Practical Application of a Method for Assessing the Progression of Gingival Recessions in Orthodontically Treated Patients – A Pilot Study

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Abstract

Aims: The objective of the present study was to discuss the practical application of a new method for measuring bone width in the anterior section of the mandible to assess the progression of gingival recessions after orthodontic treatment based on a description of case studies.

Methods: Three cases with skeletal classes I, II and III aged 20-29 were presented. We assessed the risk of gingival recessions around lower incisors by analysing cephalograms before and after orthodontic treatment. The following values were analysed: the angle of buccal bone thickness in the anterior section of the mandible (API-CEJ2-B), the height of bone dehiscence (CEJ2-Id) and the width of the mentalis (B-D). Recession height (RD) and width (RW) were clinically measured using calibrated 1mm periodontometer.

Results: The mean baseline angle of API-CEJ2-B[°] was 22.23° before and no lower than 16° after treatment. In all patients CEJ2-Id was 0.56 mm before and greater than 1.4 mm following treatment. This was reflected clinically in the absence of new gingival recessions or the progression of an already existing recession in the area of the lower incisors in the first two cases. In the third case, height of recessions was increased to 1.25 mm average value. The mean baseline width for B-D was 13.46 mm; in all cases it increased up to 14.5 mm after treatment, most significantly in the case of a female patient with skeletal class II.

Conclusions: An analysis of cephalometric images, including basic cranio- and gnathometric measurements together with a careful assessment of bone, mucosal and dental parameters of the alveolar ridge, can be a useful instrument to determine the risk of gingival recessions and to choose the right orthodontic treatment option, ensuring the highest possible aesthetic-functional treatment outcome.

Key Words: Gingival recessions, Orthodontic treatment, Cephalometric analysis

Introduction

Gingival recession is classified as a borderline condition between periodontal disease and a healthy state [1]. Connective tissue attachment loss occurs as a result of the apical displacement of the gingival margin below the CEJ (cemento-enamel junction) combined with the exposure of the tooth root surface [2-4]. Lang and Löe [5] as well as Kassab [6] called recession local or generalised exposure of the root surface of teeth without accompanying inflammation and gingival pockets.

Recessions are a problem that affects society as a whole. Connective tissue attachment loss affects both patients in well-developed populations as well as those in poorer populations with limited knowledge of oral hygiene [7]. Recessions tend to increase with age [8,9] and occur more frequently in men [10]. The etiopathogenesis of recessions is complex. Geiger described the congenital and acquired etiological factors that cause recessions [11]. Pietrzyk et al. distinguished between primary and secondary forms of recessions [12]. Primary recessions are determined by morphological and traumatic factors, while secondary recessions emerge as a result of bacterial infections of periodontal tissue. Konopka and Dominiak divided the causes of recessions according to anatomy, trauma, hygiene and age [13].

One basic factor conducive to recessions is the morphology of the alveolar process, in particular the thickness of the bone and the gingiva covering it [14]. A thin periodontal biotype characteristic of LTS syndrome (= long tooth syndrome) with extended, narrow crowns as well as barely exposed gums when smiling is more predisposed to recessions. The position of the teeth in the alveolar ridge as well as the strength and length of the muscle attachments also play an important role. Recurrent variables that have a significant impact on the development of recessions include age, sex, frequency of tooth brushing, level of dental education and the existence of dental defects [15-17]. The data available in the literature show that only some potential factors are subject to parametric assessment, or only those which are known and evaluated on a general basis. Sometimes the available literature lacks numerical and/or descriptive values for these parameters which are potentially known but not assessed. The interest of patients in orthodontic treatment has increased considerably over the last few years [18]. In a protective sense, harmonious occlusal contacts stabilise the tooth row, preclude tooth migration and tipping, stabilise the bite and prevent elongation of antagonistic teeth [19]. Beside the rehabilitation and improvement of the chewing function one factor in particular that motivates patients to seek orthodontic treatment is a concern over aesthetic issues [20,21]. Owing to the high incidence of recessions in the general population and the desire of people of increased age to have an aesthetic and more attractive smile, orthodontists often face the problem of assessing the risk of recessions or the further progression of already existing recessions probably occurring during orthodontic treatment. The treatment of

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such once appeared periodontal defects is a demanding task and surgical procedures often do not lead to a desired osseous regeneration [22], which is why a development or an increase of recessions should be prevented as far as possible, especially if only aesthetic corrections are demanded. Treatment planning should be based on a detailed analysis of the construction of the skeletal, muscular and mucosal systems. The impact of an orthodontic treatment as a cause of recessions can be assessed by analysing head films of a patient's skull both prior to treatment and after its conclusion [23]. Dominiak [24] proposed the idea of assessing the risk of periodontal recessions by measuring the angle of the buccal bone thickness API-CEJ2-B, the height of the bone dehiscence as the distance CEJ2-Id, as well as the width (API-B) and height (CEJ2-B) of the bone in the anterior section of the mandible during a broader cephalometric analysis (*Figure 1*). Based on these measurements, the following values are strong prognostic factors in the development of recessions: API-CEJ2-B angle <16°, bone dehiscence height >1.4 mm and patient´s age >24. The multiple regression model devised for the study helped to explain their potential recession-forming impact in 72% of cases [24].

