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Evaluation of the effect of orthognathic surgery on alveolar bone level: a cone-beam computed tomography study

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ABSTRACT

Aims: Three-dimensional examination of preoperative and postoperative changes in alveolar bone levels with cone-beam computed tomography (CBCT) in cases with skeletal class II and III anomalies treated with different surgical methods, supported by cephalometric images.

Methods: A total of 32 patients, 18 girls and 14 boys, who applied to Dicle University Faculty of Dentistry Department of Orthodontics for orthognathic surgery-supported orthodontic treatment and were treated with orthognathic surgery after initial orthodontic treatment was started, preoperatively in Dicle University Oral Diagnosis and Radiology Department. It was created by retrospectively examining CBCT images taken before and after. To examine changes in alveolar bone level, 28 measurements were made using alveolar bone levels and reference points determined on teeth.

Results: When the preoperative and postoperative groups were compared, a significant difference was found in the upper anterior bone level, upper palatinal bone thickness, lower anterior bone level, upper trifurcation buccal, upper distobuccal root middle buccal, lower bifurcation buccal, lower distal root middle buccal values at the $p<0.05$ level. A statistically significant difference was observed in the enamel cement joint width value in the comparison between the sexes. When the correlation between class II and class III anomalies was examined, it was observed that lower anterior bone thickness, lower anterior bone level/root and lower lingual bone level/root values were statistically associated with more alveolar bone loss in class III patients.

Conclusion: Orthognathic surgery causes alveolar bone loss in the patient. In order to minimize the side effects of the operation on the patient's periodontal tissues, oral hygiene, applied forces, fixation between the jaws and methods should be carefully evaluated.

Keywords: Alveolar bone loss, cephalometry, orthognathic surgery, cone-beam computed tomography

INTRODUCTON

During the birth, growth and development of a person, the facial structures formed anatomically depend primarily on genetics; secondarily, it depends on environmental factors. Dentofacial deformities occur as a result of abnormal or disproportionate growth of facial structures. This situation may occur prenatally or developmentally; it may also occur as a result of postnatal factors such as trauma, infection and other external factors.[1]

Depending on these factors; in order to correct the musculoskeletal system, dento-osseous and soft tissue deformities of the jaws and related facial structures, diagnosis, treatment planning and application should be carried out in a coordinated manner by combining orthodontics and maxillofacial surgery.[2]

Studies have found that approximately 20% of the world's population has some type of facial deformity.[3] This situation directly affects individuals' quality of life and social satisfaction.[4,5]

The aims of orthognathic surgery treatment are multifaceted. When planning treatment, improving facial aesthetics, providing a functional occlusion, protecting and widening the airway if possible, ensuring or maintaining periodontal health, healthy temporomandibular joint, and most importantly, eliminating the patient's main complaints with the least complications should be taken into consideration.[6]

Complications that mostly occur during routine orthodontic treatment; periodontal problems, alveolar bone loss and root resorption. Studies have mostly focused on periodontal tissues and osseous bone losses due to orthodontic treatment. However, studies on bone loss after orthognathic surgery, which is performed more frequently today, have been observed very rarely.

It should not be forgotten that good oral hygiene and periodontal condition before surgery are important factors affecting the success of surgery and the risk of complications.

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Various complications related to orthognathic surgery that occur after treatment and the changes that may occur in the alveolar bone have become a matter of concern. Since orthognathic surgery procedures depend on many different factors in different ways, different procedures and periods, the complications that may arise and the responses of the tissues need to be carefully evaluated in a broad context. When the literature was reviewed, no study was found in which the alveolar bone level of both anterior and posterior teeth was evaluated together with the changes in the anterior incisor tooth angles in class II and class III cases after orthognathic surgery.

Therefore, the aim of our study is to plan and start treatments at Dicle University Faculty of Dentistry, Department of Orthodontics; To examine pre-and postoperative alveolar bone levels, both anteriorly and posteriorly, in class II and class III cases that underwent orthognathic surgery at Dicle University Faculty of Medicine, Department of Plastic, Reconstructive and Aesthetic Surgery.

METHODS

Purpose and Type of Research

The material of this study was collected from a total of 32 patients, 18 girls and 14 boys, who applied to Dicle University Faculty of Dentistry Department of Orthodontics for orthodontic treatment supported by orthognathic surgery and were treated with orthognathic surgery by the same surgeon using the same operation method after the initial orthodontic treatment was started. It was created by retrospectively examining cone beam computed tomography (CBCT) images taken before and after the operation in the department of radiology.

Ethical Aspect of Research

The ethics committee report with protocol number 2021-06 was received from the Local Ethics Committee of Dicle University Faculty of Dentistry Deanery (Date: 27.01.2021, Decision No: 2021-06). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

In our study, the entire patient database was evaluated and an attempt was made to evaluate as many patients as possible who met the conditions.

Population and Sample of the Research

In our study, 32 patients between the ages of 18-46 applied to Dicle University Faculty of Dentistry Orthodontics Department for orthognathic surgery-supported orthodontic treatment; While only 5 of them have class II malocclusion, the remaining 27, the majority, have class III malocclusion. In addition, maxillary advancement-mandibular setback was applied to 21 class III patients, mandibular setback was applied to 3 class III patients, maxillary advancement was applied to 3 patients, and mandibular advancement was applied to 5 class II patients.

Data Collection and Analysis

CBCT images taken before and after surgery, with a minimum period of 6 months, a maximum of 21 months, and an average of 9.9 months, were used. Preoperative CBCTs were taken to be used for anatomical dental and osseous examination and orthognathic surgery planning.

A total of 56 measurements were made for each patient, both upper and lower and before and after surgery, from the alveolar sections around the incisors and molars using CBCT images. NemoStudio 2019 (NemoStudio, Software Nemotec, SL, Spain) software was used to examine the CBCT images and make measurements on the relevant sections.

