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ORIGINAL RESEARCH

EVALUATION OF CHANGES IN ALVEOLAR BONE HEIGHT FOLLOWING REMOVABLE ORTHODONTIC APPLIANCES AT UNIMUS DENTAL HOSPITAL

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ABSTRACT

Introduction: *Malocclusion is a condition characterized by misalignment of the teeth and improper jaw alignment, which can lead to impaired chewing function. One type of orthodontic appliance that can be used in the treatment of malocclusion is the removable orthodontic appliance. This appliance offers the advantage of being easily removed and reinserted by the patient, thereby helping to maintain better oral hygiene, and carries a lower risk of root resorption and periodontal complications compared to fixed orthodontic appliances. Research on changes in alveolar bone height has largely focused on the use of fixed orthodontic appliances, while studies on removable orthodontic appliances remain limited.* ***Aim:*** *This study aims to evaluate the differences in alveolar bone height before and after the use of removable orthodontic appliances in patients at Unimus Dental Hospital.* ***Methods:*** *This study applied an analytical observational approach with a cross-sectional design. The study was conducted by measuring the alveolar bone height on panoramic radiographs before and after the use of removable orthodontic appliances on 10 teeth in 17 subjects using ImageJ® software.* ***Result:*** *Both the paired sample t-test and the Wilcoxon signed-rank test results showed p-values greater than 0.05.* ***Conclusion:*** *There was no difference in alveolar bone height before and after the use of removable orthodontic appliances in patients at the Unimus Dental Hospital*

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INTRODUCTION

Malocclusion is a condition characterized by misalignment of the teeth and improper jaw alignment, which can impair masticatory and speech functions and affect the patient's physical and emotional health.[1] Globally, malocclusion is considered the third most common oral health condition after caries and periodontal disease.[2] In Indonesia, the prevalence of malocclusion remains high, with an estimated 80% of the population affected by the condition.[3] The high incidence of malocclusion highlights the need for appropriate treatment through orthodontic care. Orthodontic treatment aims to correct abnormal tooth positions to achieve a more ideal

alignment, both functionally and aesthetically.[4] Orthodontic appliances that can be used in the treatment of malocclusion include removable orthodontic appliances, fixed orthodontic appliances, and fixed-removable orthodontic appliances.[3] Removable orthodontic appliances offer several advantages, such as being easily removed and reinserted by the patient, maintaining oral hygiene more effectively, relatively lower treatment costs, and lower risks of complications such as root resorption, decalcification, and periodontal disorders compared to fixed orthodontic appliances.[5]

One type of tooth movement produced by removable orthodontic appliances is tipping. Tipping occurs when orthodontic forces act on the crown of the tooth, causing it to tilt around a specific pivot point.[6] The force required to move a single-rooted tooth ranges from 25–40 g/mm; forces below 25 g/mm may not produce optimal tooth movement, whereas forces above 40 g/mm may damage periodontal tissues and delay tooth movement.[7] Suboptimal application of orthodontic forces can elicit biological responses in periodontal tissues, including the alveolar bone.[8] The alveolar bone is a complex structure located on top of the basal bone of the maxilla and mandible that forms the tooth sockets.[9] In areas subjected to pressure, bone resorption occurs, whereas bone apposition occurs in areas subjected to traction.[8] Resorption during orthodontic treatment generally occurs at less than 1.5 mm, with the normal range considered to be 1–2 mm.[10] Although alveolar bone resorption is generally within normal limits, excessive alveolar bone loss can reduce tooth support, potentially causing occlusal instability and decreasing the patient's quality of life.[11]

Therefore, evaluation of alveolar bone height is important in orthodontic treatment. Radiography serves as a diagnostic tool to evaluate changes in hard tissues during orthodontic treatment.[12] Panoramic radiography is frequently utilized because it provides a comprehensive view of the maxillary and mandibular structures with relatively minimal radiation exposure.[12] Previous studies have mainly focused on alveolar bone height changes associated with fixed orthodontic appliances; however, studies involving removable orthodontic appliances remain limited. Based on this, the researchers intend to further investigate the relationship between alveolar bone height and removable orthodontic appliances. This study aims to determine the differences in alveolar bone height before and after the use of removable orthodontic appliances in patients at the Unimus Dental Hospital, with the expectation of contributing to the scientific field of orthodontics and supporting clinical decision-making regarding the use of removable orthodontic appliances.