Aims and Objectives

The aim of the present study was to discuss the practical application of a new method for measuring bone width in the anterior section of the mandible and assessing the risk of gingival recessions based on a description of selected case studies.

Material and Methods

The study presents three female patients treated in the Policlinic of Medical University of Wroclaw, Poland between 2011-2013 with skeletal class I, II and III, aged between 20 and 29 years. Treatment of all patients was performed by one orthodontist, but two independent practitioners estimated initial and final results. All patients were information about proper hygiene of oral cavity e.g. tooth brushing without pressure, using oscillating-rotating toothbrushes with pressure indicators, below three times per day. Recession height (RD) and width (RW) were measured clinically before and 1 month after orthodontic treatment, using calibrated 1 mm periodontometer. The conditions of qualification for the research were achieve plaque index acc. to Silness and Löe (PI) [25] and Gingival Index (GI) <20% [26], Probing Pocket Depth (PPD) <4 mm at the four surfaces of the tooth with recessions.

Intraoral photographs of all patients were assessed. In addition, cephalometric analyses of the patients' head films were performed both before treatment and after removing the fixed orthodontic appliance, taken within a month of completing the treatment. Intraoral photographs were used to assess, on a scale of 0-1, the presence or deepening of gingival recessions on the vestibular side of the mandibular incisors. It was assumed that the absence of a visible Cemento-enamel Junction (CEJ) indicated the absence of gingival recession.

In the present study we used digital head films of the facial section of the patients' skulls taken in centric occlusion. Head films with a centimetre measure scale were qualified for the study, which made it possible to calibrate the images and achieve real linear measurements. The patients' cephalograms were evaluated using Ortodoncja software, version 7.0.7 (Ortobajt®, Poland). This software was enlarged to include an analysis comprising the following measurements of the structure of the bone in the anterior section of the mandible: the angle of the buccal bone thickness of the alveolar process in the anterior section of the mandible API-CEJ2-B[°], bone dehiscence height CEJ2-Id[mm], the width of the bone as the distance API-B[mm] and bone height CEJ2-B[mm]. To

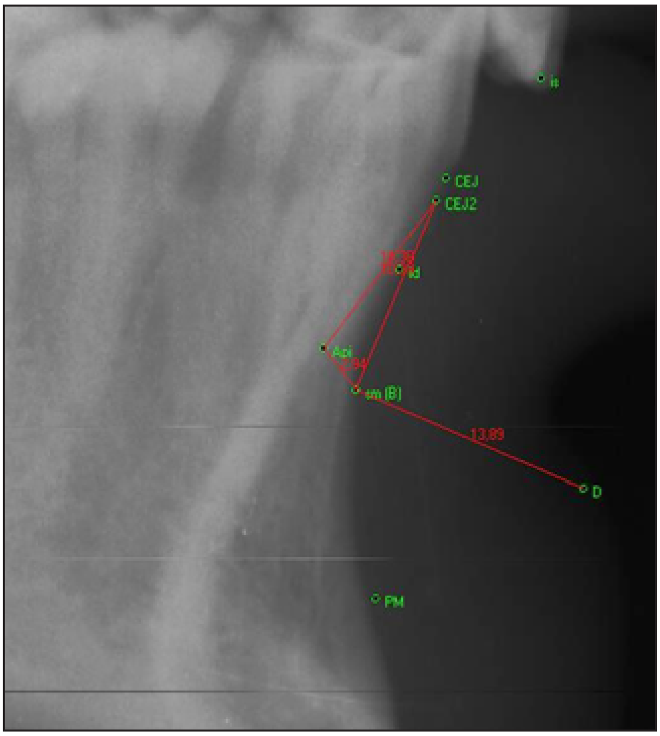

Figure 1. *Radiological measurement of angle of buccal bone thickness API-CEJ2-B, distance CEJ2-B, API-B, and width of the mentalis B-D.*