Linear Measurements

Upper anterior bone level (UABL): Distance between the buccal enamel cementum border and the buccal alveolus crest, parallel to the upper incisor axis.

Upper palatal bone level (UPBL): Distance between the palatal enamel cementum border and the palatal alveolus crest, parallel to the upper incisor axis.

Upper anterior bone thickness (UABT): Distance between the root tip and the intersection of the buccal maxillary curvature perpendicular to the upper incisor axis.

Upper palatal bone thickness (UPBT): The distance between the root tip and the intersection of the palatal maxillary curvature, perpendicular to the upper incisor axis.

Upper root length: The distance between the intersection point between the upper incisor-enamel-cement junction width and the tooth axis and the root tip.

Upper enamel cementum junction width: Distance between the upper incisor buccal and palatal cementum enamel junctions.

Lower anterior bone level (LABL): Distance between the buccal enamel cementum border and the buccal alveolus crest, parallel to the lower incisor axis.

Lower lingual bone level (LLBL): The distance between the lingual enamel cementum border and the lingual alveolar crest parallel to the lower incisor axis.

Lower anterior bone thickness (LABT): The distance between the root tip and the intersection of the buccal mandibular symphysis, perpendicular to the lower incisor axis.

Lower lingual bone thickness (LLBT): The distance between the root tip and the intersection of the lingual mandibular symphysis, perpendicular to the lower incisor axis.

Lower root length: The distance between the intersection point between the lower incisor-enamel-cement junction width and the lower incisor axis and the root tip.

Upper trifurcation buccal: The shortest distance between the buccal alveolar border and the tooth in the horizontal section of the upper first molar at the trifurcation level.

Upper trifurcation palatal: The shortest distance between the palatal alveolar border and the tooth in the horizontal section of the upper first molar at the trifurcation level.

Upper distobuccal root middle buccal: The shortest distance between the buccal alveolar border and the tooth in the horizontal section of the upper first molar tooth at the level of the middle of the distobuccal root.

Upper distobuccal root mid-palatal: The shortest distance between the buccal alveolar border and the tooth in the horizontal section of the upper first molar at the level of the middle of the distobuccal root.

Upper mesiobuccal alveolar height: The distance between the crest of the alveolar crest and the crest of the mesial tubercle in the frontal section of the upper first molar at the level of the mesial tubercle.

Upper middle alveolar height: The distance between the alveolar crest and the buccal ridge crest in the frontal section of the upper first molar at the buccal ridge level.

Upper distobuccal alveolar height: The distance between the top of the alveolar crest and the top of the distobuccal tubercle in the frontal section of the upper first molar at the level of the distobuccal tubercle.

Lower bifurcation buccal: The shortest distance between the buccal alveolar border and the tooth in the horizontal section of the lower first molar at the bifurcation level.

Lower bifurcation lingual: The shortest distance between the lingual alveolar border and the tooth in the horizontal section of the lower first molar at the bifurcation level.

Lower distal root middle buccal: The shortest distance between the buccal alveolar border and the tooth in the horizontal section of the lower first molar at the level of the middle of the distal root.

Lower distal root mid-lingual: The shortest distance between the buccal alveolar border and the tooth in the horizontal section of the lower first molar at the level of the middle of the distal root.

Lower mesiobuccal alveolar height: The distance between the alveolar crest and the mesiobuccal tubercle in the frontal section of the lower first molar at the level of the mesiobuccal tubercle.

Lower middle alveolar height: The distance between the alveolar crest and the buccal middle tubercle in the frontal section of the lower first molar at the level of the buccal middle tubercle.

Lower distobuccal alveolar height: The distance between the top of the alveolar crest and the top of the distobuccal tubercle in the frontal section of the lower first molar at the level of the distobuccal tubercle (Figure 1-4).

