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Original article

DIAGNOSIS OF THE ALVEOLAR BONE CONDITION IN CASES OF TEETH WITH ANTERIOR CROSS BITE

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ABSTRACT

Anterior cross bite is an occlusal etiological factor for the occurrence of gingival recession and resorption of the alveolar bone.

Aim: To examine the condition of the alveolar bone in relation to incisor inclination in subjects with anterior cross bite.

Materials and methods: Sixty one eligible subjects, with a mean age of 25.66±10.51 years, presented with anterior cross bite of a single teeth or a group of teeth. The distribution of patients by sex is women-42.6% and men-57.4%. The inclination of the upper and lower incisors was evaluated and analysed with Steiner C method. The bone resorption in the two jaws (distance from the enamel-cement junction of the incisors up to the beginning of the alveolar bone) was measured up to 0.01 mm.

Results: Protrusions constituted a higher percentage than retrusion in both jaws. The mean value of bone resorption in the maxilla of subjects with retrusion was 4.01mm, whereas in subjects with protrusion, it was 3.42mm ($p = 0.062$). The mean value of bone resorption in the mandible of subjects with retrusion was 4.56mm, whereas in subjects with protrusion, it was 4.36mm. The bone resorption mean of the patients with retrusion in the mandible was 0.55mm higher than the mean of the patients with retrusion in the maxilla with high statistical significance ($p = 0.008$).

Conclusion: Higher levels of bone resorption were observed in the mandible as compared to the maxilla. A significant linear relationship was found between the inclination of the incisors and the degree of bone resorption.

Keywords: gingival recession, anterior cross bite, lateral cephalometric radiographs,

INTRODUCTION

The anterior cross bite is a result of an anatomical or functional disturbance in the occlusion and appears with lingual inclination of the maxillary incisors relative to those of the mandible and/or the vestibular movement of the lower incisors. Lack of space in the upper and lower dental arches leads to incorrect position of the teeth in the anterior segment, which can also cause cross bite of single teeth. In cases of sagittal deviation of teeth, dehiscence and/or fenestration are observed due to the buccolingual inclination of the teeth. The vestibular inclination of the mandibular incisors is considered to be a risk factor for the occurrence of gingival recession. Many studies have shown the relationship between proclination and translation of the incisors and bone dehiscence and/or fenestration with subsequent gingival recession.

The vestibular plate of the alveolar ridge at the lower incisors and canines is the thinnest [1]. When the growth of the individual proceeds normally, the lateral lower incisors erupt more lingually than the central ones. The more pronounced labial position of the lower central incisors is associated with a thinner vestibular compact bone. Therefore, a thin periodontal biotype, absence of attached gingiva, and reduced thickness of the alveolar bone due to abnormal tooth position, frenal attachment and even improper tooth brushing are predisposing factors for gingival recession [2]. Besides the natural path of vestibular eruption, other factors changing the position of the lower incisors are the crowding of teeth as a result of lack of space, the protrusion of the lower incisors due to an active etiological factor, trauma or bone lesions in this area [3]. The result of their action is a thinner vestibular compact bone and migration of the gingival mar-

gin in the apical direction. If there is a mismatch between the size of the teeth and the jaws, the lower front teeth will not be positioned correctly. There is no normal proximal contact between them, and this threatens the surrounding alveolar bone, which is thinning [4]. This deformation and the accompanying recession can be observed even in mixed dentition and even in a more severe form in permanent dentition [5].

With the wrong ratio of the upper and lower incisors, the vector of masticatory forces changes direction, and they exceed the adequate capacity of the tissues. The front teeth of the cross-bite are subjected to excessive stress during their operation, which causes a change in their position [6]. The direction of movement of the teeth in these cases depends on occlusal forces. Studies of masticatory force have shown that it is of different magnitude - the values are significantly lower in hyperdivergent individuals and without significant difference in the maximum bite force between hypodivergent and normodivergent individuals [7]. Therefore, the type of vertical growth will also have an additional influence on the occlusal load.

Normal physiological forces are beneficial for periodontal tissues as they provide an additional stimulus to keep the periodontal ligament and alveolar bone healthy. During biting, the anterior cross bite provokes larger forces exceeding the normal limits. In these cases, the number of periodontal fibers and their width increase. In the case of normal occlusion of the incisors, the masticatory forces are oriented along the main axis of the teeth and are transferred to the alveolar bone. When the direction of these forces is changed, the periodontal fibers and the adjacent bone are not able to effectively absorb this load. The longer period of time of influence of the abnormal forces, their frequent application and the mucogingival stress, are the reason for the change in the morphology of the alveolar bone.