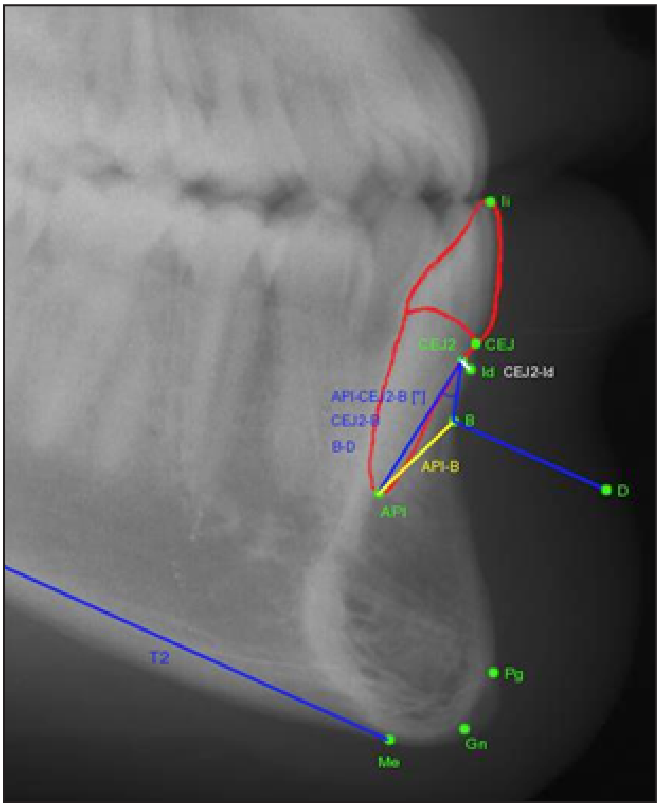

Figure 2. *Cephalometric measurements according to Dominiak.*

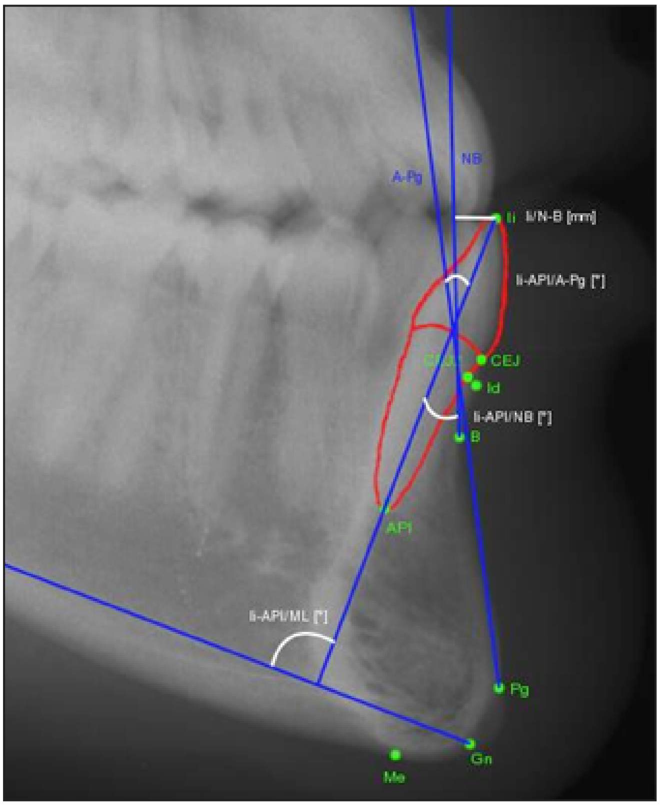

Figure 3. *Measurements describing the position of the lower incisors.*

Table 1. *Results of cephalometric analysis of the head film of the first female patient.*

Parameter	**Before therapy**	**After theraphy**	**Norm**
API-CEJ2-B [°]	19.8	17.3	>16
CEJ2-Id [mm]	0.7	0.9	< 1.4
API-B [mm]	5.3	5.2	
CEJ2-B [mm]	11.0	11.3	
B-D [mm]	13.9	15.1	13.5 ± 2.6
Ii-API/A-Pg [°]	29.3	25.4	22 ± 4
Ii-API/ML [°]	100.6	95.6	94.0
Ii-API/NB [°]	31.1	25.0	25.0
Ii/N-B [mm]	6.9	5.6	4.0

Table 2. *Results of cephalometric analysis of the head film of the second female patient.*

Parameter	**Before therapy**	**After therapy**	**Norm**
API-CEJ2-B [°]	26.1	20.2	>16
CEJ2-Id [mm]	0.8	1.1	< 1.4
API-B [mm]	4.8	3.8	
CEJ2-B [mm]	10.5	9.8	
B-D [mm]	10.6	12.1	13.5 ± 2.6
Ii-API/A-Pg [°]	27.5	26.7	22 ± 4
Ii-API/ML [°]	104.7	103.1	94.0
Ii-API/NB [°]	35.7	34.4	25.0
Ii/N-B [mm]	7.6	8.0	4.0

determine the angle of buccal bone thickness among other things, we had to establish the API point at the most anterior positioned mandibular incisor, for which the following measurements were used: Ii-API/A-Pg[°], Ii-API/ML[°], Ii-API/NB[°], Ii/N-B[mm] (*Figure 3*). The norms for the parameters assessed in the study are presented in *Table 1-3*.

