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How much should incisors be decompensated? periodontal bone defects during presurgical orthodontic treatment in class III double-jaw orthognathic surgery patients

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A B S T R A C T

Introduction: The aims of this study were to evaluate periodontal bone defects around the lower and upper incisors and to identify changes in the buccolingual inclination of the incisors during orthodontic decompensation in skeletal Class III orthognathic surgery patients.
Materials and Methods: The sample consisted of 26 adults with skeletal Class III deformity who had undergone presurgical orthodontic treatment and orthognathic surgery. Lateral cephalograms obtained before orthodontic treatment and before surgery were used to determine the inclination and position changes of the incisors. Cephalometric measurements were taken using Dolphin Imaging 11.95. Three-dimensional images were generated from cone-beam computed tomography (CBCT) scans prior to surgery and used to detect periodontal bone defects, including fenestration (F) and dehiscence (D).
Results: Intraclass correlation coefficients (ICC) were determined and the measurements showed high reproducibility. The cephalometric data showed normal distribution and there were no differences between genders in terms of cephalometric changes, dehiscence, fenestration, or coexistent (D-F/DF) formation. The patients presented maxillary incisor retroclination and mandibular incisor proclination, which was consistent with the tooth decompensation. CBCT assessment was performed for a total of 208 teeth; while 81 upper and 94 lower incisors had D-F/DF formation, 23 upper and 10 lower incisors were healthy. Statistically significant correlations were not found between the inclination degree of the incisors and D-F/DF formation.
Conclusions: Decompensation of incisors during presurgical orthodontic treatment increases the risk of periodontal defects. There is no linear relationship between the increase in the inclination degrees of incisors and D-F/DF formation.

1. INTRODUCTION

Patients with severe skeletal and dental dysplasia are usually treated with a combination of orthodontic and surgical treatment. Untreated skeletal Class III patients generally have proclined upper incisors and retroclined lower incisors to compensate for the negative overjet. Presurgical orthodontic treatment protocol includes decompensation of the incisors by retroclining the proclined maxillary incisors and proclining the mandibular incisors to more normal axial inclinations. However, the necessary amount of incisor decompensation and its effects on the periodontal bone changes, including fenestration and dehiscence, are poorly understood. The findings in the literature are controversial. Some studies [1,2] have shown no correlation between the amount of proclination of the mandibular incisor teeth and gingival recession, but some researchers [3,4] have found that labial bone dehiscence and retraction of the gingival

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All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008 (5). Informed consent was obtained from all patients for being included in the study.

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margin can occur after excessive proclination of mandibular incisors in adults. Another study concluded that there is a correlation between gingival recession and retroclined mandibular incisors in adults with untreated mandibular prognathism [5].

Dehiscence and fenestration are periodontal bone defects that can cause exposure of the bone surface. Dehiscence is a defect that results in the lowering of the crestal bone margin to expose the root surface; fenestrations are isolated areas in which the root is denuded of the bone [6,7]. Many factors can affect these bone changes during orthodontic treatment, such as the magnitude and frequency of orthodontic force, oral hygiene habits, buccolingual crown inclination, amount of tooth movement, the volume of periodontal tissues, and various predisposing factors [8].

There are two-dimensional (2D) and three-dimensional (3D) imaging modalities available to assist in the examination of periodontal defects. The 2D imaging methods, including periapical, bitewing, and panoramic radiography, are easily acquired, cheap and provide high-resolution images [9]. There are limitations to these modalities, however, such as overlapping anatomical structures, difficulties in standardisation, underestimation of the size and occurrence of bone defects, and lack of visualisation of dehiscence and fenestrations due to the superimposition of contralateral cortical bony or dental structures [10,11]. Cone-beam computed tomography (CBCT) and conventional computed tomography (CT) are valuable 3D imaging modalities used to detect periodontal defects [9]. CBCT has certain advantages compared with conventional CT, including reduced radiation dose, smaller voxel size, easier image acquisition, high image accuracy and reduced artefacts [12].