METHODS

The research adopted an analytical observational cross-sectional design, purposive sampling was used to select the participants, a non-random sampling method (non-probability sampling). The study sample consisted of 17.[13] orthodontic patients who treated by clinical students at the Faculty of Dentistry, Muhammadiyah University of Semarang. The sample selection for this study was based on the

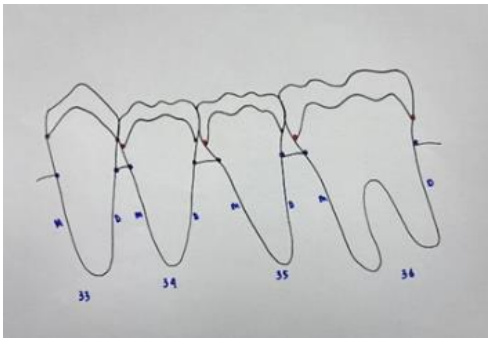
research conducted by Nauli et al. in an article titled “Decrease in Alveolar Crest Height Due to Orthodontic Treatment Using a Standard Edgewise Fixed Appliance on Molars”; therefore, the sample criteria used were adapted to the characteristics of the subjects and the research objectives outlined in that study.

The samples were selected based on the following inclusion criteria: 1. The study subjects were orthodontic patients of dental students at the Faculty of Dentistry, Muhammadiyah University of Semarang; 2. The patients had never used fixed orthodontic appliances; 3. Patients had attended at least 10 follow-up visits and/or had completed orthodontic treatment using removable orthodontic appliances with Adam clasps on their molars; 4. Patients did not have any systemic diseases; 5. Patients did not have periodontal disease or periodontitis; 6. Patients were aged 15–40 years. The exclusion criteria applied in this study were as follows: 1. Patients with extracted canines, second premolars, and molars.

This study was approved by the Health Research Ethics Committee (KEPK) of the University of Muhammadiyah Semarang Dental and Oral Hospital following an ethical review process and was approved on January 26, 2026, under reference number: 007/RSGM.KEPK/PE/2026. This study was conducted at the University of Muhammadiyah Semarang Dental and Oral Hospital from December 2025 to February 2026.

This study was conducted by measuring the difference in alveolar bone height before and after treatment with removable orthodontic appliances in patients at the University of Muhammadiyah Semarang Dental and Oral Hospital using panoramic radiographs and ImageJ® software. The alveolar bone crest height was determined by measuring the distance from the cemento-enamel junction to the alveolar bone crest before and after treatment. The Cemento-Enamel Junction (CEJ) and the alveolar bone crest were selected as reference points because they are stable anatomical landmarks that can be consistently identified on radiographs. Therefore, measuring the CEJ-AC distance is used as the standar method for evaluating alveolar bone loss.[18]

A



B

Figure 1. Determining the points to be measured on the radiograph (A) and on the patient's dental anatomy (B)
Note: Red: CEJ (Cemento-Enamel Junction), Blue: Alveolar crest

Before performing data analysis, an intra-examiner calibration test was conducted using

five randomly selected panoramic radiographs. Each radiograph was measured three times at five-day intervals to assess measurement consistency.

