

Root morphology analysis of posterior teeth using intraoral periapical radiograph

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ABSTRACT. Oral and dental health problems are still a part of ongoing national health issues in Indonesia. Through endodontic treatment, also called root canal treatment, a decayed tooth can still be preserved and restored to its original form. It is done if the dental infection has spread into the pulp or the tooth has become nonvital due to trauma or accident. Root morphology is one of the main concerns before performing endodontic treatment. A periapical radiograph taken with bisecting and paralleling techniques is the first method in intraoral radiographic examination to assist dental diagnosis and case management. This research aimed to analyze the mean length of posterior teeth using an intraoral periapical radiograph and the difference in posterior teeth length in different vertical angulations. A total of four extracted lower premolars and four extracted lower molars served as samples in this analysis. They were mounted in an occluder, and a periapical radiograph was obtained using paralleling and bisecting technique with vertical angulation of -20°, -15°, -10°, -5°, 0°, +5°, +10°, +15°, and +20°. The tooth length was measured from the crown's highest point to the tooth apex's lowest end. Data obtained was then calculated using SPSS. The result showed that the mean length of the lower premolar and molar was longer if the vertical angulation reached +20°. Analysis with one-way ANOVA for the difference in the length of premolars, mesial root, and distal root of lower molars between a direct measurement with digital caliper and measurement on periapical radiographs taken with paralleling technique and bisecting technique in all vertical angulations showed a p-value of > 0,05. There were no significant differences in the mean length of lower premolars and the mesial and distal root of lower molars between direct measurement using a digital caliper and measure on periapical radiographs taken with paralleling technique and bisecting technique in vertical angulations of -15°, -10°, -5°, 0°, +5°, +10°, +15°, and +20°.

KEYWORDS: Vertical angulation, posterior tooth root morphology, periapical radiograph

INTRODUCTION

Dental and oral health problems are still a part of ongoing national health issues in Indonesia. Based on the results of Basic Health Research (Riskedas) in 2018, the leading dental problems in Indonesia were tooth decay, cavities, and pain (45.3%), while 19% were the absence of a tooth because of extraction/falling out. The prevalence of people in Indonesia with edentulousness was 51.4%. It showed many cases of missing/extracted teeth, and one of the leading causes was dental caries.¹

Dental and oral health can influence an individual's quality of life. Endodontic procedures can preserve a decayed tooth and restore its original form. According to Riskedas, in 2018, 57.6% of the Indonesian population experienced dental and oral

problems, but only 10.2% sought treatment from dental professionals.¹

Endodontic treatment is a treatment of root canal, performed if the infection has spread to the pulp or if the tooth has become nonvital due to trauma or accident. Root morphology is one of the main aspects that must be considered before initiating endodontic treatment. Dashrath et al. studied the root morphology of maxillary first premolars in the Nepal population, which consisted of tooth length, root length, and root number. The mean length of the maxillary first premolars was 21.0 mm, and the mean of its root length was 12.76 mm. They found a varied number of roots, with 58% having one root, 20% having two roots, 21% fused roots, and 1% having three sources.²⁻⁵

Periapical radiograph taken with bisecting or paralleling technique is often viewed as the first choice of radiograph techniques in dental case management. Bisecting technique is more often used in dentistry because of more straightforward patient adaptation. However, the drawback of this technique is distortion due to errors in vertical and horizontal angles. Mistakes in vertical angulation in the bisecting process caused vertical distortion, which appeared as a shortening or lengthening of the tooth.^{6,7}

Several kinds of literature have stated that vertical angulation for mandibular premolar was around -10° to -15°, and for mandibular molar was -

5° or 0° to -5°. White and Pharoah studied vertical angulation in several populations, including North America, India, and Brazil, and found varied values of vertical angulation. For mandibular premolar, vertical angulation in North America was -10°, in India -15°, and in Brazil -10° to -5°. For mandibular molar, vertical angulation in North America was -5°, India -10° to 0°, and Brazil -5° to 0°. ⁶⁻⁸

Based on that explanation, it was in our interest to analyze the root morphology of posterior teeth by digital periapical intraoral radiograph using paralleling and bisecting techniques with varied vertical angles.

