Evaluation of Vertical Distortion on Periapical Radiographs Based on Clinical Endodontic Patients' Tooth Measurements

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Abstract

Vertical distortion plays an important role in determining the working length of endodontic treatment. The objective of this study was to determine the mean value of vertical distortion on the periapical radiographs of maxillary and mandibular teeth based on the measurement of the difference in the radiographic and actual size of the tooth length.

The study was carried out on 120 samples of medical records, along with periapical radiographs of endodontic patients, divided into 60 samples of maxillary teeth and 60 samples of mandibular teeth. The measurement of clinical tooth length was obtained by using the value of actual working length plus 1 mm, as recorded in the patient's endodontic dental record data. The radiographic tooth length measurement was obtained using the patient's initial periapical radiograph. The value of vertical distortion was obtained by measuring the difference between the radiographic measurement and the clinical tooth length. Intraobserver and interobserver reliability tests were performed using the Intra Correlation Coefficient (ICC) test, and comparative analysis was performed using the Student T-test independent. The analysis showed that the mean vertical distortion in the maxillary teeth was 1.58 mm, with a maximum value of 5.53 mm. The mean value of vertical distortion in the mandibular teeth was 1.48 mm, with a maximum value of 3.96 mm. A total of 52 (43.33%) samples were elongated, 55 (45.83%) samples were shortened, and 13 (10.83%) samples were not distorted.

This study's results indicate no statistical difference in vertical distortion between estimated clinical tooth length and tooth length measurements on the radiographs.

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Introduction

Periapical projection is a radiographic examination technique often used as the first choice in managing dental cases.[1] Periapical radiographs provide a complete and detailed view of the intended dental object, including the surrounding bone and supporting tissues.[2] However, although they are widely used, the interpretation of periapical radiographs also has various limitations. The most common issue is distortion. Radiograph distortions can generally occur in vertical and horizontal directions. Distortions can be influenced by the position of the X-ray source, the objects, and the location of the radiograph.[3]

Vertical distortion is an error resulting from an image's projection on a radiograph in terms of its vertical dimension, which can be in the form of elongation or shortening of an image. Vertical distortion occurs due to incorrect determination of X-ray angulation in the vertical direction. Various studies regarding vertical distortion on periapical radiographs have been carried out.[4,5] Research on common errors in periapical radiographs by Dastgir Bhatti et al.[6] indicates that errors are generally due to improper vertical angulation. The study showed that the percentage of vertical distortion in the sample in elongation was 7.0%, and the shortening was 2.6%. Furthermore, the study also proved that radiographic images of the maxillary teeth are more often distorted than mandible teeth.[6] This was presumably due to the

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rigidity and anatomical curvature of the hard palate in the maxillary arch, which makes it difficult to place radiographic film. Although various studies on vertical distortion have been carried out, studies about vertical distortion on periapical radiographs of the maxillary and mandibular teeth require further research.

Root canal treatment is often performed in dentistry. Radiography examination plays an important role in determining the working length of an endodontic treatment, and radiographic images must be interpreted with high accuracy.[7,8] In this study, the sample radiographs were determined to be of good quality and used as early diagnostic tools to measure the root canal's working length. Although they were diagnostically acceptable, errors occurred in the periapical radiographs, resulting in minimal vertical distortions. This study aims to evaluate whether vertical distortions on radiographs have a significant value on actual tooth length and to determine the average value of vertical distortions on radiographs.

Materials and methods

The researcher submitted a permit application letter to the Faculty of Dentistry, Universitas Indonesia, Research Ethics Commission, and it was approved through an ethical approval letter number 62/Ethical Approval/FKGUI/X/2021 with protocol number 090850921.

A descriptive cross-sectional study was performed using periapical radiographs in the endodontic dental records of patients at a dental hospital. This research was conducted between August and November 2021. Samples were taken using consecutive non-randomized sampling of 120 periapical radiographs, divided into 60 maxillary and 60 mandibular teeth samples that met the inclusion criteria. Sample inclusion criteria were dental record data of permanent endodontic teeth in patients > 12 years old, which contained three periapical radiographs from initial diagnosis, working length and actual working length of the tooth, completed root canal treatment, and radiographs of good quality evaluation that could be measured. The initial measurement was based on the formula: [clinical crown length/clinical tooth length]=[radiographic crown length/radiographic tooth length]. The values of the estimated and actual working lengths were provided in the patients' endodontic dental record data. The measurement of clinical tooth length was obtained by using the value of the actual working length plus 1 mm, as recorded in each dental record, whereas the measurement of the radiographic tooth length was obtained by using the patient's initial periapical radiograph. The value of vertical distortion was obtained by measuring the difference between the radiographic tooth length measurement and the clinical tooth length. Sample exclusion criteria included teeth with more than ½ crown tissue loss, periapical radiographs of teeth with extensive fractures, radiographs taken using localization methods (such as the same lingual opposite buccal technique), root anatomical structures of teeth with severe dilacerations, obstructed root canals, and external resorption.