Orthodontic treatment restores normal occlusal relationships optimises occlusal loading and periodontal health and aesthetics [8]. Orthodontic therapy improves the relationship between teeth and the tissues that surround and support them. Orthodontic therapy's success depends on an orthodontist's ability to diagnostics and anticipate any periodontal issues [9-11].

AIM

To examine the condition of the alveolar bone at the position of maxillary and mandibular incisors in relation to incisor inclination in subjects with anterior cross bite confirmed by lateral cephalometric radiography.

MATERIALS AND METHODS

Materials

Sixty-one eligible subjects with an anterior cross bite of single teeth or a group of teeth were included in the retrospective study RCT. The patient's age ranged between 18 and 45 years, with a mean age of 25.66±10.51. Among them, 35 were men (57.4%) and 26 were women (42.6%). The patients have visited to the Department of Periodontics and Department of Orthodontics, Faculty of Dental Medicine – Plovdiv, for consultation and treatment. They were informed of the nature and objective of the study and signed informed consent. The study was approved by the institutional Ethics in Human Research Committee (protocol No. 2106 /2020). Patients included in the study met the following criteria:

1. Subjects with no previous orthodontic treatment.
2. Patients above 18 years old whose skeletal growth is completed.
3. Presence of gingival recession on at least one of the teeth in a cross bite.
4. The teeth in cross bite should not have crowns, cervical lesions and/or cervical fillings.

Exclusion criteria:

1. Subjects with unsatisfactory oral hygiene according to the Green Vermillion oral hygiene index(Debris scores 2 and 3).
2. Distorted images or images without adequate sharpness on the radiographs.

Research Questions

The following scientific hypotheses and tasks were investigated:

• Is there a significant difference in the occurrence of retrusions and protrusions in the maxilla and in the mandible?

• Is bone resorption significantly different in cases of incisors with retrusions vs. those with protrusions?

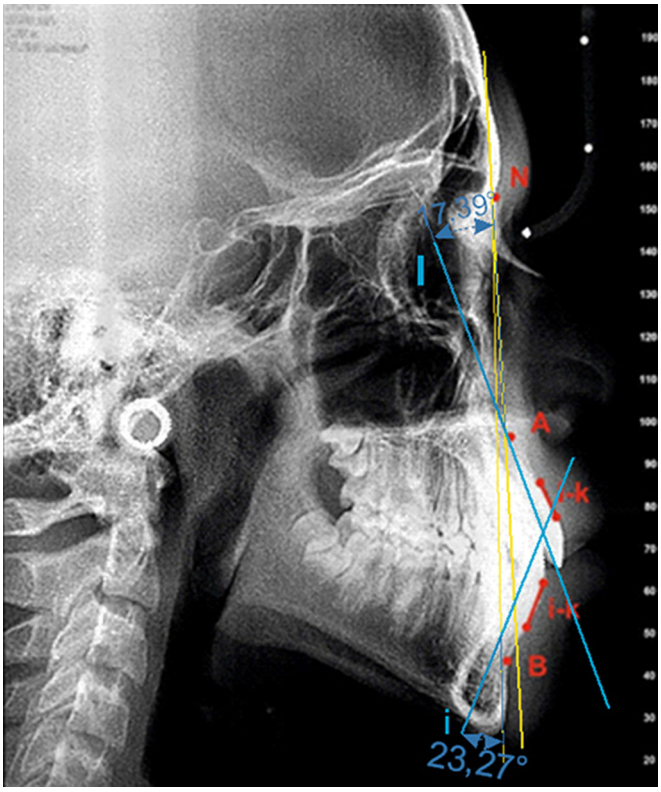
• Is bone resorption significantly different in the maxilla compared to that in the mandible?

• Is there a significant correlation between incisor inclination and bone resorption?

Analysis method

The included subjects performed lateral cephalometrics radiography in the Department of Imaging in the Faculty of Dental Medicine at the Medical University of Plovdiv. The morphological data analysis methodology used is cephalometric analysis with Audax Ceph Orthodontic Software Suite. A single operator performed all the tracing in a standardised manner to avoid errors due to inter operator variations. The inclination of the upper and lower incisors was evaluated and analysed using Steiner C's method [12], as shown in Figure 1.