MATERIALS AND METHODS

This research was an experimental, analytical study. It was conducted in the Installation of Dental Radiology in Dental and Oral Hospital of Universitas Sumatera Utara from February to December 2020. The sample population in this research consisted of all lower posterior teeth, excluding extracted third molar. According to inclusion and exclusion criteria, the selected samples in this research were four lower premolars and four lower molars. Inclusion criteria were teeth with intact crowns, caries that had not spread into the pulp, and teeth with good apical foramen. Exclusion criteria were teeth with fractured root.

Samples were mounted on an occluder, and then a periapical radiograph was taken with paralleling and bisecting techniques in vertical angulations of -20°, -15°, -10°, -5°, 0°, +5°, +10°, +15°, and +20° with target-object distance (TOD) of 3 – 8 cm. The resulting radiographs were measured from the highest point of the crown to the lowest point of the apex. Normality and homogeneity tests were performed on the resulting data, and one-way ANOVA was subsequently completed.

RESULTS

The result showed that the mean length of lower posterior teeth as measured by digital caliper was 21.65 ± 1.79 mm for premolars, 21.07 ± 1.05 mm for the mesial root of the molars, and 20.04 ± 1.13 mm for the distal root of the molars (Table 1). Measurement on periapical radiographs, which were taken by paralleling technique, showed that the mean length of the lower posterior teeth was 22.87 ± 1.68 mm for

premolars, 21.27 ± 0.91 mm for the mesial root of the molars, and 20.55 ± 0.82 mm for the distal root of the molars (Table 2). The following tables showed the mean length of premolars (Table 3), the mesial root of molars (Table 4), and the distal root of molars (Table 5), measured on periapical radiographs taken by a bisecting technique using varied vertical angulations.

Table 1. The mean length of posterior teeth was measured using a digital caliper

Teeth	n	Min	Max	Mean $\pm$ SD (mm)
Premolars	4	19,63	24,00	$21,65 \pm 1,79$
Mesial root of molars	4	19,75	22,17	$21,07 \pm 1,05$
Distal root of molars	4	18,75	21,17	$20,04 \pm 1,13$

Table 2. The mean length of posterior teeth as measured on periapical radiographs taken by paralleling technique

Teeth	n	Min	Max	Mean $\pm$ SD (mm)
Premolars	4	21,00	25,10	$22,87 \pm 1,68$
Mesial root of molars	4	20,40	22,20	$21,27 \pm 0,91$
Distal root of molars	4	19,50	21,50	$20,55 \pm 0,82$

Table 3. The mean length of premolars as measured on periapical radiographs taken by a bisecting technique using varied vertical angulation in 3 – 8 cm distance.

Angle	Mean $\pm$ Standard Deviation (mm)					
	3 cm	4 cm	5 cm	6 cm	7 cm	8 cm
-20°	22,00 $\pm$ 1,57	22,00 $\pm$ 1,52	22,27 $\pm$ 1,39	22,12 $\pm$ 1,58	21,85 $\pm$ 1,45	22,20 $\pm$ 2,03
-15°	22,45 $\pm$ 2,11	22,22 $\pm$ 1,91	22,17 $\pm$ 1,83	22,30 $\pm$ 1,92	22,40 $\pm$ 2,07	22,37 $\pm$ 1,83
-10°	22,62 $\pm$ 1,87	22,57 $\pm$ 1,75	22,35 $\pm$ 1,87	22,72 $\pm$ 2,15	22,50 $\pm$ 2,05	22,40 $\pm$ 2,03
-5°	22,57 $\pm$ 1,93	23,00 $\pm$ 1,68	23,17 $\pm$ 1,20	23,10 $\pm$ 1,24	22,85 $\pm$ 1,43	23,35 $\pm$ 2,46
0°	22,87 $\pm$ 1,57	22,90 $\pm$ 1,53	22,85 $\pm$ 1,33	22,67 $\pm$ 1,56	22,67 $\pm$ 1,43	22,80 $\pm$ 1,43
+5°	22,77 $\pm$ 1,75	22,60 $\pm$ 1,80	22,60 $\pm$ 1,80	22,60 $\pm$ 1,88	22,60 $\pm$ 1,81	22,35 $\pm$ 1,98
+10°	22,65 $\pm$ 1,86	22,97 $\pm$ 1,58	22,55 $\pm$ 1,76	22,77 $\pm$ 1,72	22,77 $\pm$ 1,80	22,30 $\pm$ 0,94
+15°	23,12 $\pm$ 1,62	22,92 $\pm$ 1,62	22,90 $\pm$ 1,51	22,82 $\pm$ 1,58	22,80 $\pm$ 1,80	22,72 $\pm$ 2,01
+20°	22,95 $\pm$ 1,86	22,75 $\pm$ 1,74	22,80 $\pm$ 1,85	23,22 $\pm$ 2,36	23,10 $\pm$ 2,41	23,40 $\pm$ 1,89