The critical values determining the development of recessions were adopted in accordance with the studies by Dominiak [24], and were as follows: angle of API-CEJ2-B <16°, height of bone dehiscence >1.4 mm and age of patient >24.

Table 3. *Results of cephalometric analysis of the head film of the third female patient.*

Parameter	**Before therapy**	**After therapy**	**Norm**
API-CEJ2-B [°]	20.8	18.2	>16
CEJ2-Id [mm]	0.2	0.8	< 1.4
API-B [mm]	8.1	4.2	
CEJ2-B [mm]	4.7	8.1	
B-D [mm]	15.9	16.3	13.5 ± 2.6
Ii-API/A-Pg [°]	20.4	23.6	22 ± 4
Ii-API/ML [°]	79.0	83.1	94.0
Ii-API/NB [°]	11.5	14.4	25.0
Ii/N-B [mm]	1.8	1.9	4.0

The width of the mentalis was also assessed as the distance between point B and the author's point D [mm] [24]. To determine this point a straight line T2' was drawn as a line parallel to T2 (the line connecting the tangential point of the lower bulge of the angle of the mandible with the straight line exiting from Menton) passing through point B. Point D was located on this straight line at the point where it intersects with the outline of the soft tissue (*Figure 2*).

All those who qualified for the study were informed about the objectives of the tests and measurements and their written consent was obtained through the signing of protocols approved by the Bioethics Committee, number KB-69/2013.

Case Series

Case study 1

Female patient M.W., aged 29 and with skeletal class I. In her childhood, the upper and lower right first premolars had been removed for orthodontic reasons. The treatment plan provided for the extraction of the upper and lower left first premolars, but the patient did not give her consent for this. The proposed solution entailed intensive approximal reduction of the enamel on the left side of the dental arches. The treatment involved a bioprogressive technique using braces with 0.18 slot and segmented arch wires. *Figures 4A-C* show the dentition of the female patient prior to treatment on the day the appliance was removed and one year after retention as well as after two operations to cover a recession in the area of the lower left canine. An analysis of head films (*Figures 5A and 5B, Table 1*) indicated that prior to treatment the API-CEJ2-B angle was 19.8° and bone dehiscence height CEJ2-Id amounted to 0.7 mm. At the end of the treatment the API-CEJ2-B angle was 17.3° while CEJ2-Id amounted to 0.9 mm. The bone parameters in the anterior section of the mandible deteriorated after treatment. However, they did not exceed the threshold values. The width of the mentalis prior to treatment was 13.9 mm, but following treatment it had increased to 15.1 mm. Gingival recession had deepened significantly around the lower left canine for the value 8 mm and width 7 mm.

Case study 2

Female patient A.G., aged 27 and with skeletal class II. The treatment was carried out without any teeth being extracted. Retrusion of the anterior upper teeth had blocked protrusive movement of the mandible, and development of the maxillary dental arch made it possible to achieve correct occlusal

Figure 4. *Intraoral photographs of the female patient case 1 prior to orthodontic treatment (20.02.2011), on the day of the removal of the device (12.04.2013) and after one year of retention (25.04.2014) and recession coverage using connective tissue graft.*

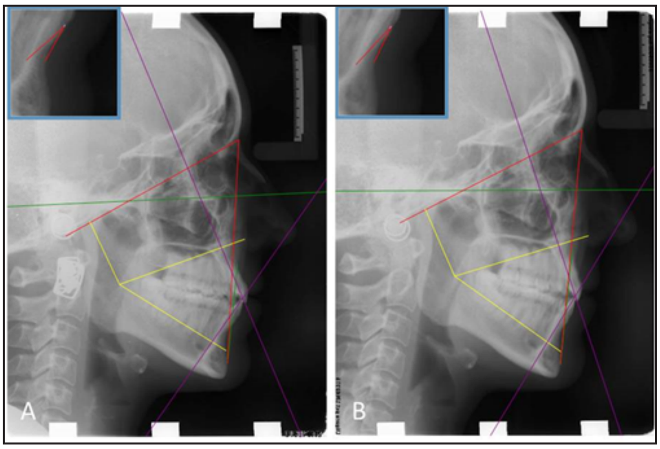

Figure 5. *Analysis of a head film of patient case 1 before and after orthodontic treatment.*