Fig. 1. Inclination of maxillary and mandibular incisors using Steiner C method.



The inclination of incisors in the maxilla and mandible was measured in degrees. The distance from the enamel-cement junction of the incisors up to the beginning of the alveolar bone of the two jaws (bone resorption) was measured in mm with an accuracy of up to 0.01 mm.

Cephalometric landmarks that are used:

Bone points:

N point – the most anterior and upper point of the frontonasal suture;

A point – the most concave point between the ANS point (spina nasalis anterior) and the alveolar bone;

B point – the most concave point between the alveolar bone and the Pog point.

Lines:

N-A line – N point and A point are connected;

N-B line – N point and B point are connected;

I – the axis of a maxillary incisor;

i – the axis of a mandibular incisor.

Angular measurements:

∠ I-NA (°) – Angular relationship between the axis of a maxillary incisor and the line connecting N point with A point with a reference value of 22°;

∠ i-NB (°) – the angle between the axis of a mandibular incisor and the line connecting N point with B point with a reference value of 25°.

Distances we have introduced to measure alveolar resorption:

I-k – the distance from the CEJ to the beginning of the alveolar bone of the maxilla;

i-k– the distance from the CEJ to the beginning of the alveolar bone of the mandible (Figure 1)

Method for Statistical Analysis

They used Statistical Package SPSS, Version 25 (2017); Minitab Version 18.1 (2017); and MedCalc Statistical Software version 18.11.3 (2019).

RESULTS:

Basic characteristics of the patients

The mean number of teeth in the cross bite was 8.0±3.0, with a range between 2 and 12 teeth shown in Table 1.

Table 1. Basic characteristics of the patients in the study

Variables	Descriptive Statistics
Age	
o Mean ±SD	25.66±10.51
o Min.-Max.	18-45
Sex N (%)	
o Male	35 (57.4%)
o Female	26 (42.6%)
Number of teeth in cross bite	
o Mean±SD	8.0.±3.0
o Min-Max	2-12

The patients were categorised into groups depending on the inclination as follows: 1) Patients with incisor retrusion (**I/NA<22**°) and with incisor protrusion (**I/NA>22**°) in the maxilla and 2) Patients with incisor retrusion (**i/NA<25**°) and incisor protrusion **(i/NA>25**°) in the mandible (Table 2). Fisher's exact test was used to compare the distribution of patients between the different categories.

The results showed that protrusions constituted a higher percentage than retrusion in both jaws. In the maxilla, 64% (N = 29) of the patients had protrusion and 36% (N = 22) had retrusion, with a high significance of the difference of 32%, p = 0.004. In the mandible, the patients with protrusion constituted 67% (N = 41) and those with retrusion33% (N = 22), with the very high significance of the difference (34%), p < 0.001.

Bone resorption, measured in millimeters, was compared between the patients with retrusion and protrusion through an independent-sample t-test. As a whole, higher mean resorption values were observed in the patients with retrusion in both jaws versus those in the patients with a protrusion, however, the differences were not statistically significant (Table 2)

Table 2. The occurrence of protrusions and retrusions in the maxilla and mandible

Categories incisor inclination	**N (%)**	Fisher's p	**Bone resorption** Mean±SD	t-test p
		Maxilla		
Retrusions I/NA<22°	22 (36%)	0.004	4.01±1.12mm	0.062
Protrusions I/NA>22°	39 (64%)		3.42±1.04mm	
Mandible				
Retrusions I/NA<22°	20 (33%)	<0.001	4.56±1.13mm	0.689
Protrusions I/NA>22°	41 (67%)		4.36±1.41mm	

Bone resorption between the maxilla and mandible for the cases with retrusion and protrusion showed significantly higher values in the mandible. The bone resorption mean of the patients with retrusion in the mandible was 0.55mm higher than the mean of the patients with retrusion in the maxilla (4.56±1.13mm vs. mandible 4.01±1.11mm), resulting in high statistical significance (p = 0.008). The cases with a protrusion in the mandible exceeded the bone resorption means of those in the maxilla with 0.940mm (4.36±1.41mm vs. mandible 3.42±1.04mm), with very high statistical significance of the difference, p < 0.001. (Fig. 2) illustrates the differences in the individual and mean values of bone resorption between the maxilla and mandible for the patients with retrusion (**panel A**) and protrusion (**panel B**).