Statistical Analysis

The independent variables were clinical tooth length measurement data and periapical radiographs of the maxillary and mandibular tooth samples. The dependent variable was the measurement of the value of vertical distortion on periapical radiographs of the maxillary and mandibular teeth samples. First, a normality test was performed using the Kolmogorov–Smirnov test. The T-test independent was used for normal distribution data. Intra-and inter-observer reliability tests were carried out using the Intra Coefficient Correlation method on 30% of the 120 samples. The intraobserver and interobserver reliability tests were 0.984 – 0.977. Therefore, it can be concluded that the level of agreement was of excellent reliability. SPSS (version 17.0; SPSS Inc. Chicago, IL, USA) was used to analyze the data with a statistical significance set at $p<0.05$.

Results

The frequency distribution of the data is shown in Table 1. Based on the type of vertical distortion, 52 (43.33%) of the data were elongated, 55 (45.83%) were shortened, and 13 (10.83%) were not distorted. Based on the upper and lower jaws, the maxillary was elongated by 26 (43.33%), shortened by 29 (48.33%), and there was distortion in 5 (8.33%). In the mandibular, 26 (43.33%) were elongated, 26 (43.33%) shortened, and there was no distortion in 8 (13.33%).

Vertical distortion	Maxilla (%)	Mandible (%)	Frequency (%)
Elongation	26 (43.33%)	26 (43.33%)	52 (43.33%)
Foreshortening	29 (48.33%)	26 (43.33%)	55 (45.83%)
No distortion	5 (8.33%)	8 (13.33%)	13 (10.83%)
Total	60 (100%)	60 (100%)	120 (100%)

Table 1. Frequency distribution of vertical distortion types in the maxillary and mandibular.

Jaw	variable	Mean±SD (mm)	*p* value
Maxilla	Clinically	24,20 ± 2,81	0,459
	Radiographically	23,79 ± 2,33	
Mandible	Clinically	20,92 ± 3,10	0,457
	Radiographically	20,72 ± 2,51	
Maxilla and mandible	Clinically	22,56 ± 3,38	0,451
	Radiographically	22,25 ± 2,86	

Table 2. Differences in measurements between clinical and radiographic tooth lengths in the maxilla and mandible.

Jaws	Vertical distortion	Minimal (mm)	Maximal (mm)	Mean±SD (mm)	p value
Maxilla	Elongation	0.51	4,39	1,58 ± 1,23	0,975
	Foreshortening	-5,53	-0,50		
Mandibula	Elongation	0,47	3,96	1,48 ± 1,04	
	Foreshortening	-3,73	-0,55		

Table 3. Vertical distortion in the maxillary and mandibular on the radiographs.

The mean and standard deviation of clinical tooth length measurements for the entire sample was 22.56 ± 3.38 mm, and the mean value and standard deviation for tooth length measurements on radiographs for the entire sample was 22.25 ± 2.86 mm (Table 3). There was no significant difference between clinical and radiographic tooth length measurements, with a p-value of 0.451 ($p > 0.05$). Similar results also found no significant difference in the mean value of the clinical tooth lengths and radiographic tooth lengths when they were divided into the maxillary and mandibular tooth length groups.

It was found that the estimated average value of the vertical distortion measurement results based on measurements of the length of the teeth in the maxillary was 1.58 ± 1.23 mm, with the lowest value being -5.53 mm and the highest value being 4.39 mm. Meanwhile, the estimated average value of the vertical distortion measurement results on the mandibular was 1.48 ± 1.04 mm, with the lowest value being -3.73 mm and the highest value being 3.96 mm. The mean value of vertical distortion in the maxillary and mandibular groups was, therefore, a p-value of 0.975. This indicates that there was no statistically significant difference in the average value of the vertical distortion measurements in the maxillary and mandibular jaw groups.