contacts. Prior to treatment the angle of API-CEJ2-B was 26.1° and the bone dehiscence height was CEJ2-Id 0.8 mm. Following treatment the angle decreased to 20.2°. On the other hand, the bone dehiscence height increased to 1.1 mm. The angle of the buccal bone thickness in the anterior section of the mandible declined during treatment but did not reach the borderline value of 16°, similarly as in the case of bone dehiscence height. The female patient had low measurements for mentalis width: 10.6 mm prior to treatment and 12.1 mm after treatment (*Figures 7A and 7B, Table 2*). Despite declining significantly, although without exceeding the limit values, the parameters of bone height and width for the anterior section of the mandible did not result in gingival recession in the area of the lower incisors (*Figures 6A and 6B*).

Case study 3

Female patient K.K., aged 20 and with skeletal class III was treated using non-extraction methods. As an alternative to extraction, stripping of patient's lower teeth was performed. The space achieved in the arch was used for the derotation of the anterior teeth. Prior to treatment the API-CEJ2-B angle in the anterior section of the mandible was 20.8° and CEJ2-Id amounted to 0.2 mm. Following treatment, the angle of API-CEJ2-B decreased to 18.2°. On the other hand, the bone dehiscence height increased to 0.8 mm. Prior to orthodontic treatment the width of the mentalis (B-D) was 15.9 mm, and after treatment it had increased to 16.3 mm (*Figures 9A and 9B, Table 3*). In this case, none of the bone parameters exceeded the limit values. As a result of the deterioration of the bone structure parameters, the gingival recessions in the

Figure 6. *Intraoral photographs of the female patient case 2 before (05.01.2011) and after orthodontic treatment (18.03.2013).*

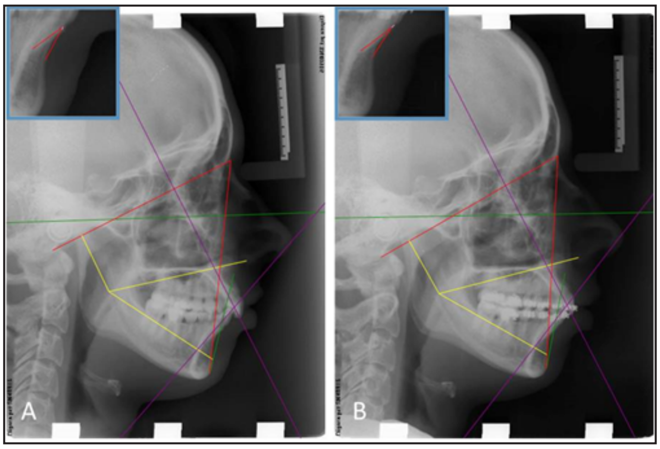

Figure 7. *Analysis of a head film of patient case 2 before and after orthodontic treatment.*

Figure 8. *Intraoral photographs of the female patient case 3 before (10.03.2011) and after orthodontic treatment (29.04.2013). Visible recessions and wedge defects are seen on the left and right canine and incisors (tooth 32, 31 and 42) after treatment.*

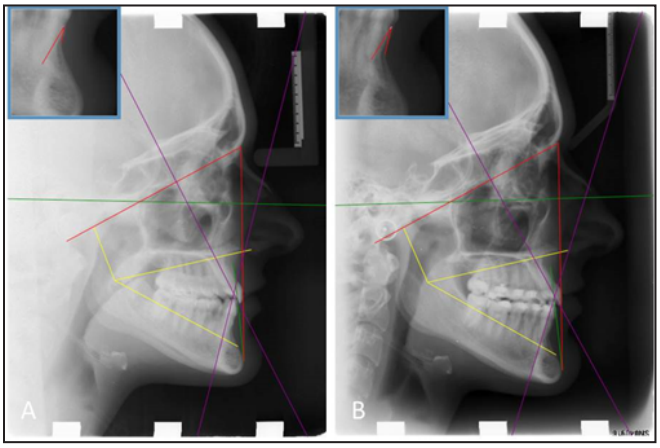

Figure 9. *Analysis of a head film of patient case 3 before and after treatment*

Table 4. *A comparative analysis of bone parameters and treatment effects achieved.*

Patient Age	API-CEJ2-B [°]		CEJ2-Id [mm]		Treatment effect
Patient 1 29	19.8	17.3	0.7	0.9	No recessions around lower incisors. Periodontal recession had deepened significantly around lower left canine.
Patient 2 27	26.1	20.2	0.8	1.1	Absence of periodontal recessions in anterior section of mandible.
Patient 3 20	20.8	18.2	0.2	0.8	Recessions observed prior to treatment did not intensify.

region of the anterior teeth, observed prior to treatment, had been increased to: 1 mm (tooth 32), 2 mm (tooth 31) and 1 mm (tooth 41). In spite of the initially oral hygiene instructions, there were observed non-caries lesions as a wedge defects (*Figures 8A and 8B*).