This study aimed to evaluate periodontal bone defects around the lower and upper incisors and to identify the buccolingual inclination changes of the incisors during orthodontic decompensation treatment in skeletal Class III orthognathic surgery patients.

2. MATERIALS and methods

This study comprised 26 patients (12 men and 14 women; mean age: 17.44±2.80 years) with skeletal Class III mandibular prognathism who underwent orthognathic surgery. Power analyses were performed in the G*Power (version 3.1.9.2; Axel Buchner, Universität Düsseldorf, Düsseldorf, Germany) program. Accordingly, the sample size required to detect a medium-sized effect in the population with 80% power (effect size: 0.55) was found to be 22 and to strengthen the study, 26 patients were included. All of the subjects had presurgical and postsurgical orthodontic treatment, underwent double-jaw orthognathic surgery (mandibular setback via sagittal split ramus osteotomy (SSRO) and maxillary advancement via Le Fort I osteotomy) with rigid internal fixation, and had no additional surgeries such as genioplasty, malar augmentation or rhinoplasty.

Inclusion criteria were as follows:

1. Skeletal Class III malocclusion (ANB $< 0°$),
2. Dental Angle Class III malocclusion (molars, premolars and canines are in Class III tubercle-fissure relation),
3. The level of crowding was classified in three ways; mild (0–3 mm), moderate (4–6 mm), and severe (> 6 mm). The patients had less than 3 mm crowding in the lower and upper arch were included (mild crowding), [13]
4. No severe facial asymmetry,
5. Orthodontic treatment protocol with 0.018-inch straight-wire fixed appliance, full bonding including the second molars, final archwire with 0.016–0.022 inch stainless steel wire, and no use of intrusion mechanics in the upper or lower arch,
6. Lateral cephalometric films taken before orthodontic treatment and again before orthognathic surgery and CBCT images taken before surgery.

Exclusion criteria included craniofacial syndromes, tooth size anomaly, periodontal problems, or moderate to severe crowding in maxilla and mandible, premolar tooth extraction for orthodontic purposes and root resorption before orthodontic treatment. In our study, in order to evaluate the relationship between D-F/DF formation and incisor inclination more objectively, it was paid attention to the periodontal health findings of the patients in the clinical examination records during the preoperative period and after the orthognathic surgery. Patients with gingival health and absence of bleeding on probing, erythema, oedema, patient symptoms, attachment or bone loss on probing were included in the study.

Permission to conduct the study was obtained from the Erciyes University Human Research Regional Ethical Committee after the Research Scientific Committee at the same institution approved the experimental protocol (No:2020/532). The patients were selected from the archives of the Oral and Maxillofacial Radiology Department.

2.1. CBCT images and lateral cephalograms

The CBCT images and lateral cephalograms of 54 patients were analysed and 26 patients who met the inclusion criteria were included in the study. All measurements were made by the same author, who is experienced in analysing CBCT scans. All CBCT images were acquired in the standard position (patient in the supine position) and with the same device (Newtom VG; QR, Verona, Italy). Scanning time of the device is 14–18 s, collimation height is 13 cm, irradiation time is 3.6 s, voxel size is 0.3 mm^3, FOV (Field of View) range is 16×18 and axial slice thickness was 0.25 mm. The sagittal images were axially corrected and an NNT programme (QR, Verona, Italy) was used to analyse the CBCT images in a dark room.

2.2. Tested variables

Cephalometric radiographs taken before orthodontic treatment (T0) and before orthognathic surgery (T1) were used to assess;

1. The position of the maxilla (SNA angle) and mandible (SNB angle) relative to the cranial base,
2. Sagittal intermaxillary relation (ANB angle),
3. The inclination of the upper incisors relative to the cranial base (U1-SN (°))
4. Sagittal position of the upper incisors relative to the maxillary alveolar base (U1-NA (mm)) and inclination of the upper incisors relative to maxilla (U1-NA (°)) and palatal plane (U1-PP (°)).
5. Sagittal position of the lower incisors relative to the maxilla and mandible (L1-APog (mm), L1-NB (mm)) and inclination of the lower incisors relative to mandibular plane (IMPA (°)) and NB plane (L1-NB (°)).