The relationship between the inclination of the upper and lower incisors and the alveolar bone resorption in both jaws in the two groups of patients was examined by Pearson's r-correlation and single linear regression analysis (Fig. 3). In the maxilla, the results show a significant negative correlation for patients with retrusion (r = -0.530, p = 0.013).

The adjusted R-square indicates that 24% of the variability in alveolar bone-resorption in patients with retrusion in the maxilla could be attributed to incisor inclination. Lower inclination values are associated with higher resorption levels. The regression equation shows the following algorithm for predicting bone resorption from incisor inclination: *Bone resorption = 8.262-0.2537inclination* (**panel A**).

For the patients with a protrusion, a significant positive correlation was observed (r=0.630, p<0.0001). According to the adjusted R-square, 38% of the variability in bone resorption in cases with à protrusion in the maxilla could be linked to incisor inclination. Higher inclination values are associated with higher bone resorption levels, with a regression equation as follows: *Bone resorption = -1.203+0.1762 inclination* **(panel B).**

Fig. 2. Individual and mean bone resorption values in the maxilla and mandible for cases with retrusion and protrusion

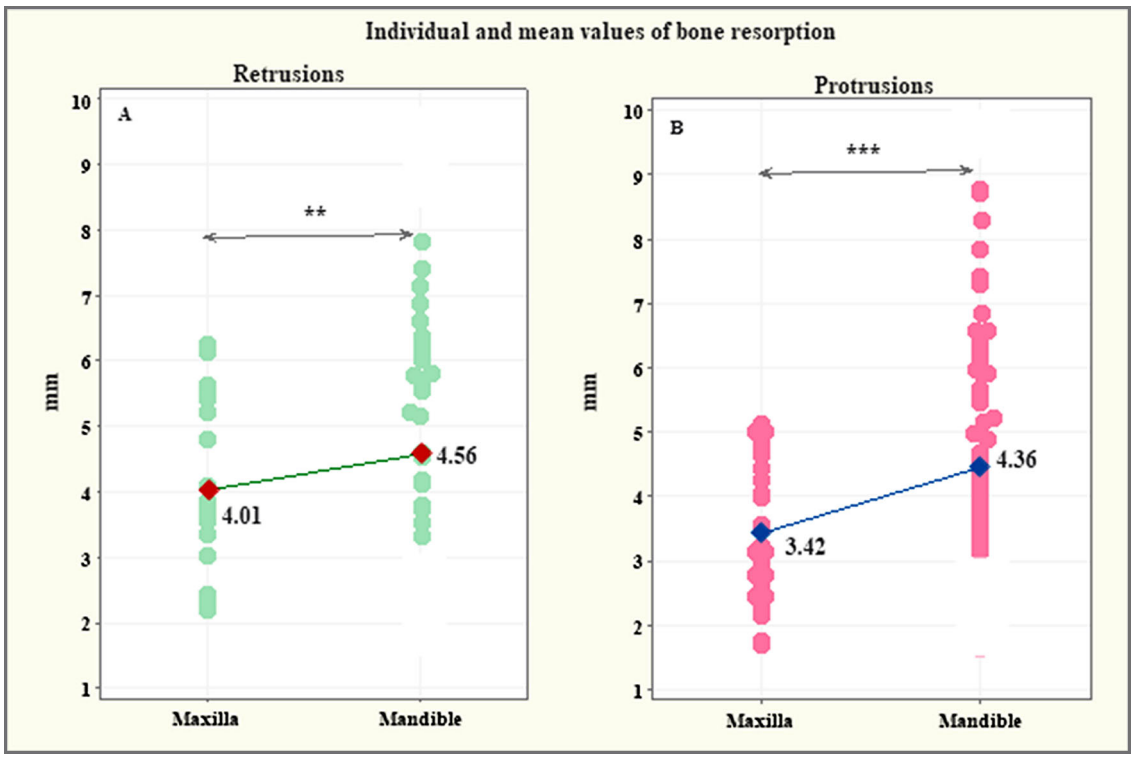
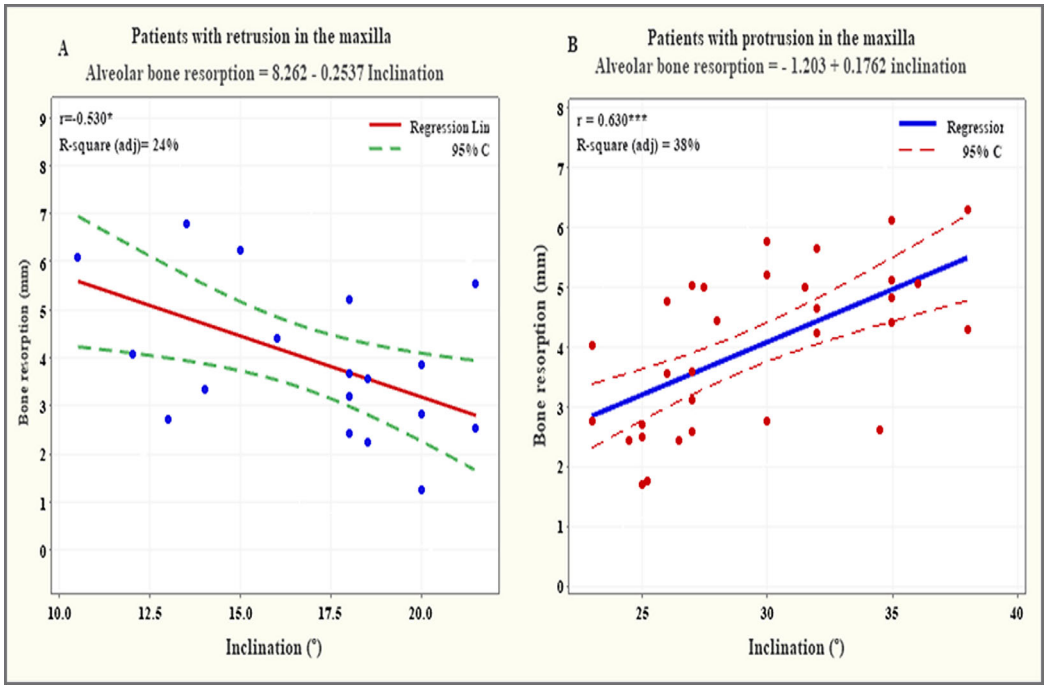