Discussion

The inclination angle of the front teeth and the bending forces resulting from it can reach high levels and increase the risk of periodontal destruction on account of an occlusal trauma which is the lower, the more axially the load of the front teeth is and the closer the contact point of upper and lower front tooth lies in the area of the centre of resistance. Hence, the inclination of the front teeth is of big interest within the treatment planning [27].

One of the more important factors that should be assessed prior to the beginning an orthodontic tooth movement procedure, especially in the case of incisors, is the anatomic structure of the alveolar ridge, including the mandible symphysis. This is due to the existence of orthodontic "walls", demarcated by the cortical bone of the alveolar ridge at the height of the root apex of the incisors, a borderline which cannot be exceeded during treatment. This limitation, described by Handelman [28] is in accordance with the observations of Wennström [29], who stated that as long as tooth movement occurs within the alveolar ridge, it will not cause periodontal recession. On the other hand, when the bone wall is crossed as a result of excessive tooth movement in a vestibular direction, the height of the cortical bone of the alveolar ridge will be reduced [30-32]. These authors explained the principle of how alveolar bone loss occurs, but did not offer any method for assessing the critical values of bone width for orthodontic treatment. Numerous experimental and clinical studies have shown, moreover, that moving teeth in the opposite direction or the cessation of force [33-35] leads to the reconstruction of bone height, caused by, among other factors, the size of the fenestration and/or bone dehiscence, as well as the state of the periodontal tissue. In contrast to this view is a study by Nyman & Karring [34], which demonstrated that bone regeneration is significantly restricted if both, its organic and non-organic elements, are lost. Hence, the possibility of bone self-regenerating depends on the degree of vestibular bone loss. The greater the bone loss, the less likely it is that it can be regenerated and may assure the proper size of the alveolar process [36]. Moreover, it has been proven that bone regeneration occurs when the soft tissue, covering the root, has been preserved. In the case of buccal plate loss, where the keratinized gingiva has appropriate thickness, the role of bone formation is assumed by the periosteal cells, i.e. bone is formed on the side of the periosteal [34]. This mechanism is disturbed when tissue on the vestibular side becomes too thin, both as a result of excessive force, and through a genetically conditioned periodontal biotype. Hence, periodontal recession can be avoided by assessing the following determinants prior to orthodontic treatment: the width and height of the alveolar ridge structure, in particular buccal plate thickness in front of the tooth in the region from the crest of the alveolar ridge up to the region of the root apex in the sagittal plane, as well as bone dehiscence occurring before treatment and assessment of periodontal biotype. The results of the authors' own observations presented in *Table 4* show that the angle of API-CEJ2-B in each patient following treatment was no less than 16° and the height of bone dehiscence was >1.4 mm. These results were reflected clinically in the absence of recessions in the region of the mandibular incisors in Case 1 and 2 and a slight increase in Case 3 presented in this study. Probably last case recessions could be a result of wrong methods of tooth brushing, because in each of these teeth wedge defects were visible. Based on an assessment of the parameters describing the position of the lower incisors (*Tables 1-3*) we can state that retrusion occurred in the female patients 1 and 2. Due to this position of the incisor crowns, in the marginal area of the alveolar ridge the pressure of the mentalis and lower lip is exerted and can increase vertical bone loss and cause recessions. Thus, from a clinical point of view it may be valuable to assess muscle parameters, in particular, measure the width of the mentalis. Another study conducted by the authors [24] established the mean value of B-D prior to treatment at 13.5 (2.6 mm). Following orthodontic treatment this value increased significantly to 14.3 ± 3mm. A significant increase was then observed in patients with gingival recessions, whereas in the control group without recessions the treatment did not lead to a change in the B-D values, which remained at the level of 14 mm ± 2.7 mm. An also significant fact is that an expansion treatment reduced the width of the mentalis, while the width increased when retraction was used. This can be reflected clinically in the occurrence of gingival recessions. In patients with recessions, the B-D score was lower than in patients without recessions, i.e. the muscle was shorter, which might have exerted greater pressure on the surrounding tissue. Similarly, especially when the arch is expanded, an increase in the width of the mentalis following treatment might be a consequence of its expansion, by which the muscle mass also increases. In this case the time needed to carry out the tests may be also important. As a matter of routine, cephalometric images were taken one month after the treatment was completed. No remote observations, which might have helped determine the real effect on the width of the mentalis, were made. Similarly, in all three clinical cases described by the authors, the mean width of the mentalis increased from 13.46 mm up to 14.5 mm.