Cephalometric measurements were made with Dolphin Imaging 11.95 (Patterson Dental Supply, St. Paul, MN) (Fig. 1).

CBCT images were used to detect periodontal bone defects (fenestration and dehiscence) just before the orthognathic surgery. Each tooth root was evaluated in axial and cross-sectional slices at two surfaces (buccally and lingually). An alveolar defect was identified when there was no cortical bone around the root in at least three sequential views. Fenestration and dehiscence formation assessment was based on the article by Enhos et al. [8] Dehiscence was diagnosed if the alveolar bone height was more than 2 mm from the

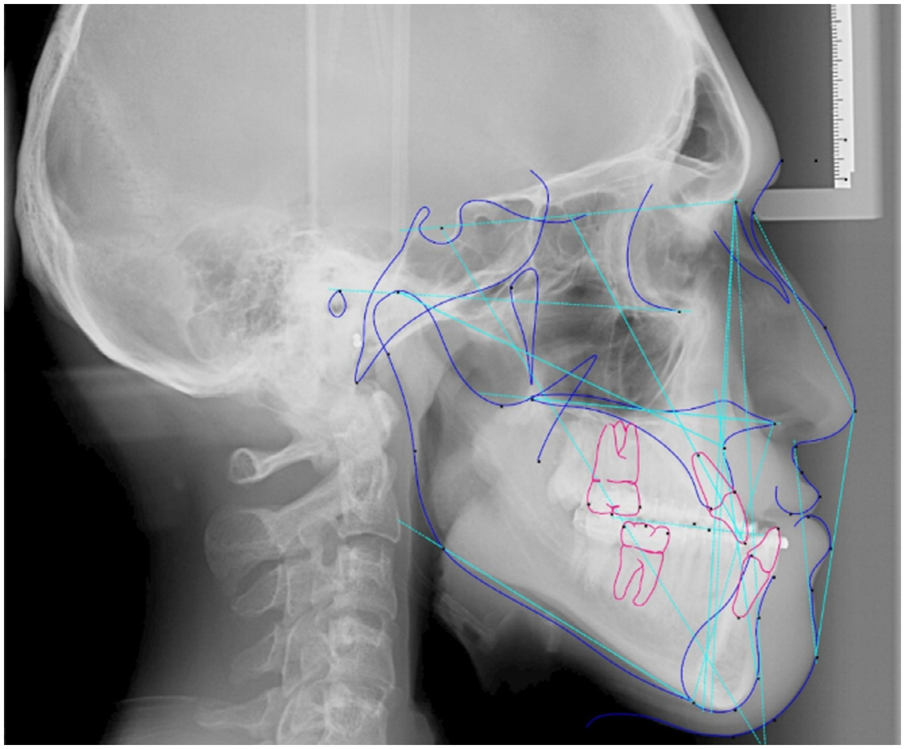

Fig. 1. Cephalometric digitization of a patient at T1 stage.

cementoenamel junction (Fig. 2); when the defect did not involve the alveolar crest, it was classified as fenestration (Fig. 3).

2.3. Statistical analysis

The distribution of cephalometric measurements was evaluated using Kolmogorov–Smirnov and Shapiro–Wilk tests. Gender differences in cephalometric measurement data were evaluated using independent-sample t-tests. Paired-sample t-tests were used to compare cephalometric values between the T0 and T1 periods, while independent-sample t-tests were used to compare cephalometric changes from T0 to T1 between genders. Fisher's exact tests were used to compare categorical data from the CBCT dehiscence assessments, and the distributions of the data between groups are presented in cross tables as percentages and frequencies.

