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The effect of changing vertical irradiation angle of periapical radiography bisecting technique on the length dimension of mandibular teeth

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ABSTRACT

Objectives: This research is aimed to determine the effect of changing the vertical irradiation angle with a change in angle of +10°, +5°, -5°, -10° in bisecting technique periapical radiography on the length dimension of mandibular teeth.

Materials and Methods: This study used a laboratory experimental method with a post test only control group design. The samples used in this study were teeth I1, I2, C, P1, P2, M1, and M2 region 4. All teeth were treated by changing the angle from the standard angle recommended by White and Pharoah with changes of +10°, +5°, -5°, and -10° in each tooth using a Morita Veraview iX 70 Kv, 7mA dental X-ray unit.

Results: The results showed that the angle change of -10°, -5° causes foreshortening and +10°, +5° causes elongation. Based on the results of the Saphiro-Wilk and Kruskal-Wallis test, it is known that there are significant differences in the dimensions of tooth length at +10°, +5°, -5°, -10° against changes in the angle 0° or angulation form White and Pharoah ($p < 0.05$) .

Conclusion: There is a significant effect on the change of vertical irradiation angle with angle changes of +10°, +5°, -5°, -10° in bisecting technique periapical radiography on the length dimension of mandibular teeth.

Keywords: *Bisecting technique, vertical angulation, tooth length*
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INTRODUCTION

Radiographic examination in dentistry has a role as a supporting examination that helps dentists see the condition of the patient's mouth more clearly and in detail.[1] The quality of radiographic images needs to have parameters such as contrast, sharpness, and noise to provide clear and complete information results to make a diagnosis.[2,3] Radiographic techniques for supporting examinations are chosen by dentists because the images obtained are faster and more accurate, and can evaluate the condition of the teeth and mouth after treatment.[4] Medical radiography is divided into two types, intraoral and extraoral. Intraoral radiography consists of periapical, bitewing, and occlusal. Intraoral radiography consists of 3 techniques, one of which is periapical radiography.[5] Periapical radiographs depict a crown in detail, the tooth root, alveolar bone, and surrounding tissues. Periapical radiographs consist of bisectris and parallel techniques.[6]

The bisecting angle technique is commonly used in dental practice as it is easier to place the receptors, making it more adaptable to patients.[7] However, there are often errors when determining the length of radiographic images, such as distortion or variations in interpretation due to a lack of three-dimensional aspects.[8] Distortion can occur in the form of elongation or foreshortening of the tooth size due to incorrect vertical angle settings.[9]

The management of dental treatment requires high accuracy as in the case of root canal treatment, the occurrence of vertical distortion causes failure in the obturation process. images with vertical distortion need to be repeated which causes the patient to be exposed to excessive radiation exposure.[10] Excessive radiation exposure has the potential to cause cancer because it is carcinogenic. Excessive exposure to radiographic light is not in accordance with the ALARA (As Low As Reasonably Achievable) principle of avoiding excess radiation that has no benefit to the patient, as a dose reduction concept in radiation protection.[11]

Difficulties such as the presence of mandibular anatomical obstacles such as a shallow floor of the mouth, short frenulum, and short arch width cause the position of the receptor to be not ideal.[12] The change in measurement of the radiographic image with tooth length is an important parameter in the success of an action.[13] So it is necessary to find an angle tolerance in irradiation so as not to affect the

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measurement of the vertical dimension. Therefore, the authors would like to conduct a study to determine the effect of vertical irradiation angle in bisectric technique periapical radiography on radiographic images of mandibular tooth length.

MATERIALS AND METHODS

This study used a laboratory experimental method with a post test only control group design. The data obtained were primary data conducted at the Radiology Installation, Educational Dental and Oral Hospital, Faculty of Dentistry, Universitas Trisakti which was conducted in September - November 2023.

The population used in this study is all mandibular dental elements, region four in the jaw model. The samples used in this study used 7 teeth that had been implanted in the region 4 phantom, incisor 1, incisor 2, canine, premolar 1, premolar 2, molar 1, and molar 2.

The inclusion criteria in this study are having a crown that is still intact, if there are defects (abrasion, attrition, caries) it does not affect the vertical and horizontal dimensions of the tooth, the root is still intact and, the apical foramen is still good. The exclusion criteria in this study were crown fracture, and root fracture.

The tools used in this study are digital calipers, lecrons, wax knives, water passes, glass plates, white cloth mats, spirtus lamps, HP all-in-one 22-c0xx devices with a resolution of 1920 x 1080, dental X-ray unit Morita veraview V080 type EX-2 70 kV. 7mA. 2 sec, DBSWIN 5.11.0 software, microsoft excel software, Dürr dental Vistascan mini plus.