Table 4. The mean length of the mesial root of the molars as measured on periapical radiographs taken by a bisecting technique using varied vertical angulation in a 3 – 8 cm distance

Angle	Mean $\pm$ Standard Deviation (mm)					
	3 cm	4 cm	5 cm	6 cm	7 cm	8 cm
-20°	20,97 $\pm$ 1,48	20,67 $\pm$ 1,21	20,60 $\pm$ 1,14	20,77 $\pm$ 1,27	20,72 $\pm$ 1,26	20,65 $\pm$ 1,09
-15°	21,15 $\pm$ 1,22	21,15 $\pm$ 1,16	21,12 $\pm$ 1,20	21,02 $\pm$ 1,13	21,15 $\pm$ 1,27	20,97 $\pm$ 1,13
-10°	21,45 $\pm$ 1,10	21,40 $\pm$ 1,15	21,42 $\pm$ 1,18	21,45 $\pm$ 1,16	21,42 $\pm$ 1,07	21,40 $\pm$ 1,22
-5°	21,75 $\pm$ 1,22	21,70 $\pm$ 1,30	21,65 $\pm$ 1,24	21,62 $\pm$ 1,26	21,70 $\pm$ 1,32	21,77 $\pm$ 1,36
0°	22,35 $\pm$ 1,32	22,00 $\pm$ 1,21	21,97 $\pm$ 1,27	21,77 $\pm$ 1,28	22,02 $\pm$ 1,34	21,80 $\pm$ 1,31
+5°	21,92 $\pm$ 1,40	22,25 $\pm$ 1,30	22,07 $\pm$ 1,29	22,30 $\pm$ 1,51	22,20 $\pm$ 1,21	22,15 $\pm$ 1,38
+10°	22,52 $\pm$ 1,55	22,62 $\pm$ 1,46	22,30 $\pm$ 1,52	22,32 $\pm$ 1,33	22,40 $\pm$ 1,34	22,77 $\pm$ 1,90
+15°	23,02 $\pm$ 1,71	22,82 $\pm$ 1,79	22,80 $\pm$ 2,01	23,07 $\pm$ 1,64	22,80 $\pm$ 1,68	22,65 $\pm$ 1,84
+20°	23,35 $\pm$ 1,69	23,52 $\pm$ 2,05	23,50 $\pm$ 1,40	23,12 $\pm$ 1,73	22,95 $\pm$ 1,66	23,10 $\pm$ 1,74

Table 5. The mean length of the distal root of the molars as measured on periapical radiographs taken by a bisecting technique using varied vertical angulation in a 3 – 8 cm distance