2.4. Methodological error

To determine the intraoperator measurement reliability for CBCT and lateral cephalometric measurements, all images were remeasured after a 15-day interval by the same observer. Intraclass correlation coefficients (ICC) were calculated and the differences between the first and second measurements were not significant. The ICC

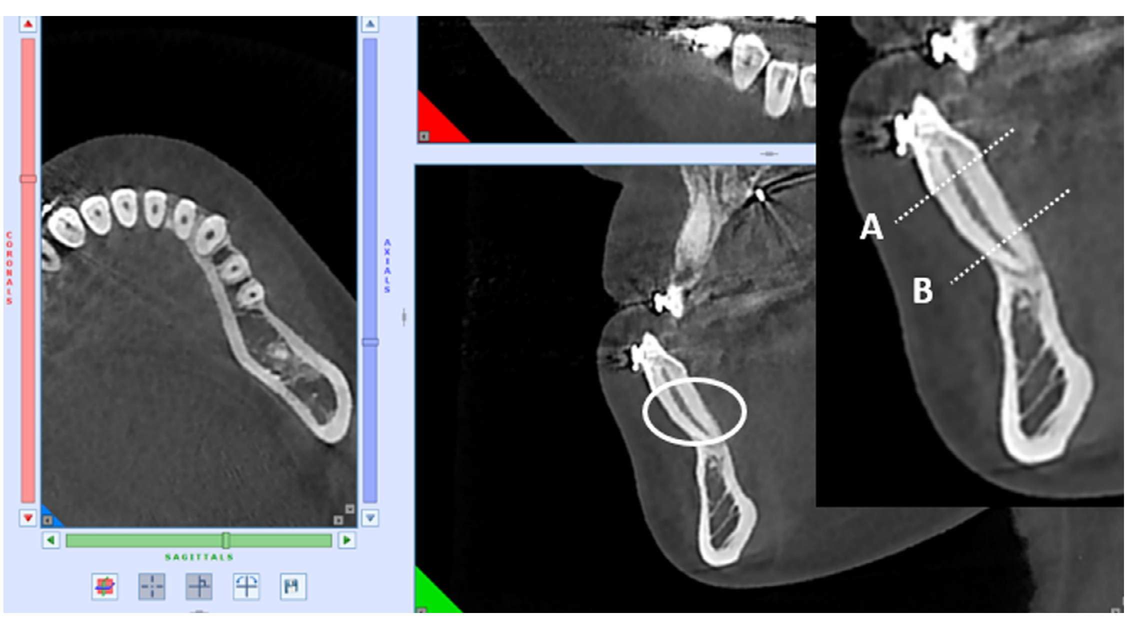

Fig. 2. Dehiscence: at least three sequential views (A indicates cemento-enamel junction; B, bone level).