In this study, the teeth of incisor 1, incisor 2, canine, premolar 1, premolar 2, molar 1 and molar 2 of region 4 were measured first using digital calipers vertically to obtain the actual tooth length. After measurement, all teeth were planted using baseplate wax on the mandibular model by shaping according to the angulation in humans so that the position of the teeth in the phantom matches the original. Furthermore, radiographs were taken

Table 1. Radiograph capture results

Teeth	Actual Tooth Length	Angle Change				
		-10°	-5°	White and Pharoah	+5°	+10°
Incisor 1	19,8 mm	18,6 mm (Foreshortening 6%)	19,2 mm (Foreshortening 3%)	20,2 mm (Elongation 2%)	20,8 mm (Elongation 5%)	21,3 mm (Elongation 7,5%)
Incisor 2	20,8 mm	19,6 mm (Foreshortening 5,7%)	20 mm (Foreshortening 3,8%)	20,8 mm	21,4 mm (Elongation 2,8%)	22 mm (Elongation 5,7%)
Canine	25,1 mm	22,8 mm (Foreshortening 9,1%)	23,4 mm (Foreshortening 6,7%)	25,1 mm	25,4 mm (Elongation 1,1%)	25,8 mm (Elongation 2,7%)
Premolar 1	23 mm	22,4 mm (Foreshortening 2,6%)	22,6 mm (Foreshortening 1,7%)	23,2 mm (Elongation 0,8%)	23,6 mm (Elongation 2,6%)	24,4 mm (Elongation 6%)
Premolar 2	23,8 mm	21,5 mm (Foreshortening 9,6%)	22,4 mm (Foreshortening 5,8%)	23,7 mm (Foreshortening 0,4%)	24,4 mm (Elongation 2,5%)	26 mm (Elongation 9,2%)
Molar 1	19 mm	17,4 mm (Foreshortening 8,4%)	18,2 mm (Foreshortening 4,2%)	19 mm	19,8 mm (Elongation 4,2%)	21,1 mm (Elongation 11%)
Molar 2	20,6 mm	19,7 mm (Foreshortening 4,3%)	20,4 mm (Foreshortening 0,9%)	20,7 mm (Elongation 0,4%)	22 mm (Elongation 6,7%)	23,1 mm (Elongation 12,1%)

Table 2. Post hoc test results of angle changes of 10°, -5°, +5°, +10° against White and Pharoah angulation

	Angle Change	Incisor 1	Incisor 2	Canine	Premolar 1	Premolar 2	Molar 1	Molar 2
0°	-10°	0.008*	0.006*	0.008*	0.007*	0.007*	0.005*	0.005*
	-5°	0.008*	0.007*	0.005*	0.007*	0.006*	0.007*	0.006*
	+5°	0.008*	0.007*	0.007*	0.006*	0.008*	0.004*	0.004*
	+10°	0.008*	0.007*	0.008*	0.007*	0.007*	0.006*	0.006*

Table 3. Results of taking radiographs based on White and Pharoah's textbook angulation

Teeth	Results
Incisor 1	Elongation 2%
Incisor 2	No change
Canine	No change
Premolar 1	Elongation 0,8%
Premolar 2	*Foreshortening* 0,4%
Molar 1	No change
Molar 2	Elongation 0,4%

Table 4. Results of taking radiographs with a change in vertical irradiation angle of –10°

Teeth	Results
Incisor 1	Foreshortening 6%
Incisor 2	Foreshortening 5,7%
Canine	Foreshortening 9,1%
Premolar 1	Foreshortening 2,6%
Premolar 2	Foreshortening 9,6%
Molar 1	Foreshortening 8,4%
Molar 2	Foreshortening 4,3%

Table 5. Results of taking radiographs with a change in vertical irradiation angle of –5°

Teeth	Results
Incisor 1	Foreshortening 3%
Incisor 2	Foreshortening 3,8%
Canine	Foreshortening 6,7%
Premolar 1	Foreshortening 1,7%
Premolar 2	Foreshortening 5,8%
Molar 1	Foreshortening 4,2%
Molar 2	Foreshortening 0,9%

Table 6. Results of taking radiographs with a change in vertical irradiation angle of +5°

Teeth	Results
Incisor 1	Elongation 5%
Incisor 2	Elongation 2,8%
Canine	Elongation 1,1%
Premolar 1	Elongation 2,6%
Premolar 2	Elongation 2,6%
Molar 1	Elongation 4,2%
Molar 2	Elongation 6,7%

Table 7. Results of taking radiographs with a change in vertical irradiation angle of +10°

Teeth	Results
Incisor 1	Elongation 7,5%
Incisor 2	Elongation 5,7%
Canine	Elongation 2,7%
Premolar 1	Elongation 6%
Premolar 2	Elongation 9,2%
Molar 1	Elongation 11%
Molar 2	Elongation 12,1%

using the provisions of the standard angle of vertical angulation by White and Pharoah, all teeth were treated by changing the angle from the standard angle to -10°, -5°, +5°, +10° on each tooth using a Dental X-ray unit Veraview V080 type EX-2 70 kV. 7mA with five repetitions each angle change. The angle was changed to see if the change could cause distortion in the form of lengthening and shortening. The results of taking radiographs were observed and measured vertically and horizontally using DBSWIN 5.11.0 software. Data processing of this study used the SPSS program.