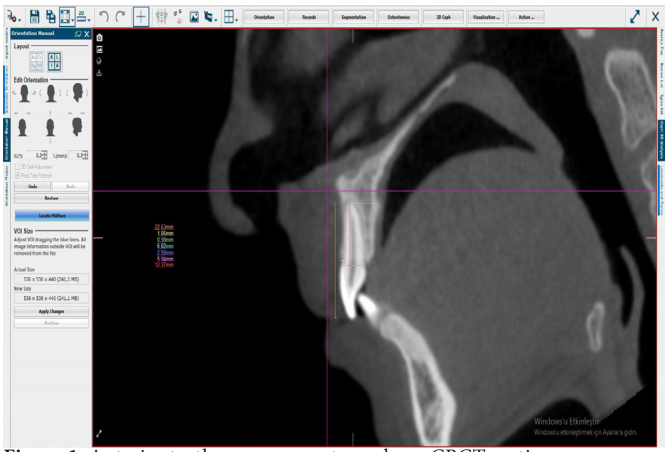

Figure 1. Anterior teeth measurements made on CBCT section

Figure 2. Posterior teeth measurements made on horizontal CBCT section

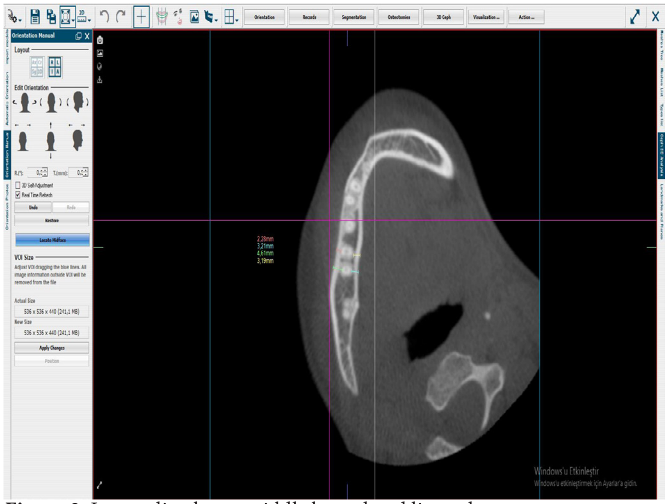

Figure 3. Lower distal root middle buccal and lingual measurements

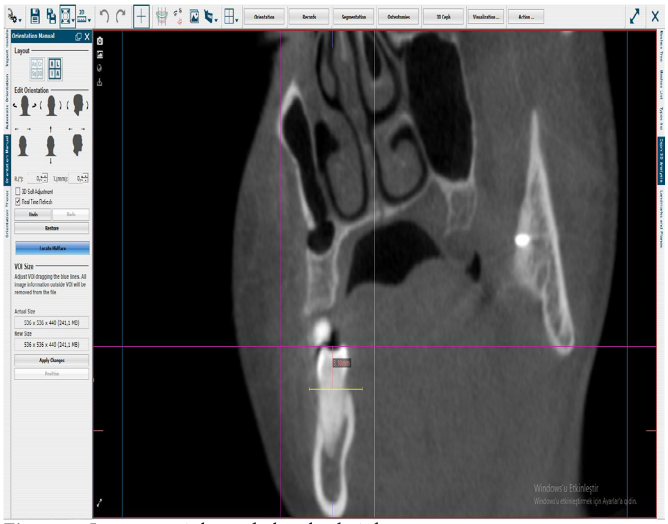

Figure 4. Lower mesiobuccal alveolar height

Statistical Analysis

Normal distribution of the data was tested with the Shapiro-Wilk test. Mann-Whitney u test was used to compare non-normally distributed measurements in 2 groups, and Kruskal-Wallis and Dunn multiple comparison tests were used to compare more than 2 groups. Wilcoxon signed rank test was used to evaluate the changes in measurements before and after surgery.

Relationships between numerical variables were evaluated with the Spearman correlation coefficient. Analyzes were made using the SPSS for Windows 24 program. A p-value of less than 0.05 was considered statistically significant.

RESULTS

For sample size estimation, we used the upper anterior bone level data from Kim et al.[16] according to the power analysis performed using G*Power Software version 3.1.9.2 (Universität Düsseldorf, Germany), it was determined that the alpha error probability was 0.05 and the sample size should consist of 15 patients for 80% power.

When the gender distribution of the patients is examined, it is seen that 56.3% are female and 43.8% are male. When the class distribution is examined, it is seen that 84.42% are class III and 15.6% are class II. When the group distribution of the patients is examined, it is seen that 65.6% are patients who have undergone double jaw surgery, 25% have only mandible surgery, and 9.4% have only maxilla surgery (Table 1).

There is a statistically significant difference between preoperative and postoperative measurements of upper anterior bone level, upper palatal bone thickness, upper root length, UABL/root UPBL/root, (UABT+UPBT)/CEJW, lower anterior bone level, lower root length LABL/root, LLBL/root, (LABT+LLBT)/CEJW, upper trifurcation buccal, upper DBR middle buccal, lower bifurcation buccal, lower DBR middle buccal, L1-mandibular plane values (p<0.05).

It is seen that the postoperative measurements of the upper anterior bone level, UABL/root, UPBL/root, lower anterior bone level, LABL/root, LLBL/root, (LABT+LLBT)/CEJW values are higher than the preoperative measurements.

Postoperative measurements of preoperative measurements of upper palatal bone thickness, upper root length, (UABT+UPBT)/JECW, lower root length, upper trifurcation buccal, upper DBR middle buccal, lower bifurcation buccal, lower dr middle buccal, L1-mandibular plane values appears to be higher.

L1-mandibular plane, (UABT+UPBT)/CEJW, lower anterior bone thickness, (LABT+LLBT)/CEJW values were statistically