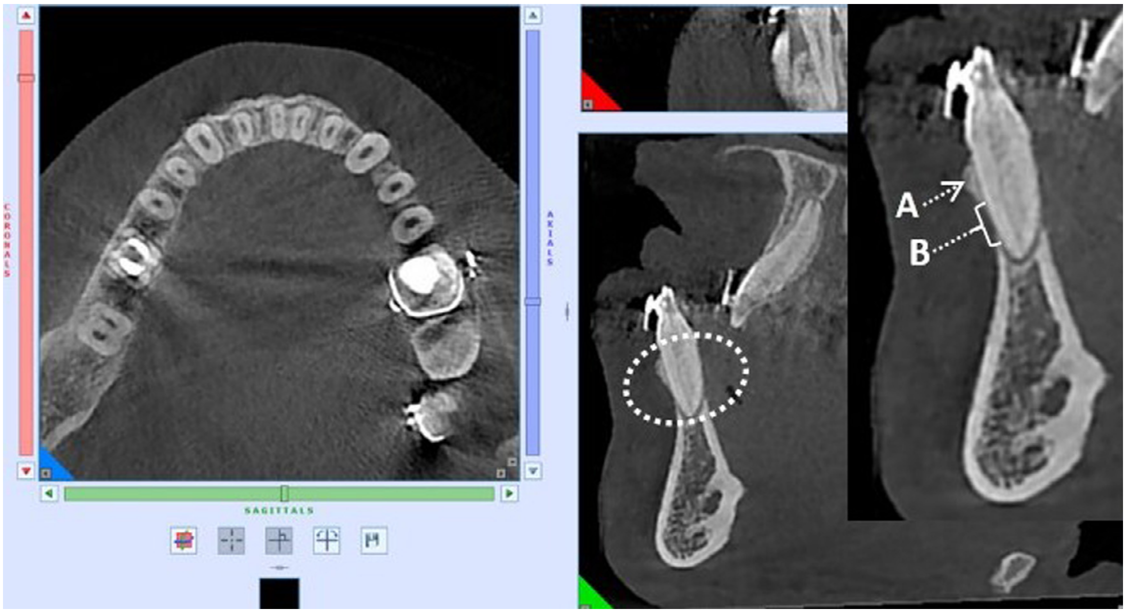

Fig. 3. Fenestration: at least three sequential views (A indicates bone; B, fenestration area/cement of the root).

values were between 0.945 and 0.997, indicating high measurement reliability.

3. RESULTS

The cephalometric data showed normal distribution. The values of the cephalometric measurements at T0 are given by gender in Table 1. There was no difference between genders in terms of pre-treatment cephalometric parameters Table 2. shows the differences in cephalometric measurements between T1 and T0 by gender. It was determined that there was also no significant difference between genders in the change in cephalometric measurements between T0 and T1. For this reason, the data from the male and female participants were taken as a single sample.

The cephalometric measurements at T0 and T1 are given in Table 3. After the decompensation period (presurgical orthodontic treatment), the lower incisors proclined and protruded and these changes were statistically significant (P<0.001). The IMPA angle increased from 76.91±5.54° to 85.01±5.84° and the position of the lower incisors with respect to the NB plane increased by an average of 2.15 mm (P<0.001).

The upper incisors also became significantly retracted and retroclined after orthodontic decompensation. The U1-SN angle decreased from 107.35±7.29° to 104.96±7.19° (P=0.043) and the U1-NA measurement indicating the position of the upper incisors relative to the maxillary alveolar base decreased from 5.93±2.53 mm to 5.02±2.23 mm (P=0.017).

The CBCT findings were categorised as either healthy (H), dehisced (D), fenestrated (F), or coexistent (D-F/DF) in order to ensure compliance with the test. The relationship between D-F/DF and gender was examined and is shown in Table 4. According to our findings, there is no relationship between sex and the occurrence of D-F/DF.

Data on the presence of D-F/DF after decompensation in the upper incisors and the distribution of these symptoms according to the degree of retroclination are presented in Table 5. The change in the U1-PP angle was categorised as either greater or less than 0° and, according to our data, there is no relationship between the retroclination of the upper incisors and D-F/DF formation. Eighty-one of the 104 upper incisors examined had D-F/DF, and 23 of them were healthy.

The relationship between D-F/DF and the amount of IMPA change in the mandibular incisors is shown in Table 6. The change in the IMPA angle was categorised as either below or above 7° and, according to our data, there is no relationship between the proclination of the lower incisors and D-F/DF formation. Ninety-four of the 104 lower incisors examined had D-F/DF formation, and 10 of them were healthy.

Table 1
Comparison of T0 period cephalometric measurements between genders.

	Female (n = 14)		Male (n = 12)		p value
Measurements	Mean	SD	Mean	SD	
SNA (°)	79.01	2.52	78.26	4.62	0.606
SNB (°)	82.99	3.42	83.21	4.32	0.888
ANB (°)	−3.98	2.42	−4.95	2.37	0.313
U1-SN (°)	107.45	7.44	107.23	7.45	0.939
U1-PP (°)	115.98	5.99	116.55	7.47	0.830
U1-NA (mm)	5.70	2.24	6.20	2.92	0.626
U1-NA (°)	28.44	6.62	28.98	8.29	0.855
L1-APog (mm)	4.96	2.39	5.40	3.28	0.694
IMPA (°)	79.06	5.34	74.40	4.84	0.079
L1-NB (mm)	3.25	2.33	2.81	1.55	0.582
L1-NB (°)	19.20	6.15	16.25	3.86	0.164

Table 2
Comparison of T0-T1 differences between genders in cephalometric measurements.

