POTENTIAL RELATIONSHIP BETWEEN INCLINATION OF THE LOWER INCISORS AND MANDIBULAR SYMPHYSIS PARAMETERS IN PATIENTS WITH ANTERIOR CROSSBITE

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Abstract: In the majority of cases anterior crossbite presents with vestibular inclination of the lower anterior teeth. Vestibular bone coverage in cases of protrusion is less thick. Development of recessions in this area depends on the anatomical features of the mandibular symphysis.
Aim:To study the potential relationship between the inclination of the lower incisors and the parameters of the mandibular symphysis in patients with anterior crossbite using profile teleradiography and 3D cone beam computed tomography.
Material and methods: We examined 20 patients with anterior crossbite aged 18-37 years (mean age 25.70 ± 5.95) who had not undergone orthodontic treatment. Profile teleradiographs and 3D cone beam computed tomography were performed on the included subjects. The inclination of the lower incisors and the parameters of the symphysis were measured (width at the narrowest and widest part and height – vestibularly and lingually).
Results: Protrusion was prevalent in patients – 6 (30%) patients had retrusion and 14 (70%) had protrusion which is a significant difference of 40% (p = 0.26). The difference in the measurement of the inclination of the incisors using the two methods is not statistically significant (p = 0.128). Symphysis width measured on 3D cone beam computerized tomography amounts to 5.79 ± 0.74 mm in the narrow part and 15.41 ± 1.89 mm in the wide part. The height of the symphysis has a value of 24.19 ± 3.52 mm vestibularly and 25.20 ± 3.0 mm lingually. A significant positive correlation (Table 3) was found between the vestibular height of the symphysis and the inclination of the incisors in the mandible (r = 0.473, p = 0.035). A greater inclination of the incisors is associated with higher values of the vestibular height of the symphysis.
Conclusion:We found a high level of consistency between teleradiographic and 3D cone beam tomographic measurements of the inclination of the lower incisors. Protrusion of lower incisors is associated with higher values of the symphysis measured vestibularly.
Keywords: inclination of the lower incisors, mandibular symphysis, anterior crossbite, lateral cephalogram, 3D cone beam computerized tomography

1. INTRODUCTION

One of the reasons for anterior crossbite is the greater vestibular inclination/movement of the lower anterior teeth.[Mitchell, 1996; Mutafchiev, Krumova & Yordanov, 2003] Central lower incisors are most prone to recessions because their vestibular bone coverage is less thick and as a result the apical base is reduced.[Andrade et al, 2014; Ruf, Hansen & Pancherz, 1998] ClossLQ, Bortolini LF, Santos-Pinto A, Rösing CK (2008) study the relation between the lower jaw anatomy and the presence of recessions in lower incisors and canines. According to them the development of the recession can be a result of different anatomical characteristics of the symphysis.[Closs et al, 2014] Research claims that symphysis morphology is related to the quantity of alveolar bone.[Hoang et al, 2016] Lateral cephalometry has long been used to study the alveolar bone thickness. However, structures are three-dimensional and overlap in 2D images. 3D cone beam computed tomography (CBCT) offers three-dimensional data with better accuracy and certainty, allowing for measurements comparable to the real anatomical dimensions. [Foosiri, Mahatumarat & Panmekiate, 2018] It can read small deviations in the size and shape of the structures and it increases the accuracy of diagnosis and analysis of the treatment and final result. The created 3D models can be viewed in different projections. Thus, the approach to patient's diagnosis can be individualized. [Gurgurieva, 2011] The relationship between the morphology of the mandibular symphysis and the vestibular bone support remains unresolved. [Foosiri, Mahatumarat & Panmekiate, 2018] This made us focus on these relationships and do a preliminary study of the morphology of the mandibular symphysis, the associated vestibulo-lingual inclination of the anterior teeth and the alveolar bone loss in patients with anterior crossbite.

2. AIM

To study the potential relationship between the inclination of the lower incisors and the parameters of the mandibular symphysis in patients with anterior crossbite using Lateral cephalometry and 3D cone beam computed tomography.

3. MATERIALS AND METHODS

The study involved 20 patients with anterior crossbite of a single or group of teeth and gingival recessions in this area, of whom 16 (80%) men and 4 (20%) women, of mean age 25.70±5.95 years, age range 18 to 37 years. The number of teeth in crossbite varied between 2 and 12 for the individual patients, with a mean number of teeth in crossbite8.0±3.0 teeth (Table 1).