Table 1. Comparison of pre-and post-operative measurements in millimeters p<0.05

	Pre-operative	Post-operative		
Variables	**Mean±SD**	**Mean±SD**	**Average difference [95% CI]**	**p**
UABL	2.3±1.01	2.75±1.23	-0.45 [-0.73--0.16]	0.004*
UPBL	3.05±2.1	3.41±2.02	-0.35 [-0.72-0.01]	0.052
UABT	3.46±1.35	3.48±1.24	0.02 [-0.45-0.49]	0.674
UPBT	5.18±2.4	4.32±1.83	-0.86 [-1.39--0.33]	0.004*
Upper root length	12.19±1.51	11.7±1.64	-0.49 [-0.74--0.23]	0.001*
UABL/root	0.19±0.09	0.24±0.11	0.05 [0.02-0.07]	0.001*
UPBL/root	0.26±0.2	0.31±0.22	-0.05 [-0.09--0.01]	0.004*
(UABT+UPBT)/SEJW	1.33±0.29	1.21±0.3	-0.12 [-0.17--0.06]	0.001*
LABL	5.41±2.43	6.86±2.47	-1.45 [-2.02--0.87]	0.001*
LLBL	7.58±3.73	8.27±3.2	-0.69 [-1.35--0.03]	0.070
LABT	4.61±1.96	4.29±1.83	-0.32 [-0.8-0.16]	0.065
LLBT	1.97±1.4	1.74±1.29	-0.24 [-0.5-0.03]	0.090
Lower root length	11.75±1.25	11.39±1.29	-0.36 [-0.63--0.09]	0.005*
LABL/root	0.47±0.23	0.61±0.23	0.14 [0.09-0.19]	0.001*
LLBL/root	0.65±0.31	0.73±0.27	0.08 [0.02-0.14]	0.002*
(LABT+LLBT)/CEJW	1.2±0.41	1.21±0.77	0.01 [-0.23-0.26]	0.003*
Upper trifurcation buccal	0.7±0.8	0.43±0.61	-0.27 [-0.47--0.07]	0.010*
Upper trifurcation palatinal	0.52±0.74	0.43±0.62	-0.09 [-0.28-0.1]	0.420
Upper DBR middle buccal	0.36±0.61	0.06±0.24	-0.31 [-0.48--0.14]	0.003*
Upper DBR middle palatinal	0.9±1.13	0.87±0.92	-0.03 [-0.29-0.24]	0.936
Upper mesiobuccal alveolar height	7.97±0.95	8.33±0.95	-0.36 [-0.78-0.06]	0.080
Upper middle alveolar height	8.42±1.3	8.76±1.15	-0.33 [-0.78-0.11]	0.150
Upper distobuccal alveolar height	8±1.05	8.1±1.08	-0.1 [-0.52-0.33]	0.531
Lower bifurcation buccal	0.39±0.57	0.13±0.36	-0.25 [-0.44--0.06]	0.016*
Lower bifurcation lingual	0.9±0.91	0.92±1.07	0.03 [-0.18-0.23]	0.871
Lower DR middle buccal	0.6±0.91	0.31±0.81	-0.29 [-0.56--0.02]	0.043*
Lower DR middle lingual	2.26±1.15	2.27±1.3	0.01 [-0.26-0.28]	0.964
Lower mesiobuccal alveolar height	8.21±1.4	8.33±1.18	-0.12 [-0.49-0.26]	0.504
Lower middle alveolar height	8.13±1.1	8.58±1.37	-0.45 [-0.85--0.04]	0.054
Lower distobuccal alveolar height	7.11±0.91	7.4±1.45	-0.3 [-0.7-0.11]	0.511
U1-palatal plane	111.38˚±10.13	113.41˚±8.44	2.03˚ [-0.55-4.61]	0.058
L1-mandibular plane	85.99˚±8.41	83.67˚±6.87	-2.32˚ [-4.21--0.42]	0.024*

SD: Standart deviation, UABL: Upper anterior bone level, UPBL: Upper palatinal bone level, UABT: Upper anterior bone thickness, UPBT: Upper palatinal bone thickness, LABL: Lower anterior bone level, LLBL: Lower lingual bone level, CEJW: Cement enamel junction width, LABT: Lower anterior bone thickness, LLBT: Lower lingual bone thickness significant. (UABT+UPBT)/CEJW value decreased more in women than in men.

When examined between class II and class III groups, the changes in lower anterior bone thickness, lower root length, LABL/root, LABL/root values are statistically significant.

Lower anterior bone thickness decreased more in class III patients than in class II patients. Lower root length decreased more in class II patients than in class III patients. Changes in LABL/root and LLBL/root values changed more in class II patients than in class III patients (Table 2, 3).

When patients who had only lower and only upper jaw surgery were compared, the change in lower anterior bone level changed more in patients who had only lower jaw surgery than in patients who had only upper jaw surgery. Lower anterior bone thickness measurement changed more in patients who had double jaw surgery than in patients who had single mandible surgery. Lower distal root mid-lingual measurement changed more in patients who underwent double jaw surgery than in patients who underwent single upper jaw surgery.

DISCUSSION

Today, the Le Fort I osteotomy procedure for the correction of severe dentofacial deformities has been modified and improved in recent years and has become one of the standard operations performed in oral and maxillofacial surgery.[7]

The surgery, that is, Le Fort 1, which is usually performed together with bilateral sagittal split ramus osteotomy (BSSRO), allows changes in all three directions of space, is frequently preferred to correct functional and cosmetic irregularities, and is used in the treatment of a wide variety of malocclusions.[8]

Oral rehabilitation combined with orthognathic surgery is a long and challenging process that relies on the cooperation of the patient throughout the treatment to achieve the goals of functional improvement, prevention and correction of deformities, and improvement of quality of life.[9]

No matter how accurate the diagnosis, how comprehensive the approach, and how meticulous the surgical technique, complications will occur in a small percentage of patients after orthognathic surgery. This situation is an expected possibility.

Table 2. Comparison of differences in millimeters according to the operated jaw p<0.05

