Decrease in alveolar crest height due to orthodontic treatment method using standard edgewise fix appliance molar

Jessy Nauli, Bergman Thahar, Jono Salim, Endah Mardiati

Department of Orthodontics Faculty of Dentistry Universitas Padjadjaran

ABSTRACT

Orthodontic treatment could influence alveolar bone height. The longer the treatment, the more effect it will be. The purpose of this study was determined the differences in alveolar bone height at the canine, second bicuspid, mandibular first molarin the case of mandibular premolar extraction with different treatment duration. This study is a retrospective – comparative analytic study, involving 17 samples which have finished orthodontic treatment at FKG Unpad PPDGS orthodontic clinic. The alveolar bone height was determined from panoramic x-rays obtained by measuring the ratio of alveolar crest and the cemento enamel junction to the tooth cusp (Bjorn method). The results of study was then analyzed using t-student test with P_{value}=0.05, showed a significant correlation in alveolar bone height reduction. In the group less than 2-years treatment, there was a reduction in alveolar bone height only at the mesial side of tooth 35 while there was a significan reduction at the distal canine, the mesial - distal second bicuspid and the mesial - distal side of the mandibular first molar in a group more than 2 years-treatment. This study concluded that there was a significant influence between the duration of treatment and alveolar bone height reduction in the group more than 2-years treatment.

Key words: Standard Edgewise, duration of orthodontic treatment, alveolar bone height

ABSTRAK

Perawatan ortodonti dapat mempengaruhi tinggi puncak tulang alveolar. Semakin lama perawatan, semakin besar pengaruhnya. Tujuan penelitian ini untuk mengetahui perbedaan tinggi puncak tulang alveolar pada gigi kaninus, premolar kedua, molar pertama rahang bawah yang dirawat ortodonti dengan pencabutan gigi premolar rahang bawah dengan jangka waktu perawatan yang berbeda. Penelitian ini merupakan penelitian retrospektif komparatif analitik dari 17 subjek yang telah selesai dirawat ortodonti di Klinik PPDGS Ortodonti FKG Universitas Padjadjaran dengan alat cekat Standard Edgewise. Pengukuran ketinggian puncak tulang alveolar dilakukan pada foto rontgen panoramik dengan mengukur rasio jarak puncak tulang alveolar dan Cemento Enamel Junction terhadap puncak bonjol mahkota gigi (metode Bjorn). Analisis uji t-student dengan P_{value}=0.05 menunjukkan terdapat hubungan yang signifikan antara penurunan tinggi puncak tulang alveolar. Pada kelompok lama perawatan ≤ 2 tahun penurunan tinggi tulang alveolar hanya terjadi pada sisi mesial gigi 35 saja sedangkan pada kelompok > 2 tahun

Correspondence author: Jessy Nauli, Department of Orthodontic Faculty of Dentistry Universitas Padjadjaran Jl. Sekeloa Selatan No. 1 Bandung, West Java-Indonesia, Tel./Fax: +6222-2504985/2532805

terjadi penurunan tinggi tulang alveolar secara signifikan pada seluruh permukaan gigi yaitu sisi distal gigi kaninus, sisi mesial-distal premolar kedua dan sisi mesial-distal molar pertama rahang bawah. Simpulan: Dari hasil penelitian terdapat pengaruh yang signifikan antara lama perawatan ortodonti dengan penurunan tinggi puncak tulang alveolar dengan lama perawatan > 2 tahun.

Kata kunci: *Standard Edgewise*, lama perawatan ortodonti, puncak tulang alveolar.

INTRODUCTION

The relationship between orthodontic treatment and the changes in periodontal tissue has been a big concern among the experts.[1] In teeth movement mechanism, the pressure imposed on teeth will cause the resorption and apposition in alveolar bone. The result shows that orthodontic treatment not only will cause resorption in teeth roots but will also cause height reduction of the top of the alveolar bone. This is due to the areas that mostly get pressures during orthodontic treatment are the top of alveolar bone area and teeth apex area. Height reduction of the top of alveolar bone can cause teeth unsteadiness, so that it becomes unstable, and the treatment is considered imperfect.[2]