	Female (n = 14)		Male (n = 12)		p value
Differences	Mean	SD	Mean	SD	
SNA (°)	−0.01	0.27	−0.08	0.14	0.493
SNB (°)	0.06	0.22	0.00	0.28	0.521
ANB (°)	−0.07	0.19	−0.75	0.37	0.973
U1-SN (°)	−4.10	6.55	−0.38	3.93	0.099
U1-PP (°)	−3.89	7.00	−0.09	3.73	0.105
U1-NA (mm)	−1.06	1.92	−0.74	1.79	0.664
U1-NA (°)	−4.09	6.69	−0.20	4.06	0.092
L1-APog (mm)	1.75	1.41	2.47	1.52	0.225
IMPA (°)	8.48	3.50	7.66	4.11	0.588
L1-NB (mm)	1.96	1.33	2.83	1.34	0.433
L1-NB (°)	8.42	3.96	8.78	3.89	0.821

Table 3
Comparison of cephalometric measurements at T0-T1 periods.

	T0		T1		p value
Measurements	Mean	SD	Mean	SD	
SNA (°)	78.66	3.58	78.62	3.58	0.335
SNB (°)	83.09	3.78	83.13	3.74	0.483
ANB (°)	−4.43	2.40	−4.50	2.41	0.164
U1-SN (°)	107.35	7.29	104.96	7.19	**0.043***
U1-PP (°)	116.24	6.58	114.10	6.45	0.079
U1-NA (mm)	5.93	2.53	5.02	2.23	**0.017***
U1-NA (°)	28.69	7.29	26.40	7.36	0.057
L1-APog (mm)	5.16	2.78	7.24	2.05	**<0.001*****
IMPA (°)	76.91	5.54	85.01	5.84	**<0.001*****
L1-NB (mm)	3.05	1.98	5.20	1.48	**<0.001*****
L1-NB (°)	17.84	5.34	26.42	4.37	**<0.001*****

4. DISCUSSION

This study focused on patterns of change in the alveolar bone of the lower and upper incisors after decompensation via orthodontic treatment in skeletal Class III surgery patients. The number of previous studies on this subject is quite limited. Alveolar bone loss in the lower anterior teeth is more common in people with mandibular prognathism due to decompensation of the lower incisors during orthodontic treatment before surgery [14].

The traditional orthognathic treatment process of Class III skeletal malocclusions consists of three stages: pre-surgical, surgical, and post-surgical orthodontics [15]. In patients with Class III dentofacial deformities, preoperative orthodontic treatment aims to decompensate the maxillary and mandibular incisors to obtain sufficient and healthy tooth inclinations within their alveolar bones. Alveolar bone support is very important in terms of periodontal health, and the optimum stable position of the incisors is related to their alignment within the neutral zone [16]. In addition, incisors act as a guide during the surgical procedure for the amount of jaw advancement/setback. Therefore, the amount of incisor decompensation affects both the aesthetic and functional results of orthognathic treatment. In the mandible especially, the lower incisors are limited by the symphysis region. Since in Class III malocclusions the lower incisors are retroclined and prone to periodontal diseases, attention should be paid to the amount of compensation of the lower incisors during the preoperative decompensation stage [17].

The inclination and position changes of the incisors were determined via cephalometric films taken before orthodontic treatment and before surgery; routine CBCT images taken just before surgery were used to identify the presence of D-F/DF formation. CBCT images have many advantages over conventional 2D radiographs: labiolingual bone support of the incisors can be evaluated separately for each tooth, superposition and distortions do not occur as they do in 2D films, and it is possible to evaluate bone surfaces and the relationship between the teeth and the bone both quantitatively and qualitatively [18]. One study showed that quantitative assessment of the alveolar bone surface with CBCT is accurate to at least 0.5 mm bone thickness and that CBCT findings give similar results to histological measurements [19]. The use of CBCT measurements in our study therefore enabled us to make highly accurate assessments of D-F/DF formation.