	Mand (n=8)	Mand+Max (n=21)	Max (n=3)	
Variables	Mean±SD	Mean±SD	Mean±SD	p
UABL	-0.31±0.59	-0.53±0.89	-0.22±0.6	0.853
UPBL	-0.07±0.65	-0.41±1.17	-0.75±0.59	0.316
UABT	-0.04±2.08	0.12±0.97	-0.52±1.16	0.392
UPBT	-0.68±2.26	-0.91±1.15	-0.98±1.5	0.592
Upper root length	-0.43±0.53	-0.5±0.8	-0.59±0.5	0.776
UABL/root	0.03±0.04	0.05±0.08	0.03±0.07	0.887
UPBL/root	-0.03±0.04	-0.05±0.13	-0.09±0.07	0.517
(UABT+UPBT)/SEJW	-0.11±0.06	-0.12±0.16	-0.11±0.31	0.807
LABL	-2.49±1.62	-1.23±1.49	-0.18±0.3	0.041*
LLBL	-2.22±2.74	-0.18±1.11	-0.17±0.92	0.203
LABT	0.43±1.85	-0.62±1.09	-0.25±0.42	0.037*
LLBT	-0.76±0.71	-0.09±0.7	0.12±0.63	0.077
Lower root length	-0.9±1.18	-0.17±0.47	-0.22±0.24	0.091
LABL/root	0.24±0.15	0.11±0.13	0.04±0.05	0.061
LLBL/root	0.23±0.24	0.03±0.09	0.04±0.08	0.055
(LABT+LLBT)/CEJW	-0.06±0.34	-0.13±0.12	1.19±2.08	0.113
Upper trifurcation buccal	-0.51±0.62	-0.24±0.5	0.16±0.61	0.442
Upper trifurcation palatinal	-0.18±0.51	-0.02±0.48	-0.37±1.01	0.893
Upper DBR middle buccal	-0.3±0.43	-0.23±0.47	-0.84±0.24	0.057
Upper DBR middle palatinal	0.24±1.04	-0.1±0.58	-0.2±1.06	0.256
Upper mesiobuccal alveolar height	-0.2±0.91	-0.4±1.33	-0.6±0.37	0.766
Upper middle alveolar height	-0.37±1.15	-0.39±1.28	0.19±1.44	0.640
Upper distobuccal alveolar height	-0.02±1.55	-0.1±0.94	-0.28±2.14	0.947
Lower bifurcation buccal	-0.14±0.82	-0.29±0.41	-0.28±0.48	0.595
lower bifurcation lingual	-0.08±0.45	0.07±0.66	-0.03±0.06	0.583
Lower DR middle buccal	-0.13±1.24	-0.35±0.52	-0.34±0.59	0.117
Lower DR middle lingual	0.39±0.66	-0.01±0.74	-0.86±0.23	0.024*
Lower mesiobuccal alveolar height	0.15±0.87	0.01±0.79	-1.69±1.91	0.086
Lower middle alveolar height	-0.46±1.27	-0.47±1.01	-0.24±1.94	0.899
Lower distobuccal alveolar height	-0.21±0.93	-0.28±1.14	-0.63±1.78	0.847
U1-palatal plane	4.5˚±8.6	2.19˚±4.91	-5.67˚±13.5	0.565
L1-mandibular plane	-2˚±6.68	-1.72˚±4.67	-7.33˚±3.51	0.202

UABL: Upper anterior bone level, UPBL: Upper palatinal bone level, UABT: Upper anterior bone thickness, UPBT: Upper palatinal bone thickness, LABL: Lower anterior bone level, LLBL: Lower lingual bone level, LABT: Lower anterior bone thickness, LLBT: Lower lingual bone thickness, CEJW: Cement enamel junction width

Table 3. Correlations between differences with anomaly p<0.05

	Class II (n=5)	Class II (n=27)	
Variables	Mean±SD	Mean±SD	p
UABL	-0.15±0.52	-0.5±0.83	0.604
UPBL	-0.15±0.82	-0.39±1.06	0.500
UABT	0.44±2.46	-0.06±1.04	0.775
UPBT	-1.19±2.5	-0.8±1.27	0.836
Upper root length	-0.54±0.56	-0.48±0.74	0.697
UABL/root	0.02±0.04	0.05±0.08	0.696
UPBL/root	-0.05±0.05	-0.05±0.12	0.550
(UABT+UPBT)/SEJW	-0.12±0.04	-0.12±0.17	1.000
LABL	-2.55±1.94	-1.24±1.46	0.154
LLBL	-2.07±2.56	-0.44±1.59	0.169
LABT	1.08±1.51	-0.58±1.14	0.010*
LLBT	-0.82±0.68	-0.13±0.72	0.058
Lower root length	-1.43±0.9	-0.16±0.53	0.009*
LABL/root	0.26±0.14	0.11±0.13	0.045*
LLBL/root	0.22±0.19	0.05±0.14	0.022*
(LABT+LLBT)/CEJW	0.06±0.33	0±0.73	0.287
Upper trifurcation buccal	-0.51±0.74	-0.23±0.52	0.772
Upper trifurcation palatinal	-0.36±0.57	-0.04±0.53	0.255
Upper DBR middle buccal	-0.48±0.46	-0.27±0.47	0.257
Upper DBR middle palatinal	0.08±1.22	-0.04±0.66	0.309
Upper mesiobuccal alveolar height	-0.27±0.97	-0.38±1.21	0.897
Upper middle alveolar height	-0.11±1.36	-0.37±1.23	0.897
Upper distobuccal alveolar height	-0.04±0.48	-0.1±1.28	0.716
Lower bifurcation buccal	-0.02±0.97	-0.3±0.42	0.161
Lower bifurcation lingual	-0.07±0.6	0.04±0.59	0.317
Lower DR middle buccal	-0.32±1.6	-0.29±0.52	0.343
Lower DR middle lingual	0.38±0.63	-0.06±0.76	0.194
Lower mesiobuccal alveolar height	-0.24±0.8	-0.09±1.09	0.795
Lower middle alveolar height	0.18±1.05	-0.56±1.12	0.169
Lower distobuccal alveolar height	0.34±0.25	-0.41±1.18	0.065
U1-palatal plane	6±10.84	1.3±6.29	0.604
L1-mandibular plane	-3.2±7.6	-2.15±4.89	0.716

*Significant at 0.05 level, Mann Whitney u test, p: Statistical significance value, UABL: Upper anterior bone level, UPBL: Upper palatinal bone level, UABT: Upper anterior bone thickness, UPBT: Upper palatinal bone thickness, LABL: Lower anterior bone level, LLBL: Lower lingual bone level, LABT: Lower anterior bone thickness, LLBT: Lower lingual bone thickness

The aim should be to minimize these complications, increase patient comfort and have less traumatic experiences.

Many studies on the incidence and types of complications have been reported in the literature. In their study, Sousa and Turrini[10] confirmed the low prevalence of postoperative complications with a literature review and showed that the data during osteotomy were approximately 12% sensory change, 3.4% infection, 2.5% fixation problems, and 1.8% unintended fracture rates.

It should not be forgotten that good oral hygiene and periodontal condition before surgery are important factors affecting the success of surgery and the risk of complications. Lupi et al.[11] they also stated in their study that the degree of bone loss during adult orthodontic treatment may be higher than that observed in adolescents, especially if poor periodontal condition is not treated before orthodontic treatment begins. This situation paves the way for periodontal and osseous defects in the adult patient profile where orthognathic surgery is especially applied.