The influence of an orthodontic treatment to the height of the top of alveolar bone is still a matter of debate when assessed adiographically. Reed[3] indicated that teeth movement directed to the extraction area will not cause a damage to the alveolar bone. Bondemark[2] conducted a study on the height of alveolar bone in patients that had been treated for 5 years. At the beginning of the orthodontic treatment, the decrease average of cemento enamel junction distance to the top of alveolar bone in the lower jaw ranged between 0,6 mm and 0,8 mm. After 2,8 years of the orthodontic treatment, the distance average of cemento enamel junction to the top of alveolar bone in the lower jaw decreased 0,7-1,0 mm and at the end of the orthodontic treatment, the distance average of cemento enamel junction to the top of alveolar bone in the lower jaw decreased betwen 0,7 mm and 0,9 mm.

The result of the study conducted by Zacharisson[4] reported that the patients with orthodontic treatment show the loss of alveolar bone support around 0,2 – 0,5 mm compared to the control group. Baxter[5] found that there is a reduction in the height of the top of alveolar bone for 0,5 mm during the orthodontic treatment in patient group with cases of the extraction of the mandible first premolar. Alnaes et al.[6] compared the distance average of cemento enamel junction to the top of alveolar bone decreased 1,1 mm while in the control group the reduction was 0,88 mm.

Sjolien et al.[7] conducted a study on patient group with class 2 division 1 malocclusion and the control group. The result showed a significant difference of proximal alveolar bone support is more apical in patient group with orthodontic treatment primarily at the distal side of the canines. Nelson et al[8] stated that the loss average of alveolar bone in patients with orthodontic treatment is 0,31 mm while in control group, the loss average is around 0,07 – 0,11 mm.

Periodontal condition represented by the assessment of the top of alveolar bone at the side of pull out area has come into consideration because teeth extraction is a common procedure in orthodontic treatment. According to Kennedy, et al.[9] in orthodontic treatment with teeth extraction, there will occur the reduction in the height of the top of alveolar bone. In accordance with the result by Zachrisson and Alnaes[4] that stated the press side at the first premolar extraction area is the height reduction regio of the biggest alveolar bone. To evaluate changes in periodontal tissue support in teeth, especially the height of alveolar bone, radiography examination can be used. Radiographic assessment[1] on the loss of the height of alveolar bone can only be seen at the part of interdental, regio labial, and ligual, and those are difficult to observe.

Nelson et al.[8] stated that there are some important factors that can cause the loss of alveolar bone support during the orthodontic treatment. The factors are patients' age and the period of the treatment. The period of orthodontic treatment is the period of the insertion and the removal of fixed orthodontic device.[8,10] In his study, he compared the period of orthodontic treatment between

cases with first premolar extraction and cases without teeth extraction takes 4,6 months longer than the orthodontic treatment without extraction which needs approximately 23,7 months. Fink[11] stated that the period of orthodontic treatment in premolar extraction cases takes approximately 25 months. In line with Skidmore et al.[12] that stated the average period of orthodontic treatment with premolar extraction cases is 23,5 months.

In Education Program Clinic of Dentistry, Orthodontic Specialist of Faculty of Dentistry of Padjadjaran University, residents who are studying conduct orthodontic treatment using fixed device. The treatment must be taken with a predetermined standard, so it requires rather long treatment period. The longer the orthodontic treatment, the bigger the loss risk of the top of the alveolar bone. So far there has not been research on the relationship between the period of orthodontic treatment with the assessment of the height of the top of the alveolar bone in the Education Program Clinic of Dentistry, Orthodontic Specialist of Faculty of Dentistry of Padjadjaran University.

Based on the reasons, the authors are interested in finding out whether the reduce of the height of the top of the alveolar bone will increase by the longer of the treatment, especially in patients treated by fixed orthodontic at the Education Program Clinic of Dentistry Orthodontic Specialist of Faculty of Dentistry of Padjadjaran University.

MATERIAL AND METHODS

The subjects of the study are all patients that completed the orthodontic treatment in Orthodontic Clinic of Faculty of Dentistry of Padjadjaran University in the years of 2003 to 2010. The samples of the study are the part of the chosen population selected based on the criteria.