Angle	Mean $\pm$ Standard Deviation (mm)					
	3 cm	4 cm	5 cm	6 cm	7 cm	8 cm
-20°	20,20 $\pm$ 1,16	19,95 $\pm$ 0,91	19,92 $\pm$ 1,14	20,02 $\pm$ 1,02	19,90 $\pm$ 1,03	19,92 $\pm$ 0,97
-15°	20,37 $\pm$ 1,00	20,32 $\pm$ 0,86	20,20 $\pm$ 0,93	20,17 $\pm$ 0,99	20,30 $\pm$ 0,96	20,17 $\pm$ 1,00
-10°	20,37 $\pm$ 1,00	20,32 $\pm$ 0,86	20,20 $\pm$ 0,93	20,17 $\pm$ 0,99	20,30 $\pm$ 0,96	20,17 $\pm$ 1,00
-5°	20,85 $\pm$ 1,04	20,77 $\pm$ 1,02	20,72 $\pm$ 0,89	20,77 $\pm$ 1,02	20,62 $\pm$ 0,98	20,95 $\pm$ 0,98
0°	21,40 $\pm$ 1,12	21,07 $\pm$ 1,16	20,97 $\pm$ 1,28	20,75 $\pm$ 1,10	21,07 $\pm$ 1,15	20,87 $\pm$ 1,13
+5°	21,12 $\pm$ 1,26	21,30 $\pm$ 1,15	21,10 $\pm$ 1,19	21,22 $\pm$ 1,44	21,30 $\pm$ 1,19	21,15 $\pm$ 1,35
+10°	22,52 $\pm$ 1,55	22,62 $\pm$ 1,46	22,30 $\pm$ 1,52	22,32 $\pm$ 1,33	22,40 $\pm$ 1,34	22,77 $\pm$ 1,90
+15°	21,85 $\pm$ 1,52	21,72 $\pm$ 1,61	21,80 $\pm$ 1,86	21,90 $\pm$ 1,46	21,55 $\pm$ 1,34	21,37 $\pm$ 1,52
+20°	22,20 $\pm$ 1,83	22,52 $\pm$ 2,17	22,45 $\pm$ 1,70	22,10 $\pm$ 1,83	21,92 $\pm$ 1,79	22,02 $\pm$ 1,85

The normality test by the Shapiro-Wilk test on all groups showed that the data were normally distributed ($p > 0.05$). Lavene Test to analyze the homogeneity of more than two data groups resulted in a p -value > 0.05 , meaning the data groups came from a population with the same variants. One-way ANOVA was subsequently performed, and the result showed no significant differences in the mean

teeth length between a direct measurement with a digital caliper, measurement on periapical radiographs taken by paralleling technique, and measurement on periapical radiographs taken by bisecting approach in vertical angulations of -20°, -15°, -10°, -5°, 0°, +5°, +10°, +15°, and +20°. However, the TOD distance was 3 to 8 cm ($p > 0.05$).

Table 6. P-value of the teeth length measurements between digital caliper, paralleling technique, and bisecting technique with TOD 3-8 cm in vertical angulation of -20°, -15°, -10°, -5°, 0°, +5°, +10°, +15°, and +20°

Teeth	<i>p-value</i>					
	3 cm	4 cm	5 cm	6 cm	7 cm	8 cm
Premolar	0,991	0,983	0,985	0,988	0,99	0,981
Molar, mesial root	0,230	0,144	0,143	0,187	0,285	0,334
Molar, distal root	0,261	0,161	0,174	0,249	0,279	0,343

DISCUSSION

This research showed that the mean length of lower premolars and molars was longer if the vertical angulation reached +20°. Incorrect vertical angulation would result in distortion. The greater the vertical angulation, the more teeth will appear shorter, and vice versa. The smaller the vertical angulation, teeth will appear longer. Bisecting angle technique produced an inherent distortion of the resulting image. Hence there are vertical angulation values that are still tolerable and do not impact the vertical length measurement of the tooth.^{9,10}

In this research, no significant differences were found in tooth length between a direct measurement with a digital caliper, a measure on a periapical radiograph taken with paralleling technique, and a measurement on a periapical radiograph taken with bisecting approach with a significance level above 0.5. In paralleling procedure, the film was positioned parallel to the tooth, and the beam traveled perpendicular through the tooth and film with the aid of a film holder. Allothmani et al. stated that there were fewer errors in work length determination by using paralleling technique than bisecting technique.¹¹ Proper film positioning in the bisecting method before exposure was probably one of the reasons this research found no significant differences in tooth length measurement compared with the direct size with a digital caliper. If vertical angulation was becoming more negative, the upper side of the film was positioned higher, up to 1 cm, from the surface of the tooth object.