Nelson et al.[12] showed in their study that orthodontic variables such as the type of tooth movement (especially intrusion, lingual tipping) and treatment duration are more important factors for attachment loss resulting from the use of appliances during orthodontic treatment.

Steiner et al.[13] in their study on monkeys, it was shown that orthodontic movement in the labial direction caused loss of marginal bone and connective tissue attachment and gingival recession.

Yoonji et al.[14] in their study, they emphasized the need to reconsider excessive orthodontic movement, especially in skeletal class III adult patients, according to the patient's anatomical boundaries and periodontal health.

As a result of the studies carried out by all these researchers, different complications related to orthognathic surgery and the changes that may occur in the alveolar bone have become a matter of concern. Since orthognathic surgery procedures are different and depend on many different factors, the complications that may arise need to be carefully evaluated in a broad context. Although we want to examine the isolated relationship of orthognathic surgery with alveolar bone loss, we must state that we cannot completely isolate the effects of orthodontic treatment and orthognathic surgery on bone from each other.

Considering this information, our study aimed to evaluate pre-and post-operative alveolar bone levels in patients who underwent orthognathic surgery following orthodontic treatment.

Many studies have been conducted in the literature involving different numbers of patients. For example, Nicodemo et al.[15] in their study based on 29 patients aged between 17 and 46, with angle class III malocclusion and indication for surgical intervention; The patients received orthodontic preparation between 1 year and 1 year and 6 months, and then underwent orthognathic surgery.

Kim and Kook[16] conducted a study on tomography images taken at least 1 month before the surgery in 20 patients with class III crossbite and open bite who were indicated for orthognathic surgery, and found that alveolar bone level losses in the mandibular incisors were greater, especially in the lingual area, compared to the maxilla, and that the maxillary incisors were affected in the palatal area. They stated that the bone thickness on their faces was significantly greater than the lingual of the mandibular incisors and emphasized that special attention should be paid to bone loss in the lower incisor region during orthodontic treatment, especially in class III orthognathic surgery patients.

Radiographs and advanced imaging techniques are of great importance in evaluating alveolar bone changes. Bholsith et al.[18] stated that cephalometric analysis is one of the basic tools of craniomaxillofacial surgery as well as orthodontic diagnosis, and they also defined cephalometry as a two-dimensional reflection of three-dimensional structures.

Cephalometric films may have disadvantages such as non-homogeneous growth and distortions of lateral structures and incorrect landmark positions due to overlapping structures. Incorrect head position may cause incorrect diagnosis.

Choi et al.[15] reported in their study that diagnoses regarding bone structure can be made with excellent accuracy by cone beam computed tomography (CBCT). In addition, they stated that CBCT overcomes the limitations of traditional two-dimensional radiographs and provides three-dimensional images that facilitate measurements from buccal and lingual bone plates and reflect much more reality.[18] Considering this information, CBCT was preferred in our study in order to minimize distortion and to avoid errors caused by incorrect head position during the measurement of all anatomical points used in our parameters.

Lee et al.,[19] in their study on 25 class III orthognathic surgery patients, stated that the IMPA (L1-Mandibular Plane) angle, which was 92.17 degrees before surgery, decreased to 87.42 degrees after the operation. In our study, the L1-Mandibular plane angle decreased from 85.99 to 83.67 degrees. The researcher stated that excessive buccal incisor movement in orthodontic treatment before surgery causes alveolar bone resorption, and their findings are also compatible with our study.

Kim and Park[20] looked at UABL (upper anterior bone level), UPBL (upper palatinal bone level), UABT (upper anterior bone thickness), UPBT (upper palatal bone thickness), LABL (lower anterior bone level), LLBL (lower lingual bone level), LABT (lower anterior bone thickness), LLBT (lower lingual bone thickness) values in their study and found that the alveolar bone thickness in the upper jaw was thicker than in the lower jaw symphysis, but inversely with the thickness, bone losses were greater in the lower jaw symphysis region than in the maxilla anterior. In our study, alveolar bone losses are concentrated in the mandible, and mandibular anterior losses and mandibular lingual losses are greater than maxillary losses.

Many researchers have suggested that excessive labial or lingual movement of maxillary and mandibular incisors should be avoided to prevent irreversible bone loss that leaves the tooth with less bone support.[21,22] In our study, alveolar resorption occurred not only in the anterior region but also in the molar region with tooth movement directed towards the cortical bone, with the values of upper trifurcation buccal, upper disto buccal root middle buccal, lower bifurcation buccal and lower distal root middle buccal.

It is recommended that the use of elastics used after orthognathic surgery should not exceed physiological limits in terms of force and duration, and that the treatment time and amount of surgical movement should be kept as minimal as possible and the treatment should be completed with minimum tension after the operation.[23]

Current studies have shown that anterior tooth inclination causes losses such as fenestration and dehiscence, as well as local alveolar bone loss, if long-term and severe force is applied, especially in the mandible anterior.[24]

Steiner et al.[13] in their study, they found that orthodontic movement in the labial direction caused loss of marginal bone and connective tissue attachment. In our study, as seen from the decrease in UABL (upper anterior bone level), LABL (lower anterior bone level) values and changes in incisor angles, it is thought that tooth movement in the direction of the cortical bone causes alveolar bone resorption and decrease in bone thickness.

Yoonji et al.[14] in their study, they emphasized the need to reconsider excessive orthodontic movement, especially in skeletal class III adult patients, according to the patient's anatomical boundaries and periodontal health. As seen in our study, lower anterior bone thickness decreased more in class III patients than in class II patients. Our findings are consistent with Yoonji et al.[16] it is similar to their study.

