthognathic Quality of Life Questionnaire (OQLQ), Rosenberg Self-esteem Scale, Oral Health Impact Profile-14 (OHIP-14), Short Form-36 (SF-36). When these questionnaires are examined, it is seen that the questionnaires mostly evaluate aesthetic awareness, social awareness, functional recovery and postoperative complications. There are no questions that evaluate respiratory problems in detail. Considering these shortcomings while creating our questionnaire, we included questions questioning possible respiratory problems. While the score given by the patients to the 9th question after surgery was the highest, the score they gave to the 5th question was the lowest. Considering these results, we can say that there is no noticeable change in respiration after the surgery compared to the preoperative period. At the same time, we observe that the highest post-operative satisfaction is the aesthetic change of the teeth. Similar to our study, in a study in which hard and soft tissue changes and postoperative patient satisfaction were evaluated in patients with skeletal Class III malocclusion who had undergone double jaw surgery, a high satisfaction score was observed in patients in the double jaw group in the question questioning respiratory problems (28). Kiyak *et al*. (30) and Asada *et al.(29)* interpreted the high satisfaction scores of even patients with multiple problems as the main determinant of post-operative satisfaction, whether or not there were aesthetic improvements. They reported that if the patient perceives aesthetic developments as high, independent of any functional problem, their satisfaction is also high.

Conclusion

It was observed that the majority of the patients were satisfied with their quality of life after orthognathic surgery and the aesthetic, functional and psychological results of the surgery.

Türkçe özet: *Sınıf III İskelet Anomalisi Olan Hastalarda Ortognatik Cerrahi Sonrası Faringeal Havayolu Değişiklikleri ile Hasta Memnuniyetinin Değerlendirilmesi. Amaç: Çalışmamızın amacı, çift çene cerrahisi ile tedavi edilen Sınıf III maloklüzyonlu hastaların cerrahi sonrası faringeal hava yolundaki değişikliklerini belirlemek, sert doku ve yumuşak doku parametrelerini ve hyoid kemik ve dil pozisyonlarını belirlemek, çift çene grubundaki hastaların tedavi öncesi ve tedavi sonrası ölçümlerini kontrol grubu hastalarının ölçümleriyle karşılaştırmak ve ameliyat sonrası hasta memnuniyetindeki değişiklikleri değerlendirmektir. Gereç ve Yöntem: Çalışmaya çift çene cerrahisi geçirmiş 32 Sınıf III yetişkin hasta ve yirmi beş Sınıf I hasta dahil edildi. Tedavi öncesi (T1) ve tedavi sonrası (T2) sefalometrik kayıtlar alındı. Bulgular: Çift çene ortognatik cerrahi sonrası tüm faringeal hava yolu lineer ve alan parametrelerinde istatistiksel olarak anlamlı değişiklikler izlendi ($p<0,001$). Ameliyat sonrası dil ve hyoid kemiğinde belirgin superior ve posterior yönde yer değiştirme görüldü. Çift çene cerrahisi grubu ve kontrol grubunun tedavi sonrası analizi, çift çene cerrahisi grubundaki hastalarda mandibular dental parametreleri ve faringeal hava yolu ölçümlerinde istatistiksel olarak anlamlı farklılıklar ile karşılaştırıldı. Sonuç: Hasta memnuniyet anketinde tespit edilen daralmalara rağmen yüksek memnuniyet skorları gözlendi ve hastalarda solunum sıkıntısı yaşanmadığı görüldü. Anahtar Kelimeler: Ortognatik Cerrahi, Sınıf III Maloklüzyon, Faringeal Havayolu, Hasta Memnuniyeti, Sefalometri.*

Ethics Committee Approval: The study protocol has been approved by the Karadeniz Technical University Institutional Review Board for Scientific Research Ethics Committee (2020/330).

Informed Consent: Participants provided informed constent.

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Author contributions: NK participated in designing the study. SK, NK participated in generating the data for the study. SK, NK participated in gathering the data for the study. SK, NK participated in the analysis of the data. SK, NK wrote the majority of the original draft of the paper. SK, NK, SK participated in writing the paper. SK, NK have had access to all of the raw data of the study. SK, NK have reviewed the pertinent raw data on which the results and conclusions of this study are based. SK, NK, MBO, YTK, SK have approved the final version of this paper. NK guarantees that all individuals who meet the Journal's authorship criteria are included as authors of this paper.

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