RESULTS

In this study, all subjects were given treatment in the form of taking radiographs from the standard angle recommended by White and Pharoah to changes in angles of -10°, -5°,+5°, +10° with the results in Table 1. Based on Table 1, it can be seen that the tooth length from radiographs given negative angle changes, -10° and -5°, experienced foreshortening, and at positive angle changes, +10° and +5°, experienced elongation.

Data analysis was carried out using the data

Table 8. Comparison between positive and negative vertical irradiation change

	Angle Change	Incisor 1	Incisor 2	Canine	Premolar 1	Premolar 2	Molar 1	Molar 2
Elongation	-10°	6%	5,7%	9,1%	2,6%	9,6%	8,4%	4,3%
	-5°	5,7%	3,8%	6,7%	1,7%	5,8%	4,2%	0,9%
Fore-shortening	+5°	5%	2,8%	1,1%	2,6%	2,5%	4,2%	6,7%
	+10°	7,5%	5,7%	2,7%	6%	9,2%	11%	12,1%

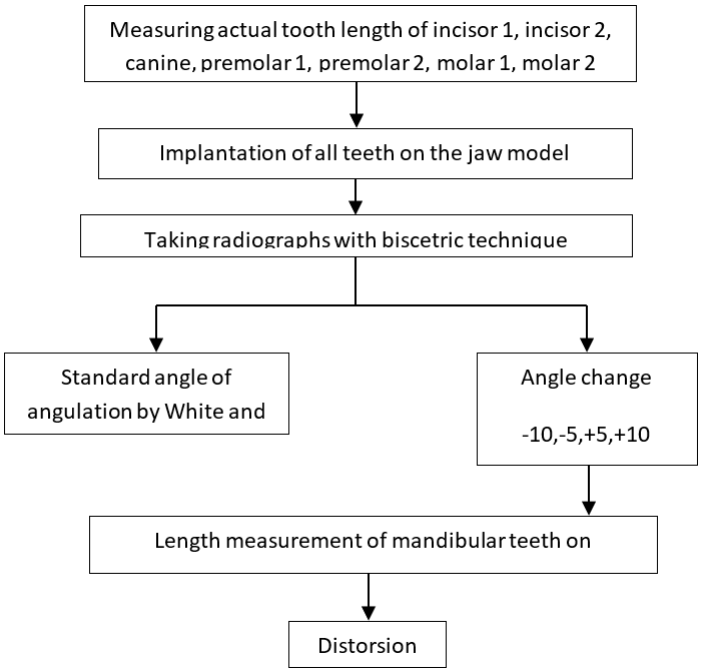

Figure 1. Bisectric technique taking scheme and vertical dimension change analysis

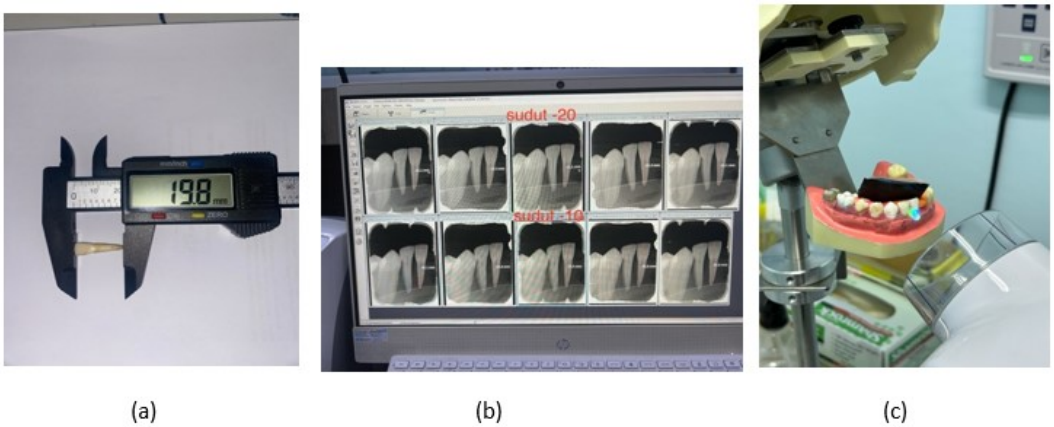

Figure 2. Research process on incisor 1, (a) Measurement of actual tooth length, (b) Radiograph with White and Pharoah angulation and measurement of radiograph, (c). X-ray tube alignment