In our study, it was observed that there was an average of 2.14° of retroclination in maxillary incisors (U1-PP) and an average of 8.1° of proclination in mandibular incisors (IMPA). While the inclination change in maxillary incisors was not significant, the proclination in the mandibular incisors was significant and within the range of changes in IMPA measurement reported in the Class III surgical decompensation literature (5° to 14°) [15,20,21]. As proclination of retroclined lower incisors is easier than retroclination of proclined upper incisors [17], orthodontists typically change the lower incisors positions while resolving the existing compensation in skeletal Class III patients. One study showed that vertical alveolar bone loss is more severe in mandibular incisors than in maxillary incisors, and there is increased bone loss in the lingual alveolar bone [22]. For this reason, it may be necessary to be especially careful when decompensating lower incisors that have small, thin root structures and are restricted by the mandibular symphysis area.

In this study, a CBCT assessment was performed for a total of 208 teeth, of which 81 upper and 94 lower incisors had D-F/DF and 23 upper and 10 lower incisors were healthy. The incidence of D-F/DF formation after orthodontic decompensation amongst our study participants was high. These findings are consistent with results reported by previous authors, who have described an increased prevalence of D-F/DF formation in the anterior teeth [15,17,22,23]. Existing studies suggest that incisor decompensation before orthognathic surgery may cause fenestration and dehiscence, especially around the mandibular incisor roots, due to the thin buccal and lingual alveolar bone thicknesses [14,15,23].

No relationship was found between the inclination degrees and D-F/DF formation. Alveolar bone changes and D-F/DF formation are associated with biomechanical events and are influenced by many factors, including periodontal environment, gingival type, the patient's oral habits, individual bone formation, and destructive

Table 4
Relationship of Dehiscence-Fenestration findings with gender (Chi-square), H: Healthy, D-F / DF: Dehiscence and / or Fenestration.

	Female (n = 14)		Male (n = 12)		Total (n = 26)		Fisher's Exact Test
Tooth Number	H	D-F/DF	H	D-F/DF	H	D-F/DF	
11	%21.4 (n = 3)	%78.6 (n = 11)	%33.3 (n = 4)	%66.7 (n = 8)	%26.9 (n = 7)	%73.1 (n = 19)	0.665
12	%7.1 (n = 1)	%92.9 (n = 13)	%16.7 (n = 2)	%83.3 (n = 10)	%11.5 (n = 3)	%88.5 (n = 23)	0.580
21	%21.4 (n = 3)	%78.6 (n = 11)	%41.7 (n = 5)	%58.3 (n = 7)	%30.8 (n = 8)	%69.2 (n = 18)	0.401
22	%14.3 (n = 2)	%85.7 (n = 12)	%25.0 (n = 3)	%75.0 (n = 9)	%19.2 (n = 5)	%80.8 (n = 21)	0.635
31	%7.1 (n = 1)	%92.9 (n = 13)	%16.7 (n = 2)	%83.3 (n = 10)	%11.5 (n = 3)	%88.5 (n = 23)	0.580
32	%7.1 (n = 1)	%92.9 (n = 13)	%16.7 (n = 2)	%83.3 (n = 10)	%11.5 (n = 3)	%88.5 (n = 23)	0.580
41	%7.1 (n = 1)	%92.9 (n = 13)	%8.3 (n = 1)	%91.7 (n = 11)	%7.7 (n = 2)	%92.3 (n = 24)	1.000
42	%7.1 (n = 1)	%92.9 (n = 13)	%8.3 (n = 1)	%91.7 (n = 11)	%7.7 (n = 2)	%92.3 (n = 24)	1.000

Table 5
Relationship of Dehiscence-Fenestration findings with U1-PP change amount (Chi-square), <0°: U1-PP change below 0°, >0°: U1-PP change above 0° H: Healthy, D-F / DF: Dehiscence and / or Fenestration.