Table 1: Background information about the patients

Variables	Statistics
Age	
○ Mean ±SD	25.70±5.95
○ Minimal-Maximum	18-37
Sex N (%)	
○ Men	16 (80%)
○ Women	4 (20%)
Number of teeth in crossbite	
○ Mean ±SD	8.0±3.0
○ Minimal-Maximum	2-12

The patients were admitted for a consultation and treatment in the Department of Periodontology and Oral Diseases and the Department of Orthodontics in the Faculty of Dental Medicine-Plovdiv. They were informed about the nature and purpose of the study. They signed a Declaration of informed consent for participation and a Patient Information Form about the risks and expected benefits of the study. The study was approved by the institutional Ethics in Human Research Committee (protocol № 2106 /2020).

The examined subjects must have complete skeletal growth (at and over 18 years of age). The teeth in crossbite must not have crowns and cervical lesions and/or cervical fillings. The patients orthodontic treatment must not have been performed. Lateral cephalograms and 3D CBCT were done on all included patients in the Department of Diagnostic Imaging, Dental Allergology and Physiotherapy (DIDAP), FDM, MU – Plovdiv. The lateral cephalograms were done in natural head posture according to the Rickets RM (1981) method. [Ricketts, 1981] To reduce the ionizing dose of radiation the CBCT was done only in the anterior segment of the upper and lower jaw of the examined patients. After scanning the patient, standardly positioned according to the manufacturer's recommendations, images in the three projection planes (sagittal, coronal and axial) were obtained as well as a 3D reconstruction. The sagittal section was used **(Fig.1).**

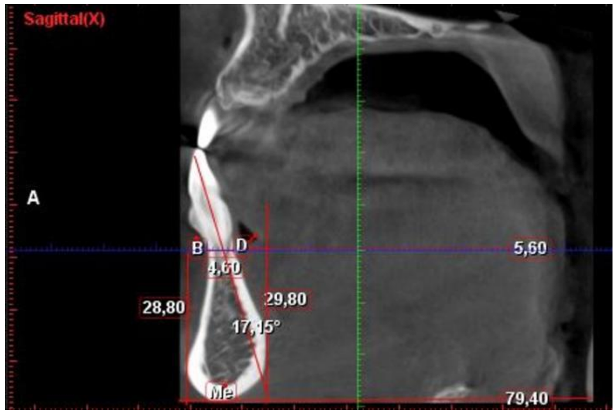

Fig. 1. CBCT 3D segment in the region of the mandibular front. Sagittal section.

A single operator performed all the tracing in a standardized manner to avoid errors due to inter operator variations. The inclination of the upper and lower incisors were evaluated and analyzed using the method of Steiner C. – 1953, shown in **Figure 2** [Proffit, Fields & Sarver, 2013]. The inclination of the incisors in mandible was measured in degrees.

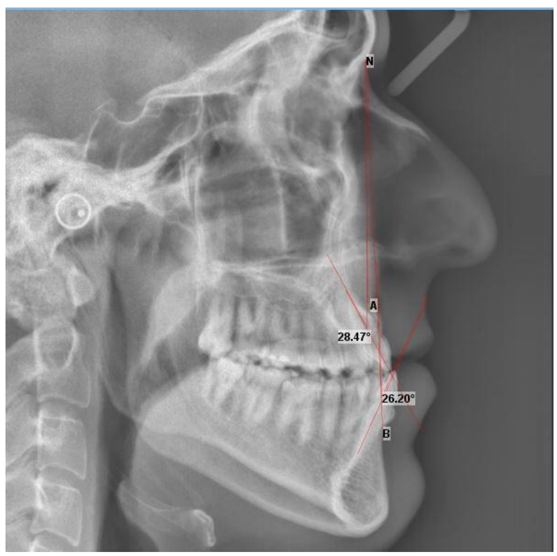

Fig. 2. Inclinationof mandibular incisors analyzed by means of the method of Steiner C.

Landmarks that are used are:

Bone points:

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

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

Lines:

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

I – the axis of a maxillary incisor;

Angular measurements:

∠ 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°.