The inclusion criteria are: 1. Male and female; 2. Has a panoramic photo before and after the orthodontic treatment with periodontal tissue structures including the mandible alveolar is clearly visible both on the mesial and distal sides: 1. Before treatment the number of permanent teeth is full except the M3, 2. Patients with mandible premolar extraction; 3. Patients who do not suffer from systemic disease and do not have periodontal disease at the beginning of orthodontic treatment; 4. Class I dental patients, class II skeletal and class III skeletal.

Exclusion criteria: patients who suffer from systemic and periodontal diseases at the beginning of orthodontic treatment. The materials used in the study: 1) panoramic radiograph; 2) acetate paper The equipments used in the study are: 1) negatoscope, 2) digital caliper (considered to have high validity and reliability), 3) 4H pencil, 4) paper tape. This study is a comparative retrospective study that compares the change of the height of the top of alveolar bone of region canines, mandible second premolar and first molar before and after treatment in patients that have completed orthodontic treatment within a period of ≤ 2 years and > 2 years. The orthodontic treatment is conducted using the standard Edgewise fixed device at the Education Program Clinic of Dentistry Specialist of Faculty of Dentistry, Padjadjaran University.

Before conducting the study, a preliminary research is carried out by measuring the ratio 1:1 between crown length to root length before and after treatment. How to measure: first, draw a line that connects cement enamel junction on the mesial and distal sides of the canines, mandible's second premolar and first molar.

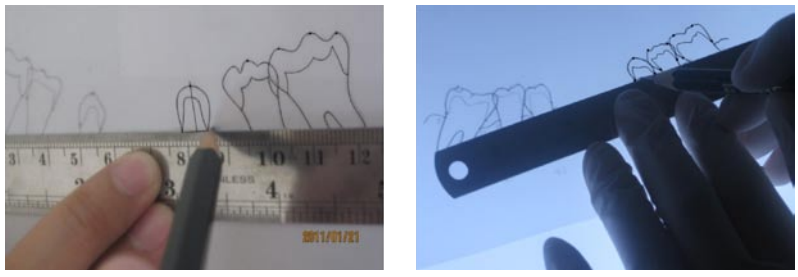

Figure 1. line withdrawal between Cement Enamel Junction. Withdrawal is drawn from the side of canines, mesial-distal side of the second premolar, and mesial-distal side of mandible first molar.

Second, determine the center line on the line connecting both of the cemento enamel junctions. On the second premolar and the first molar with two roots, the determenation of the center line on the cement enamel junction is performed on the mesial and distal roots.

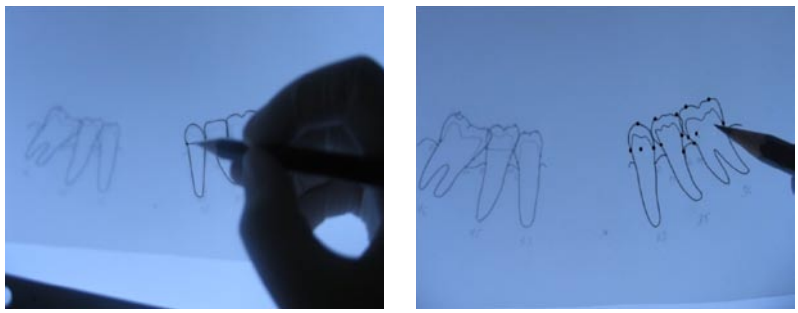

Figure 2. The determination of the center line on cementoenamel junction. The center line is determined on the line which connects both of the cementoenamel junction.

Third, draw the line that connects the top protrude of canines, mandible second premolar, first molar to the center line to the center line of Cemento Enamel Junction line.

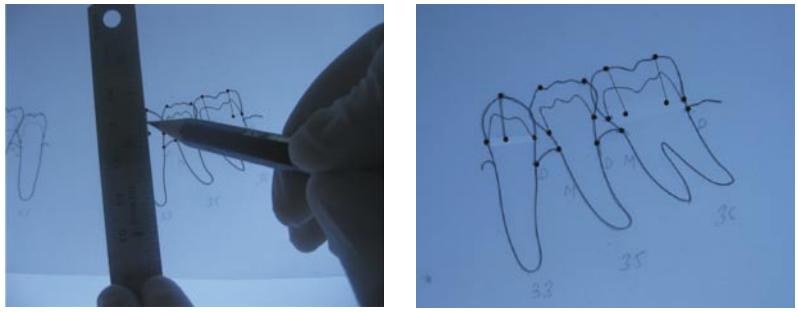

Figure 3. The determination of crown's height. Draw the line that connects the top protrude of teeth to the center line on cementoenamel junction.