In the third case, the muscle mass most slightly increased, i.e. skeletal class III, and it had the widest baseline value. On the other hand, the patient with skeletal class II had the shortest muscle prior to treatment. The same patient also experienced the biggest increase in muscle width, i.e. by 1.5

mm. The muscle width with the most average was in the case of class I and amounted 13.9 mm prior to treatment, which was similar to the results of other studies [24].

Conclusion

Although in the different cases presented in our study a distinction in muscle mass, alveolar bone supply, cephalometric and orthodontic treatment parameters as well as a connection between recessions progressions could be discovered, it only concerns a case presentation, which limits the power.

Nevertheless the use of the method outlined above enables the dentist to assess the risk of periodontal recessions during planned orthodontic treatment by identifying the position of the incisors and measuring the width and height of the bone in the anterior section of the mandible. It may also help the dentist to choose an appropriate treatment method, i.e. either expansion of the dental arches or their retraction. However, it is important that the method presented in this study is only reliable for measuring the position of lower incisors. Since all measurements are evaluated on the basis of 2D imaging in a sagittal projection. More comprehensive clinical studies are needed to draw a significant prognostic conclusion.

References

1. Tugnait A, Clerehugh V. Gingival recession-its significance and management. *Journal of Dentistry.* 2001; **29:** 381-394.

2. McComb JL. Orthodontic treatment and isolated gingival recession: a review. *British Journal of Orthodontics.* 1994; **21**: 151-159.

3. Wennström JL. Mucogingival therapy. *Annals of Periodontology.* 1996; 671-701.

4. Chambrone L, Chambrone D, Pustiglioni FE, Chambrone LA, Lima LA. The influence of tobacco smoking on the outcomes achieved by root-coverage procedures: a systematic review. *Journal of the American Dental Association.* 2009; **140**: 294-306.

5. Lang NP, Loe H. The relationship between the width of keratinized gingiva and gingival health. *Journal of Periodontology*. 1972; **43**: 623-627.

6. Kassab MM, Cohen RE. The etiology and prevalence of gingival recession. *Journal of the American Dental Association* 2003, **134**: 220-225.

7. Wennstrom, JL, Pini Prato GP. Mucogingival Therapy -- Periodontal Plastic Surgery. In: Lindhe J, Karring T, Lang NP (Editors) Clinical Periodontology and Implant Dentistry, (4th edn.) Oxford: Blackwell Munksgaard; 2003, pp. 579.

8. Sarfati A, Bourgeois D, Katsahian S, Mora F, Bouchard P. Risk assessment for buccal gingival recession defects in an adult population. *Journal of Periodontology.* 2010; **81**: 1419-1425.

9. Matas F, Sentis J, Mendieta C. Ten-year longitudinal study of gingival recession in dentists. *Journal of Clinical Periodontology.* 2011; **38**: 1091-1098.

10. Muller HP, Stadermann S, Heinecke A. Gingival recession in smokers and non-smokers with minimal periodontal disease. *Journal of Clinical Periodontology.* 2002; **29**: 129-136.

11. Geiger AM. Mucogingival problems and the movement of mandibular incisors: a clinical review. *American journal of Orthodontics*. 1980; **78**: 511-527.

12. Pietrzyk M, Górniak D, Jabłońska E. Niektóre problemy periodontalne towarzyszące terapii ortodontycznej dzieci i dorosłych. Recesje przyzębia brzeżnego. *Mag Stomatol* 2002; **12**: 8-13.

13. Konapka T, Dominiak M. Współczesne poglądy na etiopatogenezę recesji przyzębia. *Implants*. 2007; **2**: 36-40.

14. Grover V, Kapoor A, Malhotra R, Sachdeva S. Interest and satisfaction of dentists in practicing periodontics: A survey based on treatment of gingival recession. *Dental research Journal.* 2012; **9**: 404-413.

15. Sugihara N, Maki Y, Okawa Y, Hosaka M, Matsukubo T, Takaesu Y. Factors associated with root surface caries in elderly. *The Bulletin of Tokyo Dental College.* 2010; **51**: 23-30.