	<0° (*n* = 16)		>0° (*n* = 10)		Total (*n* = 26)		Fisher's Exact Test
Tooth Number	H	D-F/DF	H	D-F/DF	H	D-F/DF	
11	%25.0 (*n* = 4)	%75.0 (*n* = 12)	%30.0 (*n* = 3)	%70.0 (*n* = 7)	%26.9 (*n* = 7)	%73.1 (*n* = 19)	1.000
12	%12.5 (*n* = 2)	%87.5 (*n* = 14)	%10.0 (*n* = 1)	%90.0 (*n* = 9)	%11.5 (*n* = 3)	%88.5 (*n* = 23)	1.000
21	%37.5 (*n* = 6)	%62.5 (*n* = 10)	%20.0 (*n* = 2)	%80.0 (*n* = 8)	%30.8 (*n* = 8)	%69.2 (*n* = 18)	0.420
22	%25.0 (*n* = 4)	%75.0 (*n* = 12)	%10.0 (*n* = 1)	%90.0 (*n* = 9)	%19.2 (*n* = 5)	%80.8 (*n* = 21)	0.617

Table 6
Relationship of Dehiscence-Fenestration findings with IMPA change amount (Chi-square), <7°: IMPA change below 7°, >7°: IMPA change above 7° H: Healthy, D-F / DF: Dehiscence and / or Fenestration.

	<7° (*n* = 13)		>7° (*n* = 13)		Total (*n* = 26)		Fisher's Exact Test
Tooth Number	H	D-F/DF	H	D-F/DF	H	D-F/DF	
31	%15.4 (*n* = 2)	%84.6 (*n* = 11)	%7.7 (*n* = 1)	%92.3 (*n* = 12)	%11.5 (*n* = 3)	%88.5 (*n* = 23)	1.000
32	%15.4 (*n* = 2)	%84.6 (*n* = 11)	%7.7 (*n* = 1)	%92.3 (*n* = 12)	%11.5 (*n* = 3)	%88.5 (*n* = 23)	1.000
41	%7.7 (*n* = 1)	%92.3 (*n* = 12)	%7.7 (*n* = 1)	%92.3 (*n* = 12)	%7.7 (*n* = 2)	%92.3 (*n* = 24)	1.000
42	%15.4 (*n* = 2)	%84.6 (*n* = 11)	%00.0 (*n* = 0)	%100.0 (*n* = 13)	%7.7 (*n* = 2)	%92.3 (*n* = 24)	0.480

metabolism [24]. Therefore, it is possible that the extent of alveolar bone change and D-F/DF formation is not correlated with the degree of incisor inclination. Similarly, previous studies have observed no relationship between the rate of alveolar defect occurrence and the amount of incisor inclination [14,15,17].

It is known that variations in sex hormones can increase the periodontal inflammatory response to periodontal pathogens by altering the sensitivity of the patient [25,26]. Sex steroid hormones affect periodontal structures and bone metabolism through interactions with specific periodontal and immune cells by altering the periodontal vasculature and affecting the composition of the subgingival microflora [25,27]. However, when the relationship between D-F/DF formation and gender was evaluated, no difference was found between genders. Studies with larger sample sizes are needed to confirm this finding.

Our study had some limitations. Had CBCT images also been taken before orthodontic treatment, the accuracy of some of our findings would have been higher. In this study, the mean pre-operative orthodontic treatment time was 23.31±15.72 months, and the mean post-operative orthodontic treatment period was 8.28±7.21 months. The duration of periodontal defect occurrence may vary for each patient. Here, any D-F/DF defects that may have occurred were examined within a limited time. Evaluations may be done six months to a year after the end of orthodontic treatment for more accurate results.

During the pre-surgery orthodontic treatment period, the amount of decompensation of incisors should be evaluated individually for each patient. It should be kept in mind that the formation of periodontal defects may increase with decompensation and the movement of the lower and upper incisors should be re-evaluated according to the anatomical limits and periodontal health of the patient.

5. CONCLUSIONS

In skeletal Class III orthognathic surgery patients, dehiscence, fenestration, or coexistent (D-F/DF) formation may increase with decompensation, especially in lower incisors. There was no linear relationship between inclination degree and D-F/DF formation in this study, but further studies with long-term follow-up and larger sample sizes are required.

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