To assess the size of the mandibular symphysis, we used the Aki T. et al. (1994) method to measure the width and height of the mandibular symphysis. The widest part of the symphysis is measured between the projections of the most anterior and the most posterior point on the symphysis on the mandibular plane. [Aki et al, 1994; Closs et al, 2014] A parallel line of the mandibular plane is drawn through point B of the symphysis. This gives the uppermost anterior point of the symphysis – SyA and the point SyB – the highest posterior point. The distance between these two points determines the width of the symphysis as close as possible to the boundary of the gingival margin and the alveolar ridge. The height of the symphysis is the vertical distance along a parallel line from point B to the tangent through the lowest point of the outline of the symphysis (the mandibular plane). [Closs et al, 2014] **(Fig. 3)**

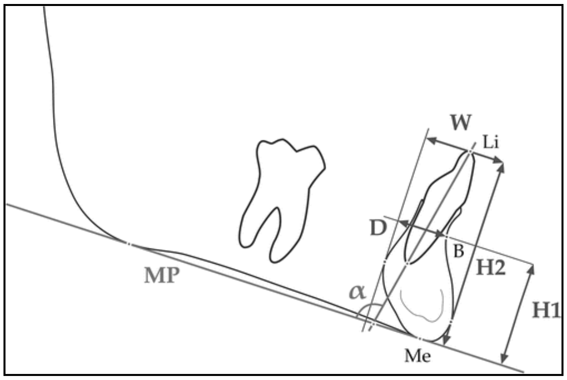

Fig. 3. Scheme for tracing of the parameters of the mandibular symphysis
(*AngleOrthod. 2014 Jan; 84 (1): 109-19.)*

To trace the symphysealparameters on the lateral cephalogram and 3D cone-beam computed tomography we utilized the CBCT Planmeca ProMax 3D Classic device in the Department of Diagnostics Imaging at the Faculty of Dental Medicine – Plovdiv.

Statistical Analysis:

The data was analyzed through the following statistical programs: IBM SPSS, version 26 (2019); MedCalc, version 19.0.7 (2020); and Minitab, version 19, 2020. The parameters of interest, including incisor inclination and symphysis dimensions, were measured on continuous scales and normally distributed according to the Kolmogorov-Smirnov test (Kolmogorov-Smirnov $p > 0.05$ for all dimensions). The dimensions of the symphysis were presented as mean values and standard deviations. The vestibular and lingual dimensions were compared through paired-samples t-test. Pearson r-correlation was used to investigate potential links between symphysis dimensions and incisor inclination. In the presence of a significant correlation, we have provided the regression equation, the R-square coefficient, and the adjusted R-square. The distribution of patients with retrusion and protrusion was presented with frequencies and percentages and the corresponding analysis was performed through Fisher's exact test. Bland-Altman's plot was used to establish the level of agreement between measurements based on lateral cephalograms and 3D cone-beam computedtomography.The mean value of the difference between the two methods was compared to zero through a one-sample t-test. Statistical significance was graded against the value of p as follows: * $p > 0.05$ - significant, ** $p < 0.01$ – very significant, *** $p < 0.001$ – highly significant.

4. RESULTS

The measurements taken by lateral cephalography were compared to those by 3D cone-beam computed tomography. The difference of means was interpreted as positive bias if the mean established through lateral cephalography was higher than that of the 3D tomography, and as negative bias if the mean by lateral cephalography was lower than the 3D mean. If the mean difference was not significantly different from zero, we accepted that the two methods were producing analogous measurements. If the mean difference was significantly different from zero, this would show that there were systematic disagreements between the two methods.

The symphysis dimensions established by each method, lateral cephalography and3D cone-beam computed tomography showed minor differences which were not significantly different from 0 (**Table2).** The highest level of agreement was observed in relation to symphysis depth with a very small negative bias of -0.05mm of lateral cephalography in comparison with 3D tomography ($p = 0.762$).

Table 2: Comparison of symphysis dimensions measured by lateral cephalography and 3D cone-beam computed tomography

Comparisons	**Mean ±SD**	**Difference (mm)**	**p**
Depth			
○ Lateral cephalogram	5.74±0.59	-0.05	0.762
○ 3D tomography	5.79±0.74		
Width			
○ Lateral cephalogram	15.60±2.06	+0.19	0.687
○ 3D tomography	15.41±1,89		
Height (vestibular)			
○ Lateral cephalogram	26.05±3.85	+1.86	0.269
○ 3D tomography	24.19±1.52		
Height (lateral)			
○ Lateral cephalogram	25.74±4.49	+0.54	0.649
○ 3D tomography	25.20±2.30		

+ = The mean of lateral cephalogram is higher than the mean of 3D;
- = The mean of lateral cephalogram is smaller than the mean of 3D

The Bland-Altman plots (**Fig. 4)** provide visual illustration of the agreement between lateral cephalograms and 3D cone-beam computed tomography in relation to the measurements of the symphysis depth (**panel A**) and width (**panel B**).