16. Preshaw PM, de Silva N, McCracken GI, Fernando DJ, Dalton CF, Steen ND, Heasman PA. Compromised periodontal status in an urban Sri Lankan population with type 2 diabetes. *Journal of clinical Periodontology.* 2010; **37**: 165-171.

17. Goutoudi P, Koidis PT, Konstantinidis A. Gingival recession: a cross-sectional clinical investigation. *The European Journal of Prosthodontics and restorative Dentistry.* 1997; **5**: 57-61.

18. Kerosuo H, Abdulkarim E, Kerosuo E. Subjective need and orthodontic treatment experience in a Middle East country providing free orthodontic services: a questionnaire survey. *The Angle Orthodontist.* 2002; **72**: 565-570.

19. Hutzen D, Proff P, Gedrange T, Biffar R, Bernhard O, Kocher T, Kordass B. Occlusal contact patterns--population-based data. *Annals of Anatomy.* 2007; **189**: 407-411.

20. Klages U, Bruckner A, Guld Y, Zentner A. Dental esthetics, orthodontic treatment, and oral-health attitudes in young adults. *American journal of Orthodontics and Dentofacial Orthopedics.* 2005; **128**: 442-449.

21. Birkeland K, Katle A, Lovgreen S, Boe OE, Wisth PJ. Factors influencing the decision about orthodontic treatment. A longitudinal study among 11- and 15-year-olds and their parents. *Journal of orofacial Orthopedics.* 1999; **60**: 292-307.

22. Zietek M, Gedrange T, Mikulewicz M. Long term evaluation of biomaterial application in surgical treatment of periodontosis. *Journal of Physiology and Pharmacology.* 2008; **59** (Suppl 5): 81-86.

23. Vasconcelos G, Kjellsen K, Preus H, Vandevska-Radunovic V, Hansen BF. Prevalence and severity of vestibular recession in mandibular incisors after orthodontic treatment. *The Angle Orthodontist.* 2012; **82**: 42-47.

24. Dominiak M. Własna metoda oceny prognozowania recesji przyzębia. Wroclaw*: Praca habilitacyjna*; 2009.

25. Silness J, Loe H. Periodontal Disease in Pregnancy. ii. Correlation between Oral Hygiene and Periodontal Condtion. *Acta Odontologica Scandinavica.*1964; **22**: 121-135.

26. Loe H, Silness J. Periodontal Disease in Pregnancy. i. Prevalence and Severity. *Acta Odontologica Scandinavica.* 1963; **21**: 533-551.

27. Rottner K, Richter EJ, Fanghanel J, Gedrange T, Kubein-Meesenburg D, Nagerl H, Proff P. Effects of centric relation prematurities of the frontal teeth. *Annals of Anatomy.* 2007; **189**: 397-403.

28. Handelman CS. The anterior alveolus: its importance in limiting orthodontic treatment and its influence on the occurrence of iatrogenic sequelae. *The Angle Orthodontist.* 1996; **66**: 95-109; discussion 109-110.

29. Wennstrom JL. Mucogingival considerations in orthodontic treatment. *Seminars in Orthodontics*. 1996; **2**: 46-54.

30. Wingard CE, Bowers GM. The effects of facial bone from facial tipping of incisors in monkeys. *Journal of Periodontology*. 1976; **47**: 450-454.

31. Steiner GG, Pearson JK, Ainamo J. Changes of the marginal periodontium as a result of labial tooth movement in monkeys. *Journal of Periodontology.* 1981; **52**: 314-320.

32. Batenhorst KF, Bowers GM, Williams JE, Jr. Tissue changes resulting from facial tipping and extrusion of incisors in monkeys. *Journal of Periodontology.* 1974; **45**: 660-668.

33. Polson AM, Reed BE. Long-term effect of orthodontic treatment on crestal alveolar bone levels. *Journal of Periodontology.* 1984; **55**: 28-34.

34. Karring T, Nyman S, Thilander B, Magnusson I. Bone regeneration in orthodontically produced alveolar bone dehiscences. *Journal of Periodontal Research.* 1982; **17**: 309-315.

35. Bimstein E, Machtei E, Becker A. The attached gingiva in children: diagnostic, developmental and orthodontic considerations for its treatment. *ASDC Journal of Dentistry for Children.* 1988; **55**: 351-356.

36. Dominiak M, Lysiak-Drwal K, Solski L, Zywicka B, Rybak Z, Gedrange T. Evaluation of healing processes of intraosseous defects with and without guided bone regeneration and platelet rich plasma. An animal study. *Annals of Anatomy.* 2012; **194**: 549-555.