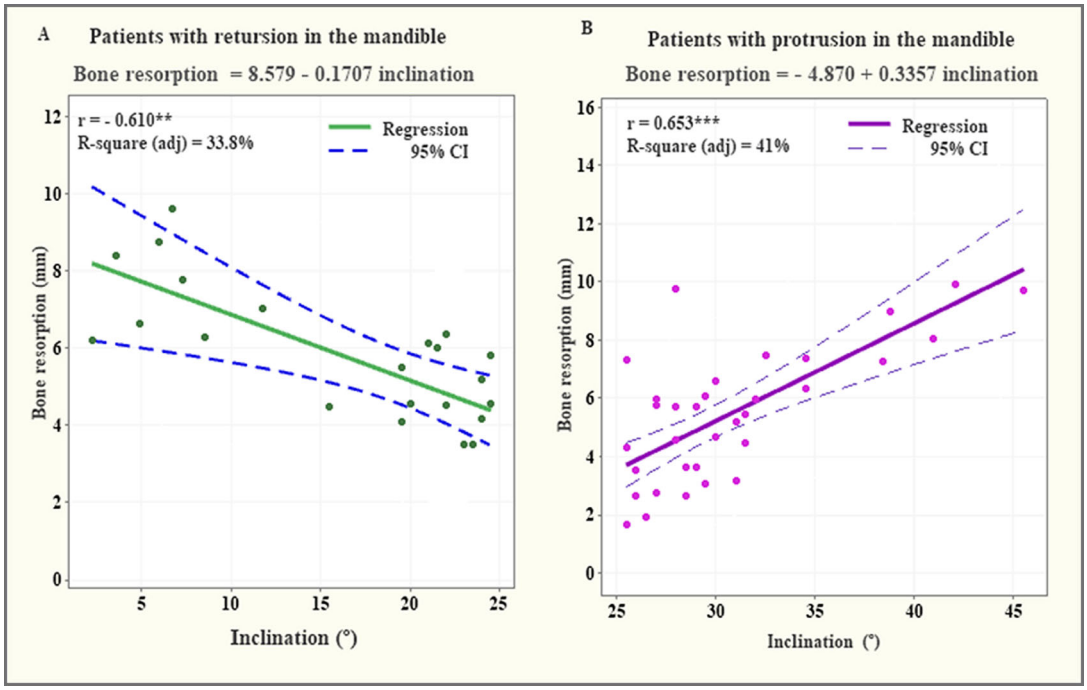
Fig. 3. Association of incisor inclination with alveolar bone resorption in the maxilla for patients with retrusion and protrusion