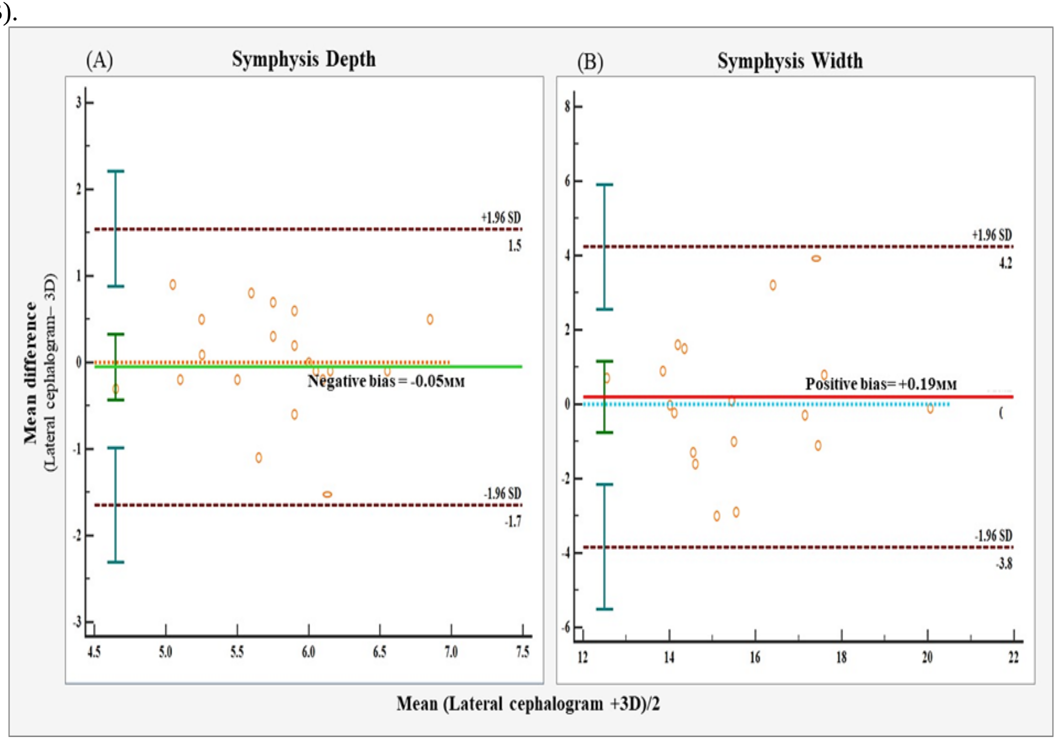

Fig. 4. Bland-Altman's plots. **Panel A**: **Symphysis depth** – The continuous line is located beneath the dotted line, illustrating a slight (not significant) negative bias – 0.05mm of lateral cephalograms in comparison with 3D tomography. All individual values are located within the 95% CI. **Panel B: Symphysis width –** The continuous line is located above the dotted line, illustrating a slight (not significant) positive bias 0.19mm of lateral cephalograms as compared to 3D tomography. All individual values lie within the 95% CI.

Figure 5 shows the Bland-Altman's plots for the level of agreement between lateral cephalography and 3D cone-beam computed tomography in the measurements of vestibular height (panel A) and lateral height (panel B).

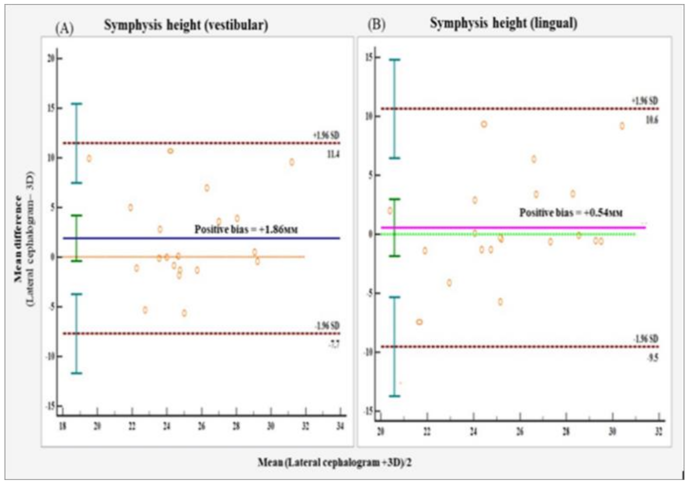

Fig. 5. Bland-Altman's plots. **Panel A**: **Vestibular height** – The continuous line is located above the dotted line, showing a positive (not significant) bias +1.86mm of lateral cephalogram in comparison with 3D tomography. All individual values are located within the 95% CI. **Panel B**: **Lingual height** – The continuous line is located a little above the dotted line, showing a positive (not significant) bias 0.54mm of lateral cephalogram in comparison with 3D tomography. All individual values are located within the 95% CI.