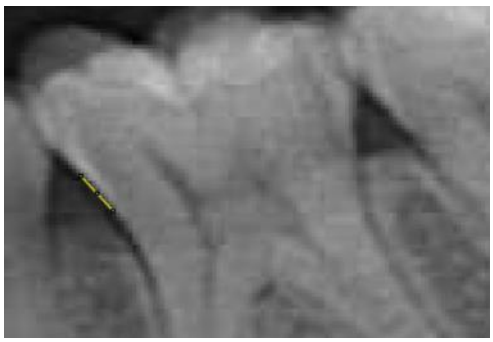


Figure 2. Draw a straight line from the CEJ to the alveolar crest on the mesial and distal sides

Alveolar bone height measurements were performed on all study subjects using the ImageJ® software application, as follows: 1.) Open the patient's digital panoramic radiograph using the ImageJ® software. To minimize measurement bias, all panoramic radiographs were first scale-calibrated prior to analysis. In addition, only panoramic radiographs of Grade 2 (diagnostically acceptable) quality were included in the study, ensuring that the images met diagnostic acceptability criteria and allowed for accurate and consistent identification of anatomical landmarks. 2.) Calibrate the measurement scale and specify the actual length (Known Distance) in millimeters, then click "OK" to save the calibration. 4.) After the image is calibrated, measurements are taken by drawing a straight line using the Straight Line Tool from the cemento-enamel junction to the alveolar bone crest on the mesial and distal aspects of the examined tooth.[14] 5.) The measurement results can be analyzed using software statistics.

Normality test was first examined using the Shapiro–Wilk test, a paired sample t-test was applied to normally distributed data, whereas the Wilcoxon signed-rank test was used for non-normal data.

RESULTS

Based on 17 panoramic radiographs obtained from patients who met the inclusion criteria, a calibration test (intra-examiner error) was then conducted by selecting a random sample of 5 panoramic radiographs, with each sample measured three times at 5-day intervals.

Table 1. Intraclass correlation coefficient test

	ICC	Sig.
Single measures	0.990	0.000

The calibration test results indicate a p-value greater than 0.90 (see Table 1), indicating consistent and stable measurements.

The results of the measurements before and after orthodontic treatment as shown in the table below.

Table 2. Alveolar bone height before treatment

	N	Min-Max	Mean ± SD
33D	17	2.02 - 3.06	2.61 ± 0.308
35M	17	2.00 - 3.00	2.58 ± 0.316
35D	17	1.69 – 2.94	2.39 ± 0.337
36M	17	1.89 – 3.52	2.60 ± 0.435
36D	17	1.69 – 3.15	2.38 ± 0.345
43D	17	1.96 – 3.82	2.61 ± 0.440
45M	17	2.06 – 3.37	2.48 ± 0.321
45D	17	1.85 – 3.77	2.59 ± 0.446
46M	17	2.03 – 3.80	2.78 ± 0.564
46D	17	2.12 – 3.67	2.74 ± 0.425

Note: 33: Mandibular Left Canine, 35: Mandibular Left Second Premolar, 36: Mandibular Left First Molar, 43: Mandibular Right Canine, 45: Mandibular Right Second Premolar, 46: Mandibular Right First Molar, M: Mesial, D: Distal.

Table 3. Alveolar bone height after treatment

	N	Min-Max	Mean ± SD
33D	17	2.04 – 3.28	2.57 ± 0.429
35M	17	1.68 – 4.24	2.55 ± 0.643
35D	17	2.06 – 2.79	2.39 ± 0.198
36M	17	1.82 – 4.18	2.62 ± 0.598
36D	17	2.00 – 2.99	2.45 ± 0.271
43D	17	1.85 – 3.44	2.58 ± 0.483
45M	17	1.73 – 3.35	2.68 ± 0.519
45D	17	2.12 – 3.64	2.74 ± 0.356
46M	17	1.94 – 3.60	2.63 ± 0.525
46D	17	2.18 – 2.93	2.57 ± 0.214

Note: 33: Mandibular Left Canine, 35: Mandibular Left Second Premolar, 36: Mandibular Left First Molar, 43: Mandibular Right Canine, 45: Mandibular Right Second Premolar, 46: Mandibular Right First Molar, M: Mesial, D: Distal.