Wehrbein et al.[25] they suggested that significant sagittal incisor movement and rotation are critical risk factors for progressive lingual and labial bone loss in patients with class III anomalies with narrow symphysis and increased vertical direction growth. The study supports our study by finding that lower anterior bone thickness decreased more in class III patients than in class II patients.

Jäger et al.[26] showed in their study that a change in tooth position changes the thickness of the labial and lingual cortical plates at the level of the root apex. As a result of our measurements, a decrease in root length was detected in maxillary teeth. It was observed that the upper incisor buccal and palatal bone levels were more resorbed than the root. The ratio of upper buccal and palatal bone thickness to cementum-enamel junction has decreased. These data support the postoperative changes in terms of UPKK (upper palatal bone thickness), (UABT+UPBT) CEJW (upper anterior bone thickness+upper palatal bone thickness/cement enamel junction width) values. In our study, it was observed that bone loss occurred in the upper incisor buccal region, and bone thickness decreased in the upper incisor palatal region.

Sun et al.[27] in their study, it was reported that the labial inclination of the mandibular incisors showed a positive correlation with the labial and total alveolar bone thickness and a negative correlation with the lingual alveolar bone height. The finding of a moderate positive correlation between lower mesiobuccal alveolar height and L1-mandibular plane in our study supports this finding.

Another CBCT study reported alveolar bone loss around the incisors in skeletal class III patients treated with orthognathic surgery. In the study, it was observed that the vertical alveolar bone level decreased more in the mandibular incisors compared to the maxillary incisors, especially on the lingual side.[16] In our findings, the lower jaw lingual bone level parameter decreased more than the upper jaw palatal bone level parameter. The findings are parallel to the study.

In the treatment of class III patients with mandibular prognathism, particular attention should be paid to the alveolar bone around the mandibular anterior teeth. Especially in extraction cases, mandibular anterior teeth are more vulnerable to bone defects during retraction compared to maxillary anterior teeth.[28] Therefore, it is also very important to evaluate and identify clinical factors associated with changes in alveolar bone dimensions in orthodontic decompensation before surgery. However, in skeletal class III patients with thin mandibular symphysis and increased vertical height, even a small amount of periodontal inflammation may pose a risk of bone loss and destruction.[29]

Guo et al.[29] emphasized in their study that the alveolar bone level, especially in the mandibular incisors, should be considered specifically in skeletal class III patients.

It should not be forgotten that orthognathic surgery procedures are performed on adult patients. In our study, patients with bone loss from both maxillary (upper anterior bone level, upper palatal bone thickness, UABL/root, UPBL/root, (UABL+UPBL)/CEJW, upper trifurcation buccal, upper DBR middle buccal $p<0.05$) and mandibular (lower anterior bone level), lower root length, AAKS/root, ALKS/root, (AAKK+ALKK)/MSBG, lower bifurcation buccal, lower DK middle buccal $p<0.05$) are evaluated. Being an adult patient, slowing down of bone regeneration or even having a risk of residual bone degeneration, and the possibility of an underlying systemic disease such as osteoporosis, osteopenia, vitamin D/calcium deficiency, menopause or pregnancy, and bisphosphonate use should be taken into consideration during the treatment planning phase.

Santos et al.[30] found in their study that alveolar bone dehiscence increased significantly only on the lingual side of the lower first molar in class II group patients. Parallel to this, in our study, lower 1st molar distal root middle lingual bone measurement changed more in patients who underwent double jaw surgery than in patients who underwent single upper jaw surgery. All 5 class II patients in our study underwent mandibular advancement surgery. The observation of bone loss on the lingual side of the lower molar teeth in operations involving the lower jaw is supported by the study.

Bondemark[31] found that the average alveolar bone loss per patient in adolescents who received orthodontic treatment for 2 years during a 5-year observation period varied between 0.1 and 0.5 mm. In our study based on the data obtained, the average bone loss was found to be 0.45 mm at the upper buccal level and 0.35 mm at the upper palatal level, while the lower incisor region was found to be 1.45 mm at the buccal level and 0.69 at the lingual level.

Nelson et al.[12] also did not find a relationship between maxillary osteotomy and lower jaw bone loss as a result of their study. The findings support our findings in that the change in the lower anterior bone level in our study, when comparing the patients who had only lower and only upper jaw surgery, changed more in patients who had only lower jaw surgery than in patients who had only upper jaw surgery, and that the maxilla was not affected statistically significantly by the surgery performed on the mandible.

CONCLUSION

Every surgical procedure carries an element of risk. However, the risks and potential morbidity of orthognathic treatment are relatively low and generally short-term.

Considering the patient's age, systemic status, surgery-related factors, dental and anatomical differences; it is not possible to make a definitive diagnosis regarding the increase or decrease of complications in orthognathic surgery depending on gender. Specific studies in this field should be increased and patient profiles in different subcategories should be diversified.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of the Local Ethics Committee of Dicle University Faculty of Dentistry Deanery (Date: 27.01.2021, Decision No: 2021-06).