The incisors mandibular inclination was outside the norms in all patients: retrusion (**i/NA<25^{o}**), protrusion **(i/NA>25^{o}**). The distribution of patients with retrusions and protrusions was compared using the Fisher test (Fisher's exact test). The patients with protrusion constituted a significant majority. In the mandible, 70% (N =14) had protrusion and 6 (30%) were with retrusion (p = 0.026).
The mean value of the width of the symphysis in the narrow part is 5.79 ± 0.74 mm, and 15.41 ± 1.89 mm in the wide part. The vestibular height of the symphysis shows an average value of 24.19 ± 3.52 mm, and lingually 25.20 ± 2.3 mm. The data are summarized in Table 3.

Table 3: Dimensions of the symphysis in the present sample

Symphysis dimensions	Statistics
Depth	
○ Mean±SD	5.79±0.74
○ Minimal-Maximum	4.60-7.81
Width	
○ Mean ±SD	15.41±1.89
○ Minimal-Maxsimum	12.20-20.11
Height (vestibular)	
○ Mean±SD	24.19±1.52
○ Minimai- Maxsimum	14.54-29.43
Height (lateral)	
○ Mean ±SD	25.20±2.30
○ Minimal-Maxsimum	18.20-29.80

The mean incisor inclination in the mandible established through lateral cephalogram was 27.10±6.63° and 24.73±8.60°through 3D cone-beam tomography, with a positive bias +2.36°of lateral cephalogram in comparison with 3D tomography, which was not significantly different from zero, p = 0.128 (Table 4).

Table 4:Comparison of incisor inclination in the mandible measured by lateral cephalogram and 3D cone-beam computed tomography

Measurements	Mean ±SD	Difference (°)	p
i/NB°			
○ Lateral cephalogram	27.10±6.63	+2.36	0.128
○ 3D tomography	24.73±8.60		

+ = The mean of lateral cephalogram is higher than the mean of 3D;
- = The mean of lateral cephalogram is smaller than the mean of 3D
The Bland-Altman's plot (**Fig. 6**) illustrates the level of agreement between lateral cephalogram and 3D cone-beam computed tomography in the measurements of incisor inclination in the mandible.

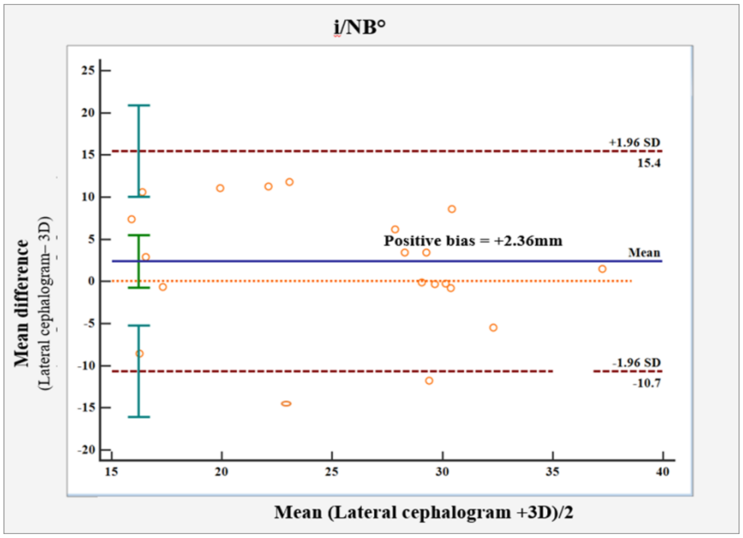

Fig. 6. Bland-Altman's plot. The continuous line is located above the dotted line, showing a small (not significant) positive bias = 12.36° of lateral cephalograms in comparison with 3D tomography. All individual values are located within the 95% CI.

The potential relationship between the inclination of the lower incisors and the size of the symphysis was investigated by correlating Pearson-r. A moderate positive correlation was found (Table 5) between the height of the vestibular symphysis and the inclination of the incisors in the lower jaw (r = 0.473, p = 0.035). The other three dimensions of the symphysis do not show a significant relationship with the inclination of the incisors.