Table 4. Alveolar bone height difference after treatment

	Min - Max	Mean ± SD
33D	-0.78 – 1.26	-0.042 – 0.543
35M	-0.92 – 1.80	-0.029 – 0.734
35D	-0.60 – 0.69	-0.006 – 0.339
36M	-1.17 – 1.47	-0.018 – 0.725
36D	-0.43 – 0.61	-0.072 – 0.297
43D	-1.05 – 1.09	-0.030 – 0.661
45M	-0.76 – 0.81	-0.205 – 0.537
45D	-1.11 – 1.79	-0.147 – 0.628
46M	-1.75 – 0.98	-0.154 – 0.722
46D	-0.86 – 0.39	-0.171 – 0.397

Note: 33: Mandibular Left Canine, 35: Mandibular Left Second Premolar, 36: Mandibular Left First Molar, 43: Mandibular Right Canine, 45: Mandibular Right Second Premolar, 46: Mandibular Right First Molar, M: Mesial, D: Distal.

Since the data is numerical, a normality test was first conducted on the difference in alveolar bone height before and after the use of removable orthodontic appliances. Based on the results of the Shapiro–Wilk normality test, the data for teeth 33D, 35D, 36M, 36D, 43D, 45M, 45D, 46M, and 46D showed a normal distribution; consequently, a parametric test was performed using a paired t-test to compare two measurements within the same group. Meanwhile, for the data with a non-normal distribution in tooth 35M, analysis was conducted using the non-parametric Wilcoxon signed-rank tests.

Table 5. Results of Paired Sample t-test

	Mean ± SD	*p*	Notes
33D	0.042 ± 0.543	0.749	Not Significant
35D	-0.006 ± 0.339	0.938	Not Significant
36M	-0.018 ± 0.725	0.919	Not Significant
36D	-0.072 ± 0.297	0.326	Not Significant
43D	0.030 ± 0.661	0.851	Not Significant
45M	-0.205 ± 0.537	0.135	Not Significant
45D	-0.147 ± 0.628	0.349	Not Significant
46M	0.154 ± 0.722	0.390	Not Significant
46D	0.171 ± 0.397	0.094	Not Significant

Note: 33: Mandibular Left Canine, 35: Mandibular Left Second Premolar, 36: Mandibular Left First Molar, 43: Mandibular Right Canine, 45: Mandibular Right Second Premolar, 46: Mandibular Right First Molar, M: Mesial, D: Distal.

Results of the paired-sample t-tests for all regions showed no significant differences, with p-values above 0.05. The findings from the Wilcoxon signed-rank test showed a p-value greater than 0.05.

Table 6. Results of the Wilcoxon Signed-Rank test

	p	Notes
35M	0.276	Not Significant

Note: 35: Mandibular Left Second Premolar, M: Mesial

DISCUSSION

Removable orthodontic treatment in the Dental Clinical Student Program at Muhammadiyah University of Semarang is performed using Adam clasps on the molars. The duration of treatment depends on the patient's specific case. Removable orthodontic treatment is generally suitable for mild malocclusion cases, such as diastema.

This research aimed to evaluate the change in alveolar bone height before and after treatment with removable orthodontic appliances in patients at the Unimus Dental Hospital using panoramic radiographs. This study was conducted on 17 panoramic radiographs measured using the Bjorn method, which measures the height of the upper alveolar bone in relation to the total crown length—specifically,

the ratio of the distance from the upper alveolar bone to the crown, to the cementoenamel junction, to the upper surface of the canine, second premolar, and lower molar before and after the use of the orthodontic appliance.[13]

According to the results of the paired t-test analysis conducted on all observed teeth, the p-value was > 0.05. These findings indicate that there was no statistically significant difference before and after use of removable orthodontic appliances.

Based on Table 6, the results of the Wilcoxon Signed-Rank tests on all measured teeth showed a p-value greater than 0.05, suggesting that there was no change in alveolar bone height before and after treatment with removable orthodontic appliances.