Fourth, connect the top protrude of canines, mandible second premolar, first molar to the center line of the cement enamel junction line as the crown length and the measurement from the center line of cement enamel junction to teeth apex as the root length, then it is measured using a digital caliper.

Preliminary study aims to find out the possibility of roots shortening. The preliminary study was conducted to 17 samples. Consequently, it is find out that the ratio of crown length and the root length before and after treatment have a significant difference, which means, there is a root shortening after treatment.

Figure 4. Determine the ratio of crown-root length. Connecting the length of crown and the center line of cementoenamel junction to teeth apex as root length, measured by a digital caliper.

RESULTS

Based on the panoramic radiograph data population acquired from the years of 2003-2010, 120 panoramic photos are obtained, but only 17 panoramic radiographs meet the inclusion criteria. Furthermore, calibration test (intra examiner error) is performed by random sampling to 5 panoramic radiographs by measuring for 3 times to each sample with 5 day measurement interval and statistically tested to find out if there is a difference between those three measurement (see attachment). After finding out that there is not any significant difference, all samples are measured.

The height of the top of alveolar bone is obtained by measuring the distance ratio of the top of alveolar bone to the top protrude of teeth crown to the distance of cement enamel junction on the top protrude of teeth crown before and after treatment. The result of measurement before and after orthodontic treatment can be seen on the attachment. Data result analysis of the changes of the top height of alveolar bone on 10 variables on 17 panoramic photos. (Table 1).

Table 1. Similarity measurement test before and after treatment (n=17).

Alveolar crest	X	$\bar{x}$	std	N	t_{hit}	p_{val}
46 M	2.17	0.13	0.10	17	5.30	0.00*
46 D	3.26	0.19	0.22	17	3.58	0.00*
45 M	2.60	0.15	0.10	17	6.40	0.00*
45 D	2.85	0.17	0.12	17	6.00	0.00*
43 D	2.49	0.15	0.10	17	5.95	0.00*
33 D	3.38	0.20	0.15	17	5.43	0.00*
35 M	3.32	0.20	0.15	17	5.43	0.00*
35 D	2.99	0.18	0.14	17	5.34	0.00*
36 M	2.57	0.15	0.10	17	6.46	0.00*
36 D	2.03	0.12	0.08	17	6.31	0.00*

Data result analysis of the changes of the top height of alveolar bone on 3 panoramic radiographs as group with treatment period ≤ 2 years can be seen in table 2.

In table 4.2, it can be seen that the changes occurred at the top height of alveolar bone is based on the proportion of the distance of alveolar bone top and cement enamel junction to the crown top of canines, mandible second premolar, first molar is not significant except on the mesial side of second left premolar. (Table 2).

Table 2. measurement result of the top height of alveolar bone in group with treatment period ≤ 2 years (n=3).

Alveolar crest	X	$\bar{x}$	std	N	t_{hit}	p_{val}
46 M	0.34	0.11	0.09	3	2.19	0.16⁰
46 D	0.64	0.21	0.17	3	2.17	0.16⁰
45 M	0.49	0.16	0.14	3	1.97	0.19⁰
45 D	0.42	0.14	0.09	3	2.65	0.12⁰
43 D	0.43	0.14	0.10	3	2.61	0.12⁰
33 D	0.68	0.23	0.15	3	2.71	0.11⁰
35 M	0.66	0.22	0.07	3	5.81	0.03*
35 D	0.77	0.26	0.22	3	2.00	0.18⁰
36 M	0.22	0.07	0.06	3	2.23	0.16⁰
36 D	0.18	0.06	0.10	3	1.00	0.42⁰

Data result analysis of the changes of panoramic radiograph in patients with treatment period > 2 years can be seen in table 3.

Table 3. Measurement result of the height of alveolar bone in group with treatment period > 2 years (n=14).