Likewise, in the mandible, a significant negative correlation was found for the cases with retrusion (r=-0.610, p=0.001), as higher resorption levels were associated with lower degrees of inclination (Fig. 4). The R-square (adj.) suggests that 33.8% of alveolar bone resorption in patients with retrusion in the mandible could be attributed to incisor inclination. The regression equation for predicting bone resorption from incisor inclination is as follows: *Bone resorption = 8.579-0.1707 inclination (***panel A***).*

For the patients with protrusion, a significant positive correlation was found (r=0.653, p<0.001), as higher resorption levels were associated with higher inclination values. Based on the R-square (adj), 41% of the variability in bone resorption in patients with protrusion in the mandible may be linked to the degree of incisor inclination, following the equation: *Bone resorption = -4.870+ 0.3357 inclination* (**panel B**).

Fig. 4. Association of incisor inclination with alveolar bone resorption in the mandible for patients with retrusion and protrusion



DISCUSSION:

The results showed that none of the patients had normal incisor inclination, these inclination changes can be defined as retrusion or protrusion. This is related to the fact that all patients were diagnosed with a cross bite of single or multiple teeth. In the sample, cases with incisor protrusion were significantly more frequent than those with retrusion both in the maxilla (64%) and in the mandible (67%). This corroborates the results reported in previous studies [13, 14].

The patients with retrusion did not differ significantly from those with a protrusion in the degree of bone resorption, measured in millimeters. This trend was stable both in the maxilla and mandible. However, for both the patients with retrusion and protrusion we found higher bone resorption levels in the mandible in comparison with the maxilla.

Digitally measured values are more precise than studies conducted in the past. Cephalometric analysis software allows the interposition of pre- and post-treatment cephalography. This software tool once again demonstrates dento-alveolar changes in the position of incisors and bone structures [15, 16].

The data revealed significant negative correlations between incisor inclination and bone resorption in the cases with retrusion in the maxilla and in the mandible. Decreasing incisor inclination below the norm (22/25) was associated with higher levels of bone resorption. The regression analysis showed that 24% of bone resorption in the maxilla and 33.8% in the mandible for patients with cross bite and retrusion could be linked to the degree of incisor inclination.

On the other hand, significant positive associations were observed between incisor inclination and bone resorption in the cases with a protrusion in the maxilla and in the mandible. Increasing incisor inclination above the norm (22/25) was associated with higher degrees of bone resorption. The R-square coefficients of determination showed that 38% of bone resorption in the maxilla and 41% in the mandible for patients with cross bite and the protrusion might be attributed to incisor inclination.

The proclination of mandibular incisors contributes to the development of gingival recession because the relation tooth-dental arch leads to vestibular prominence of the roots covered with thin, compact bone or missing such [17]. According to Vasconselos G. et al. [18], a more severe type of recession is present in cases of lingual inclination of lower incisors. Artun and Krogstad [19] found a significant correlation between the prevalence and severity of alveolar bone resorption and the excessive proclination of lower incisors (more than 10º). The results obtained in the study confirm this statement. The correlation analysis determined a significant linear relation between the inclination of the incisors and the extent of bone resorption.

The present study fully confirmed the results of all previous studies on the relationship between incisor proclination, gingival recession and bone dehiscence. The lower central incisors are most susceptible to recessions because their labial bony root coverage has little thickness [20]. Artun and Krogstad conclude that the thin alveolar bone in the frontal part of the lower jaw, which is a risk factor for the development of recessions, correlates with the increased height of the lower incisors' clinical crown in cases of protrusion. Some authors claim that recessions increase when the lower incisors are being protruded, even if there is adequate keratinised gingival width [19]. The teeth in a cross bite are overloaded during function. The trauma during biting of causes labial movement of the mandibular incisors in the thin labial compact bone of the mandible, leading to fenestration è dehiscence.

CONCLUSION:

From the results obtained, it is concluded that in patients with a cross bite in the frontal segment, protrusion of the lower frontal teeth develops more frequently than retrusion of the upper incisors. Higher levels of bone resorption were observed in the mandible as compared to the maxilla. A significant linear relationship was found between the inclination of the incisors and the degree of bone resorption. Our results suggest that between 24% and 41% of bone resorption could be linked to the degree of incisor inclination, depending on whether the cases are with retrusion or protrusion in the maxilla or mandible.

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