Based on the findings of this study, it can be concluded that no difference in alveolar bone height was observed after the use of removable orthodontic appliances. This may occur because the pressure exerted by removable orthodontic appliances is lower compared to fixed orthodontic appliances; in removable orthodontics, the resulting movement is tipping, which generates a force of 35–60 gm, whereas the movement produced by fixed orthodontic appliances is bodily movement, which generates a force of approximately 70–120 gm.[15]

This study shows similar results to a previous study, which found that resorption at the root apex was higher in patients treated with fixed orthodontic appliances than in those treated with removable orthodontic appliances—specifically clear aligners. The mean resorption at the root apex in the fixed orthodontic appliance group was 1.51 ± 1.34 mm, while the mean ARR value in the clear aligner group was 1.12 ± 1.34 mm. It can be concluded that the level of apical root resorption in patients undergoing treatment with removable orthodontic appliances (clear aligners) is lower compared to patients using fixed orthodontic appliances.[16]

A similar study was also conducted by Atae et al.,[17] comparing changes in alveolar bone and apical root resorption between users of removable orthodontic appliances, such as clear aligners and fixed orthodontic appliances. The results showed that a more significant reduction occurred in users of removable orthodontic appliances, with an average root length of 13.2 mm, whereas in clear aligner users, the average root length was 13.8 mm.[17]

This study has several limitations that should be considered. The limitation of this study is that measurements were taken using panoramic radiographs of patients before and after treatment. Panoramic radiographs have image distortion and non-uniform magnification, as well as resolution limitations; differences in patient positioning and superimposition of anatomical structures can affect the consistency of measurements. To minimize potential bias, this study used only Grade 2 (diagnostically acceptable) panoramic radiographs, ensuring that the images analyzed met diagnostic acceptability criteria and allowed for the accurate and consistent identification of anatomical landmarks. The author's recommendations for institutions based on this study include improving radiographic examination standards and enhancing the standardization of panoramic radiography procedures, particularly regarding patient positioning and image quality, to improve

the consistency and accuracy of pre- and post-treatment measurement results.

Recommendations for future researchers include using a a greater number of samples to boost statistical power and enhance sensitivity to minor changes. Additionally, the use of a longitudinal study design with a longer observation period is expected to provide a more comprehensive picture of the changes that may occur as a result of using removable orthodontic appliances.

Further research is also recommended to employ more accurate imaging methods, such as periapical radiographs or cone beam computed tomography (CBCT), so that the results of the measurements become more precise and reduce measurement bias that may occur with panoramic radiographs. Furthermore, the inclusion of other variables such as appliance wear duration, patient compliance, age, and baseline periodontal condition can provide a deeper understanding of the factors influencing changes in the periodontal tissues during orthodontic treatment.

CONCLUSION

Based on both parametric (paired t-test) and non-parametric (Wilcoxon Signed-Rank Test) analyses, all p-values were greater than 0.05, indicating that there was no statistically significant difference in alveolar bone height before and after the use of removable orthodontic appliances. Therefore, within the limitations of this study, the use of removable orthodontic appliances in patients at Unimus Dental Hospital did not result in significant changes in alveolar bone height.