Alveolar crest	X	$\bar{x}$	std	N	t_{hit}	p_{val}
46 M	1.83	0.13	0.10	14	4.70	0.00*
46 D	2.62	0.19	0.24	14	2.98	0.00*
45 M	2.11	0.15	0.09	14	6.02	0.00*
45 D	2.43	0.17	0.12	14	5.34	0.00*
43 D	2.06	0.15	0.11	14	5.18	0.00*
33 D	2.70	0.19	0.16	14	4.60	0.00*
35 M	2.66	0.19	0.16	14	4.39	0.00*
35 D	2.22	0.16	0.12	14	5.14	0.00*
36 M	2.35	0.17	0.10	14	6.53	0.00*
36 D	1.85	0.13	0.07	14	7.10	0.00*

Note: x: number of size difference before and after treatment; $\bar{x}$: average; Std: standard deviation; n: number of samples; t count: t count; p val: P. Value= 0,05; *: significant, ⁰: non significant

In table 3, it can be seen that the change occurs in the measurement of the top of alveolar bone based on the proportion of the distance of the top of alveolar bone and cement enamel junction to the teeth crown of canines, mandible second premolar, first premolar which is significant on the entire surface teeth that have been research variables. (Table 3).

DISCUSSION

Orthodontic treatment aims to move teeth into the desired direction with minimal teeth damage and their supporting tissues.[1] Every orthodontist should carefully monitor teeth health and their supporting tissue during orthodontic treatment in order to achieve a stable and safe treatment.[2]

Orthodontic treatment in Education Program of Dentistry Orthodontic Specialist of Faculty of Dentistry of Padjadjaran University is conducted using an orthodontic device Standard Edgewise. Treatment period is varied depends on the case. The result[8] stated that the period of orthodontic treatment can influence the top height of alveolar bone. The longer the treatment, the bigger possibility of the top height of alveolar bone to decrease. This study aims to find out the height difference of alveolar bone top in canines, mandible second premolar, first molar before and after orthodontic treatment in mandible premolar extraction with different treatment period.

The study is conducted to 17 panoramic radiographs measured by Bjorn method. This technique is able to measure precisely the plain of alveolar bone top in canines, second premolar, first molar, second molar. The measurement of alveolar bone top height to the total length of teeth crown is conducted to overcome imprecision problem in placing a film and the bias in determining a precise shooting angle. (Albandar, et.al. 1986) [3]. Bjorn method measures the height of alveolar bone top in its connection to the total length of teeth crown, that is the ratio of alveolar bone top distance to teeth crown to cement enamel junction distance to the top of canines, mandible second premolar, first molar before and after the treatment using fixed orthodontic device, Standard Edgewise device (Reed, et.al. 1985).

The condition of alveolar bone top in orthodontic patient group between the case of first premolar extraction and the case without mandible first premolar extraction become observational material. The observation result in canines distal side, second premolar distal and mesial sides and first molar distal and mesial sides show a decrease in the height of alveolar bone top which is bigger than that in orthodontic patient group with extraction case, the average is 8,73± 0,28 while in orthodontic patient group without extraction case, the average is 7,75± 0,13 (Reed, 1985).

Overall, the observation result on 17 panoramic radiographs to 10 research variables show the decrease of alveolar bone top height which is bigger in after treatment group using fixed orthodontic device with extraction of mandible first premolar (Table 4.1). The result is in line with the study (Zachrisson, 1974) in patients with class 2 division 1 malocclusion in which the decrease of cement enamel junction distance to the top of alveolar bone is 1,11 mm and 0,88 mm in average for control group, the difference is statistically significant. (Pvalue <0,001). Bondemark[16] stated that there is 0,2 mm height reduction in alveolar bone in orthodontic patients with mandible first premolar extraction compared to reduction in control group which is 0,1 mm along with the period of the orthodontic treatment.

The result of the group with ≤2 year treatment period does not show any significant change except on the mesial sides of lower second left premolar (Table 4.1). The result is in line with Alnaes, et.al. (1974) that orthodontic patients with mandible first premolar extraction, have a greater decrease in cement enamel junction distance to the top of alveolar bone than before treatment, and 0,22 mm on second premolar mesial side greater than the control group.