normality test, the Shapiro-Wilk test because the number of samples was less than 50 data. The normality test of tooth length dimension showed that the data was not normally distributed ($p<0.05$). The Kruskal-Wallis test showed a significant difference between the test groups ($p<0.05$), so the Mann-Whitney Post Hoc test was performed. In the 1st incisor, 2nd incisor, canine, 1st premolar, 2nd premolar, 1st molar, 2nd molar all tooth length dimensions in the angle change groups -10°, -5°, +5°, +10°. showed significant changes against White and Pahroah angulation, which is the angle of angulation according to White and Pharoah's textbook (Table 2).

DISCUSSION

The result of radiograph taken with White and Pahroah angulation to the actual tooth length is a reduction and increase in tooth size on the radiographic image. result of radiograph taken with White and Pahroah angulation can be seen in Table 3. Based on the results of the White and Pharoah angulation, it can be said that with the angle recommended by White and Pharoah without modification, there is a mismatch between the natural teeth and the radiograph image on the 1st incisor, 1st premolar, 2nd premolar, and 2nd molar.

The results of measurements on all teeth were taken by changing the vertical irradiation angle by -10°. This resulted in radiographs of reduced teeth or foreshortening. The results of the -10° angle change can be seen in Table 4. The results of measurements on all teeth made by changing the vertical irradiation angle to -5°, resulted in foreshortening of the tooth on radiographs. The results of the -5° angle change can be seen in Table 5. The radiographs taken with a +5° vertical irradiation angle showed tooth lengthening or elongation. The results of the +5° angle change can be seen in Table 6. The radiographs appeared longer due to changes in the vertical irradiation angle +10°. The results of the +10° angle change can be seen in Table 7. Foreshortening and elongation occur when X-ray direction and the imaginary line between tooth axis and receptor are not perpendicular, by changing the vertical irradiation angle from the standard angle will cause the x-ray direction to be not perpendicular and distortion will occur.

Based on data the vertical irradiation angle changes in the negative direction, it causes foreshortening in the radiograph image. Conversely, changes in the positive direction result in lengthening or elongation. Based on this difference, it can be concluded that the relationship between changes in the vertical irradiation angle in molar teeth is bi-directional. Specifically, the greater the change in angle in the positive direction, the more elongated the tooth appears. Similarly, the greater the change in angle in the negative direction, the more foreshortened the tooth appears The percentage change produced at each angle and tooth change is different. can be seen in table 8.

In research conducted by Anggara et al (2018), changes in vertical irradiation angles of +20°, +30°, +40°, +50° and +60° on maxillary premolars 1, changes in vertical irradiation angles of +30 produce tolerable tooth lengths of less than 1 mm.[6] Primazetyarini et al (2018), said that the irradiation angle can still be tolerated until the angle of +15° because the change in tooth length is still below 1 mm while the change in the vertical irradiation angle to -15° there is no significant change in the change in tooth length dimensions.[5]

The results of the normality test with the Saphiro-Wilk test found that the data were not normally distributed because the p-value was smaller than 0.05. Then it can be continued with the Kruskal-Walli's test. The results of the Kruskal-Wallis test obtained a p-value smaller than 0.05. So that the angle changes of +10°, +5°, 0°, -5°, -10° provide significant differences in tooth length. In the post hoc test, it was found that changes in angles of +10°, +5°, -5°, -10° caused significant changes in tooth length dimensions against White and Pharoah angulation in all teeth.

Poor image quality affects interpretation and diagnosis, technical errors in taking periapical radiographs in determining the vertical irradiation angle can be in the form of foreshortening, elongation, and in determining the horizontal irradiation angle in the form of overlapping.[14] Accurate measurement of tooth length dimensions is crucial in dental practice, particularly in root canal treatment. The success of this treatment greatly depends on the precision of the working length, which can be determined through periapical radiographic images. Therefore, any errors in determining the vertical irradiation angle can significantly impact the success of the treatment.[15]

CONCLUSION

There is a significant effect on the change of vertical irradiation angle with angle changes of +10°, +5°, -5°, -10° in bisectris technique periapical radiography on the length dimension of mandibular teeth. For optimal and accurate results, future research can utilize models that represent more detailed human oral anatomy and larger sample sizes.

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FOOTNOTES

All authors have no potential conflict of interest to declare for this article. This study has received ethical approval approved by the the Research Ethics Commission of the Faculty of Dentistry, Trisakti University (685/S1/KEPK/FKG/7/202). All procedures conducted were in accordance with the ethical standards.

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