REFERENCES

1. Empindonta S, Yusra Y. Hubungan antara kebutuhan perawatan ortodonti interseptif dengan tingkat pendidikan ibu. J Kedokt Gigi Terpadu. 2023;5(1):188–92.
2. Khairunnisa F, Zenab NRY, Latif DS. Proporsi klasifikasi maloklusi angle mahasiswa angkatan 2015 dan 2016 Fakultas Kedokteran Gigi Universitas Padjadjaran. Maj Kedokt Gigi Klin. 2023;8(2):64.
3. Budiman JA, Sudiono J, Amin MF, Arifin SPA, Haerunnisah S, Saraswati S, et al. Pemeliharaan Keseharan Gigi dan Mulut Dalam Rangka Pencegahan Kelainan Maloklusi di Masa Pandemi COVID-19. J Akal Abdimas dan Kearifan Lokal. 2022;3 No 1:100–9.
4. S. Pawinru A, Serliawati. Bioechanics of Tooth Movement. Makasar Dent J. 2021;
5. Utama MD, Puspitasari Y, Bachtiar R, Selviani Y, Masriadi, Ilmianti, et al. Pengaruh Lama Perawatan Ortodonti Cekat Terhadap Diskolorisasi Gigi pada Mahasiswa Kedokteran Gigi di Makassar. Sinnun Maxillofac J. 2020;02(02):30–9.
6. Ardani IGAW, Narmada IB, Hamid T, Sjafei A, Sjamsudin J, Winoto ER, et al. *Pengantar Ilmu Ortodonti II*. Surabaya: Airlangga University Press; 2017.
7. Desyani NLS, Anindita PS, Leman MA. Perbandingan Efektivitas T-spring Berdimensi Kawat 0,5 mm dan 0,6 mm terhadap Koreksi Gigi Malposisi Individual (Kajian pada Typodont). e-GiGi. 2021;9(2):311.
8. Setiawatie EM, Rubianto M, Roswandi MNI. Alveolar Bone Density after the Orthodontic Treatment in Patients of Rsgm Universitas Airlangga. Indian J Forensic Med Toxicol. 2021;15(2):2323–7.
9. Omi M, Mishina Y. Roles of osteoclasts in alveolar bone remodeling. *Genes* (United States). 2022;60(8–9):1–18.
10. Toyokawa-Sperandio KC, Conti AC de CF, Fernandes TMF, de Almeida-Pedrin RR, de Almeida MR, Oltramari PVP. External apical root resorption 6 months after initiation of orthodontic treatment: A randomized clinical trial comparing fixed appliances and orthodontic aligners. Korean J Orthod. 2021;51(5):329–36.
11. Usui M, Onizuka S, Sato T, Kokabu S, Ariyoshi W, Nakashima K. Mechanism of alveolar bone destruction in periodontitis — Periodontal bacteria and inflammation. *Jpn Dent Sci Rev* [Internet]. 2021;57:201–8. Available from: https://doi.org/10.1016/j.jdsr.2021.09.005
12. Putri NPSS, Yunus B. Penggunaan Teknik Radiografi Konvensional dan Digital pada Perawatan Endodontik (Tinjauan Pustaka). Cakradonya Dent J. 2023;13(2):97–105.
13. Nauli J, Thahar B, Salim J, Mardiati E. Decrease in alveolar crest height due to orthodontic

treatment method using standard edgewise fix appliance molar. Padjadjaran J Dent. 2014;26(3):166–73.
14. Tiago F, Rasband W. *ImageJ User Guide*. In ImageJ/Fiji 1.46; 2012.
15. Proffit WR, Fields HW, Sarver DM. *Contemporary Orthodontics*, 5th Edition. Fifth Edit. Elsevier; 2013.
16. Singh SK, Adarsh K, Kumar A, Gupta AR, Sinha A. Comparison of Apical Root Resorption in Patients Treated with Fixed Orthodontic Appliance and Clear Aligners : A Cone-beam Computed Tomography Study. J Contemp Dent Pract. 2021;22(7):5–10.
17. M DMAM, Ibrar DM, Jamil DS, Islam DZU, Malik DF, Zaheer DR. A Comparative Study of Alveolar Bone Changes and Apical Root Resorption between Clear Aligners and Fixed Orthodontic Appliances. *J Popul Theurapeutics Clin Pharmacol.* 2024;31(8):1847–54.
18. Gul SS. Prevalence and severity of circumferential alveolar bone loss using CBCT images: a retrospective study of 20,620 surfaces of 5155 teeth. Diagnostics (Basel). 2024;14(5):507. doi:10.3390/diagnostics14050507.