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

REFERENCES

1. Lye KW. Effect of orthognathic surgery on the posterior airway space (PAS). *Ann Acad Med Singap*. 2008;37(8):677-682.
2. Te Malik NA. Presurgical Orthodontic Phase. In: textbook of oral and maxillofacial surgery. *Fourth.* 2016,421-430.
3. Westermark A, Shayeghi F, Thor A. Temporomandibular dysfunction in 1,516 patients before and after orthognathic surgery. *Int J Adult Orthodon Orthognath Surg.* 2001;16(2):145-151.
4. Helm S, Petersen PE. Causal relation between malocclusion and periodontal health. *Acta Odontol Scand.* 1989;47(4):223-228.
5. Posnick JC. Definition and prevalence of dentofacial deformities. Orthognathic surgery: principles and practice. *St. Louis, MO: Elsevier.* 2014,61-68.
6. Naini FB, Gill DS. Foreword. Orthognathic surgery: principles, planning and practice. *John Wiley & Sons.* 2017,19-20.
7. Garg S, Kaur S. Evaluation of post-operative complication rate of le fort ı osteotomy: a retrospective and prospective study. *J Maxillofac Oral Surg.* 2014;13(2):120-127.
8. Panula K, Finne K, Oikarinen K. Incidence of complications and problems related to orthognathic surgery: a review of 655 patients. *J Oral Maxillofac Surg.* 2001;59(10):1128-1136.
9. Nicodemo D, Ferreira LM. Questionnaire of the psychosocial profile of the patient with anophthalmia with indication of ocular prosthesis. *Arq Bras Oftalmol.* 2006;69(4):463-470.
10. Sousa CS, Turrini RN. Complications in orthognathic surgery: a comprehensive review. *J Oral Maxillofac Surg.* 2012;24(2):67-74.
11. Lupi JE, Handelman CS, Sadowsky C. Prevalence and severity of apical root resorption and alveolar bone loss in orthodontically treated adults. *Am J Orthod Dentofacial Orthop.* 1996;109(1):28-37.
12. Nelson PA, Artun J. Alveolar bone loss of maxillary anterior teeth in adult orthodontic patients. *Am J Orthod Dentofacial Orthop.* 1997;111(3):328-334.
13. Steiner GG, Pearson JK, Ainamo J. Changes of the marginal periodontium as a result of labial tooth movement in monkeys. *J Periodontol.* 1981;52(6):314-320.
14. Choi YJ, Chung CJ, Kim KH. Periodontal consequences of mandibular incisor proclination during presurgical orthodontic treatment in class III malocclusion patients. *Angle Orthod.* 2015; 85(3):427-433.
15. Nicodemo D, Pereira MD, Ferreira LM. Effect of orthognathic surgery for class III correction on quality of life as measured by SF-36. *Int J Oral Maxillofac Surg.* 2008;37(2):131-134.
16. Kim Y, Park JU, Kook YA. Alveolar bone loss around incisors in surgical skeletal class III patients. *Angle Orthod.* 2009;79(4):676-682.
17. Bholsithi W, Tharanon W, Chintakanon K, Komolpis R, Sinthanayothin C. 3D vs 2D cephalometric analysis comparisons with repeated measurements from 20 thai males and 20 thai females. *Biomed Imaging Interv J.* 2009;5(4):e21.
18. Garib DG, Yatabe MS, Ozawa TO, da Silva Filho OG. Alveolar bone morphology under the perspective of the computed tomography: defining the biological limits of tooth movement. *Dental Press J Orthod.* 2010;15:192-205.
19. Lee S, Hwang S, Jang W, Choi YJ, Chung CJ, Kim KH. Assessment of lower incisor alveolar bone width using cone-beam computed tomography images in skeletal class III adults of different vertical patterns. *Korean J Orthod.* 2018;48(6):349-356.
20. Kim Y, Park JU, Kook YA. Alveolar bone loss around incisors in surgical skeletal class III patients. *Angle Orthod.* 2009;79(4):676-682.
21. Vardimon AD, Oren E, Ben-Bassat Y. Cortical bone remodeling/tooth movement ratio during maxillary incisor retraction with tip versus torque movements. *Am J Orthod Dentofacial Orthop.* 1998;114(5):520-529.
22. Wainwright WM. Faciolingual tooth movement: its influence on the root and cortical plate. *Am J Orthod.* 1973;64(3):278-302.
23. Gaitan-Romero L, Shujaat S, Ma H, et al. Evaluation of long-term hard tissue relapse following surgical-orthodontic treatment in skeletal class II patients: a systematic review and meta-analysis. *Int J Oral Maxillofac Surg.* 2021;50(4):477-486.
24. Lannetti G, Fadda TM, Riccardi E, Mitro V, Filiaci F. Our experience in complications of orthognathic surgery: a retrospective study on 3236 patients. *Eur Rev Med Pharmacol Sci.* 2013;17(3):379-384.
25. Wehrbein H, Bauer W, Diedrich P. Mandibular incisors, alveolar bone, and symphysis after orthodontic treatment. A retrospective study. *Am J Orthod Dentofacial Orthop.* 1996;110(3):239-246.
26. Jäger F, Mah JK, Bumann A. Peridental bone changes after orthodontic tooth movement with fixed appliances: a cone-beam computed tomographic study. *Angle Orthod.* 2017;87(5):672-680.
27. Sun B, Tang J, Xiao P, Ding Y. Presurgical orthodontic decompensation alters alveolar bone condition around mandibular incisors in adults with skeletal class III malocclusion. *Int J Clin Exp Med.* 2015;8(8):12866-12873.
28. Zhang G. Influence of orthodontic tooth movement on alveolar bone morphology and bone mineral density. *J Tissue Eng.* 2015; 19(21):3440-3444.
29. Guo R, Zhang L, Hu M, Huang Y, Li W. Alveolar bone changes in maxillary and mandibular anterior teeth during orthodontic treatment: a systematic review and meta-analysis. *Orthod Craniofac Res.* 2020;24(2):165-179.
30. Dos Santos MC, Iwaki LCV, Valladares-Neto J, Inoue-Arai MS, Ramos AL. Impact of orthognathic surgery on the prevalence of dehiscence in class II and class III surgical-orthodontic patients. *Angle Orthod.* 2021;91(5):611-618.
31. Bondemark L. Interdental bone changes after orthodontic treatment: a 5-year longitudinal study. *Am J Orthod Dentofacial Orthop.* 1998;114(1):25-31.