Table 5: Results of the Pearson correlation analysis betweenthe dimensions of the symphysis and the inclination of the incisors

Symphysis dimensions	Incisor Inclination Mandible i/NA°
Depth	
Pearson correlation coefficient	0.150
p	0.527
Width	
Pearson correlation coefficient	-0.116
p	0.626
Height (vestibular)	
Pearson correlation coefficient	0.473
p	0.035*
Height (lateral)	
Pearson correlation coefficient	0.188
p	0.427

The significant positive association between the inclination of the incisors and the dimensions of the symphysis is illustrated in **Fig. 7.** In the lower jaw, the prognostic regression equation **(vestibular height = 17.36 + 02521 i / NA°)** is related to R-square = 22.4% and R-square corrected = 18.10%.

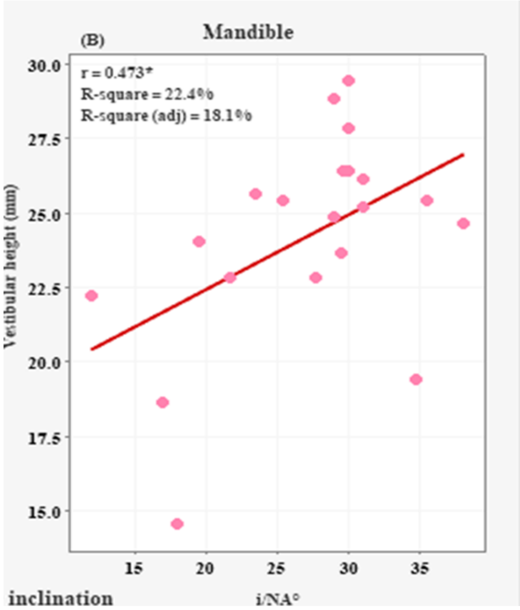

Fig. 7. Significant positive association between mandibular incisors' inclination and vestibular height of the symphysis

5. DISCUSSION

The inclination of the lower incisor is important both for predicting the patient's periodontal health and for planning orthodontic treatment. The movement of the lower incisors is limited and depends on the anatomical parameters of the mandibular symphysis. Greater vestibular inclination of the lower incisors with a narrow symphysis leads to gingival recession and bone destruction in this area. [Gütermann et al, 2014] The size of the symphysis depends on the type of growth (hypo- or hyperdivergent type of growth). [Andreeva & Dilkova, 2016] The morphology of the symphysis is related to the amount of alveolar bone. Patients with anterior crossbite, combined with sagittal changes in the lateral part of the dentition and with complete jaw growth have an increased angle of the mandibular plane (hyperdivergent). This contingent has a narrow symphysis and the movements of the roots of the lower incisors are limited. [Kalina, 2019] The long and narrow symphysis suggests progressive loss of the vestibular and lingual mandibular alveolar bone due to a thinner alveolar bone support. [Foosiri, Mahatumarat & Panmekiate, 2018] Another study of the same contingent corresponds to the above mentioned data. Mean symphysis values were compared with the standards set by Gütermann C et al (2011) for the 18-30 age group. [Gütermann et al, 2014] The width and height of the symphysis in patients with anterior crossbite showed significant deviations from the established norms for the age group 18-30 years. The narrow and wide part of the symphysis in patients with crossbite has a significantly lower value than the established norms. The vestibular and lingual height of the symphysis shows significantly higher values in patients with crossbite than normal. These results give reason to assume that the presence of a crossbite affects the width and height of the symphysis - narrow and elongated. [Krasteva et al, 2020]
The anatomy of the symphysis and the vestibular inclination of the mandibular incisors is of great importance for the occurrence of gingival recessions in the presence of malocclusions, especially in patients with anterior crossbite. The latter is an occlusal trauma that leads to a change in the position of the teeth. [Ustun et al, 2008]
Our pilot study showed that individual variations in vestibular symphysis height can be explained by the values of the inclination of the lower incisors. The greater inclination of the lower incisors in our sample corresponds to a greater vestibular height of the mandibular symphysis, which is in agreement with the studies published in the known literature.

6. CONCLUSION

1. Patients with mandibular protrusion are significantly prevalent among patients with anterior crossbite and gingival recessions.

2. We found a high level of consistency between cephalometric and 3D cone-beam tomographic measurements of the inclination of the lower incisors.
3. Patients with mandibular protrusion are associated with greater vestibular symphysis height values.

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