Decrease in the top of alveolar bone and the loss of periodontal tissue attachment in interdental can occur in the extraction chamber of first premolar which has closed, that is the second premolar mesial side (Zachrisson, et.al.)[4]. The observation in patient groups with and without mandible first premolar extraction, the average of the decrease in alveolar bone top height is 0,10 mm on mesial side of mandible left second premolar Baxter. [5] This is due to the power required by the second premolar as the anchor is bigger canines retraction, so on the mesial side of lower left second premolar can occur a height decrease in a bigger alveolar bone.

In-group with treatment period > 2 years of 14 panoramic radiographs, the decrease of alveolar bone top occurs in after treatment group with lower first premolar extraction on the entire teeth surface (Table 4.1). In class 2 malocclusion case, the height of alveolar bone top occurs on

the entire teeth proximal surface, primarily on the side of first premolar extraction with the treatment period ± 2,17 years (Janson, 2003). In orthodontic patients with class 2 division 1 malocclusion case, there is a decrease in the top of alveolar bone with the period of the treatment over 2 years.[4]

The decrease of the height of alveolar bone top on distal side of canines, mesial and distal sides of mandible second premolar is influenced by several factors, first, teeth extraction. Distal side of canines has the biggest decrease of the height of alveolar bone top due to the pressure during retraction. Teeth extraction can be a contributing factor in the loss of alveolar bone top, and it cannot get back into normal condition which adjacent to the extraction chamber (Zachrisson, et.al.).[4] Teeth extraction can worsen periodontal tissue damage directly to bone destruction indirectly by changing the shape of teeth alveolar bone adjacent to extraction chamber either the buccolingual or mesiodistal direction. The alveolar bone deformation can cause a decrease of the height of alveolar bone top in the teeth adjacent to extraction chamber in which this condition can lead to plaque build up on the teeth surface having resorption and in the end it can cause teeth unsteadiness.[17]

The second factor is the amount of the power used (Zachrisson, et.al).[4] During canines retraction, the biggest pressure occurs on the same side of alveolar bone and the apex on the opposite side. Naturally, the thickness of periodontal ligament will be maintained in accordance to the contacts between crowns. During canines retraction, the distal side of canines will undergo resorption. At the same time, the side of second premolar will undergo resorption as well due to the move as canines retract.

The third factor, condition of gum in relation to orthodontic treatment. The occurrence of gum inflammation during teeth movement in orthodontic treatment can increase the resorption of alveolar bone top. Optimal maintenance of oral hygiene can slow the pace of the decrease of the height of alveolar bone top in adults. The existence of comprehensive gingivitis during treatment needs special attention because gingivitis can potentially cause periodontal tissue damage by plaque accumulation, which eventually leads to the loss of periodontal tissue attachment and the resorption of alveolar bone top (Zachrisson) [4]. In this study, current status of patients' oral hygiene during the beginning of treatment and the absence of gum inflammation during orthodontic treatment is not assessed. Observation is only conducted based on panoramic radiograph data before and after orthodontic treatment.

The fourth factor, the habit of chewing on one side is a factor that can be taken into consideration. Mastication movement triggers the salivary gland secrete saliva which has a self cleansing effect, on the unused side, the self cleansing effect of saliva into the area is reduced, leading to the build up of plaque. Plaques are source of nutrients for bacteria, if within 24 hours plaque is not cleaned, the amount of plaque will increase, aerobic bacteria evolve and the virulence is beyond the threshold of individual. Porphyromonas actinomycetem commitans bacteria, especially Porphyromonas will cause further damage periodontal tissue. The emergence of anaerobic bacteria that secrete endotoxin cause tissue destruction, either directly or indirectly, to remove toxin that osteoclast works faster to destroy alveolar bone.[18]

The fifth factor, the increase of different resorption activity in each individual. Variation among individual must be taken into account because it is difficult to predict which individual is likely to experience a faster decrease in alveolar bone top compared to other individuals.[4]

Decrease in alveolar bone height on distal and mesial sides of molar teeth is caused by some factors. There is a procedure in orthodontic treatment, such as the effect of the placement of band on the first molar. The accumulation of plaques and periodontal tissue inflammation in molar teeth is more severe than in anterior teeth (Boyd, et.al., 1992) [19]. Plaque accumulation and gum inflammation is more in interdental part due to the use of band on molar teeth (Zachrisson, et.al., 1974). Cleansing hard plaque in gum margin covered by orthodontic band causes prolonged gum inflammation and it eventually leads to the loss of periodontal tissue attachment. Periodontal tissue attachment loss can also be caused by mechanical trauma as the result of band placement which is more to the subgingival that is difficult to clean.[14]

Mesial side of first molar teeth of alveolar

bone can be more likely to have resorption when teeth move forward due to too much power in the process of the loss of anchorage. Tipping movement of first molar teeth can cause a decrease in the height of alveolar bone.