Conversely, if vertical angulation was becoming more positive, the upper side of the film was positioned slightly lower than the tooth surface to avoid cone cutting. The difference in tooth length in bisecting technique with varied vertical angulation, from -20° to +20°, was less than 2 mm. If vertical angulation was becoming more positive, the differences in tooth length could exceed 1 mm.

This result followed the research of Heryanto et al., which was done on mandibular premolars. If the vertical angle was more positive, the height of the cups became lower. Hence the length of the tooth became shorter, and superimposition became bigger. Vertical angulation that was significantly acceptable was -20° to +15° with a p-value of >0.05, while

vertical angulation +20° showed a p-value of <0.05, indicating a significant difference with the direct measurement.¹²

This research also measured the length of the mesial and distal roots of mandibular molars. OneWay ANOVA test showed no significant differences between the actual tooth length and the estimated tooth length on the periapical radiograph obtained with paralleling and bisecting techniques in vertical angulation of 20°, -15°, -10°, -5°, 0°, +5°, +10°, +15°, +20° and TOD 3-8 cm (p>0,05).

Allothmani et al. recommended the paralleling technique in determining the endodontic working length. Vertical angulation in bisecting approach should be customized according to the anatomy of the patient's jaw. Variations in anatomy such as proclined teeth should be noticed and the vertical angulation adapted by the radiographer before acquiring a radiograph with bisecting technique.¹³

In this research, the mean length of mesial and distal roots of mandibular molars on radiographs taken with bisecting technique in vertical angulations between -5° to -20° was less than 1 mm. Some literature stated that vertical angulation for mandibular molars was -15°, -10°, and -5°. Several researchers said that although there were differences in vertical angulation for mandibular molars in pieces of literature, they still presented tooth length with distortion of less than 1 mm. The mean tooth length for paralleling technique in this paper was distorted between 0.2-0.5 mm. Therefore, we also agreed that paralleling process was better for usage on mandibular molars than bisecting technique because the resulting distortion was more negligible.

Faraj, in his research, concluded that working length estimation could be made closest to its actual clinical canal length by using a digital periapical radiograph obtained in paralleling technique, in addition to Cone Beam Computed Tomography.¹⁴ According to Frommer, paralleling gave more accurate images and protected the thyroid gland area and eye lens more than bisecting technique. The direction of the x-ray in bisecting approach with steep vertical angulation can pass through the thyroid gland and eye lens area.^{15,16}

At present, the bisecting technique is still widely used. One reason is that the film holder used in the paralleling procedure is more rigid and firm. In contrast, in bisecting strategy, the film is held with the aid of the patient's finger, hence more comfortable for both the patient and operator. In this research, the variation in vertical angulations from -20° to $+20^{\circ}$ can still be applied according to the anatomical condition of the patient. If the floor of the patient's mouth is shallow and causing the film to be

positioned higher than the surface of the tooth, then the vertical angulation can be positioned up to -20° . If the floor of the patient's mouth is deep, causing the patient to push the film at least to the same level or lower than the surface of the tooth, then the vertical angulation can be positioned up to $+20^{\circ}$. Distortion in the form of shortening or lengthening of the tooth at a perpendicular angle of $+20^{\circ}$ can reach ± 2 mm.

CONCLUSION

The measurement of the length of mandibular premolars and mesial root and distal root of mandibular molars based on radiographs obtained with paralleling technique and bisecting technique in vertical angulation of -20° to $+20^{\circ}$ showed no

significant differences. This research found that paralleling technique was better than bisecting technique because the resulting distortion was more negligible and more protective of the patient's thyroid gland and eye lens.

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