CONCLUSION

The period of orthodontic treatment using standard Edgewise fixed device turns out to have an influence on the resorption in alveolar bone top with treatment period ≥ 2 years.

In orthodontic patients treated for ≤ 2 years, the top of alveolar bone in all observed variables does not experience much alveolar bone height decrease, except on teeth 35 mesial side with average 0,22 mm. In orthodontic patient group using standard Edgewise fixed device with treatment period > 2 years, the total average of height decrease in alveolar bone occurs on the entire teeth surface, that is distal side of lower left canines (0,19), left mesial side of second premolar (0,19), distal side of second premolar (0,16), left mesial side of first molar (0,17), left distal side of first molar (0,13), right distal side of canines (0,15), right mesial side of second premolar (0,15), right distal side of second premolar (0,17), right mesial side of first molar (0,13), and right distal side of first molar (0,19).

SUGGESTION

Orthodontists should be aware that orthodontic treatment should be completed at the shortest time, because the longer the orthodontic treatment lasts, the more risk in alveolar bone resorption. Further research is needed to find out whether there is any resorption in the height of alveolar bone top in orthodontic patients class I, class II and III skeletal with treatment period ≤ 2 years.

REFERENCES

1. Bondemark L. Interdental bone changes after orthodontic treatment; a 5 year langitudinal study. *Am J orthod dentofacial orthop 1998;114:*25–31.
2. Proffit WR, Fields HW. Contemporary Orthodontics 3rd ed. St Louis Philadelphia: Mosby. 2000. P. 315-6.
3. Reed Polson, Subtelny. 1985. Long term periodontal status of teeth moved into extraction sites. *Am J orthod 1985;88:*2003 –2008.
4. Zachrisson BU, Alnaes L. Periodontal condition in orthodontically treated and untreated individuals 11. Alveolar bone loss : radiographic findings. *Angle Orthod 1974;44:*48 -55.
5. Baxter DH. The effect of orthodontic treatment on alveolar bone adjacent to the cemento-enamel junction. *Angel Orthod 1967;37*:35–47.
6. Nelson, Artun. 1997. Alveolar bone loss of maxillary anterior teeth in adult orthodontic patients. *Am J orthod* 1997;*111*:328-34.
7. Kennedy DB, Joondeph DR. The effect of extraction and orthodontic treatment on dentoalveolar support. *Am J Orthod and Dentofac Orthop* 1983;84(3);183-90.
8. Alger DW. 1988. Appointment frequency versus treatment time. *Am J orthod dentofacial orthop* 1988;94:436-9.
9. Fink DF, Smith RJ. 1992. The duration of orthodontic treatment. *Am J orthod dentofacial orthop* 102:45-51.
10. Skidmore KJ, Brook KJ, Thomson WM, Harding WJ. Factors influencing treatment time in orthodontic patients. *Am J orthod dentofac orthop 2006;129(2):*230–8.
11. Bondemark L, Kurol J. Proximal alveolar bone level after orthodontic treatment with magnets, superelastic coils and straight-wire appliances. *Am J orthod dentofac orthop 1997;67(1):*7–14.
12. Wisth PJ. Periodontal status of neighboring teeth after orthodontic closure of mandibular extraction sites. *Scand J Dent Res*; 1975;83;307-13.
13. Carranza, Newman. Clinical periodontology 10th ed. Elsevier: WB Saunders. 2006. P. 79-80.
14. Boyd RL, Baumrind S. 1992. Periodontal considerations in the use of bonds or bands on molars in adolescents and adults. *Am J Orthod and Dentofac Orthop* 1992;62(2);117-26.