Discussion

These data findings indicate that the periapical radiographs evaluated with good quality do not have significant differences in their clinical measurements. These data findings align with previous studies by Antolis et al.[9], who found that the difference between clinical tooth length and radiographic tooth length for all vertical angle changes proved insignificant ($p < 0.05$). Ardakani et al.[3] evaluated and compared the distortion of the third molars on periapical radiographs by measuring the difference in the size of the third molars in gips models with the radiographs. The results by Ardakani et al.[3] showed no significant difference between the mean third molar position on panoramic and periapical radiographs and the actual position on the models. Thus, this study concluded that distortion does not have a special effect on diagnosing the actual third molar position compared to the periapical radiographic. The difference and advantage of this study compared to the study conducted by Ardakani et al.[3] is the method of measuring teeth using gips models. In contrast, this study was conducted using clinical measurements of the ratio of working length to teeth. The data findings in this study are also in accordance with previous studies by Wettasinghe et al.[10], who found many errors in taking periapical radiographs. Most of the errors that occurred in the study, however, were not significant, so they did not affect the diagnosis of working-length measurements, and the operator did not need to re-take radiographs.

This study also showed that the average value of distortion in the maxillary and mandibular teeth was not significantly different. This is inconsistent with previous studies by Gopal et al.[11], who found significant differences in the value of vertical angulation errors between the maxillary and mandibular arches. The difference in the results of the study may have occurred because the radiographic images of the sample included pediatric patients in the inclusion criteria, and possibly due to the limited skills of the radiographer in the study, who was a preclinical dental student. However, in our study, it was found that the mean value of the vertical distortion measurements of the maxillary was slightly larger than the average value of the

vertical distortions in the mandibular. Many other studies have stated that maxillary periapical radiographs often experience vertical distortion.[6,10,11] This difficulty may be due to the shape of the maxillary anatomy, which affects the position of the radiograph in the mouth. A shallow palate or having a large torus palatinus is a common cause of film placement errors. In addition, film placement errors can be caused by the varying inclination of the maxillary teeth. Furthermore, the inclination of the maxillary incisors, which tends to be more toward the facial, can affect the correctness of the vertical angle.

In this study, the periapical radiographic technique used in the samples was not differentiated from parallel or bisection techniques, so that it might affect the vertical distortion. However, a previous study by Ibrahim et al.[12] compared parallel and bisection periapical radiographic techniques on radiographs from endodontics and found no statistically significant difference in the accuracy of radiographic measurements with parallel or bisection techniques. The parallel technique, however, was found to have higher accuracy than the bisection technique. This may have been due to the placement of the film in the bisection technique, which did not use a film holder, allowing for more significant distortion.[12] Several studies use Cone-Beam Computed Tomography (CBCT) as a gold standard for measurement accuracy in relation to vertical distortion; the researchers agreed that CBCT accurately measured the length of work compared to periapical radiography.[13,14] Adarsh et al.[15] found that using CBCT significantly differs in teeth measurement between periapical radiography and CBCT. The highest significant difference was in the root length measurement, whereas in the crown length measurement, no significant difference was found.[15] Another study concluded that this significant difference was due to the size of the 0.5-1mm difference from apex. When this difference was calculated, the calculation of the tooth's length obtained was relatively reliable.[16] It's critical to keep in mind that CBCT delivers a greater radiation exposure than traditional dental radiography. Furthermore, children should only undergo a 3D CBCT test when it is crucial for the diagnosis to be made since they are more vulnerable to radiation.[17]

Several studies on vertical distortion have been reviewed. Bhatti et al.[6] found several vertical distortion errors from a total sample of periapical radiographs: 7% in elongation and 2.6% in shortening due to improper vertical angle placement. Research by Wettasinghe et al. showed that 96.8% of the sampled periapical radiographs studied experienced errors, including vertical distortion.[10] This is also supported by research by Almogbel et al.[18], who examined the quality of periapical radiographs taken by dental students. In that study, one of the most common errors in periapical radiographs was vertical angle error or vertical distortion: 15.1% of the sample. Previous studies by Gopal et al.[11] also showed that technical errors in the form of vertical distortion are common errors in radiographic image capture. Based on the results of the several studies above, it can be concluded that technical errors in vertical distortion can be caused by various factors, such as radiographers' expertise and lack of experience, and certain anatomical conditions of the oral cavity, which make proper placement of the film difficult.

One limitation of this study is that the measurements of the estimated clinical tooth length were not measured directly on the patients. The measurements are based on patients' endodontic radiographs record data, which could have affected the value of the differences in the tooth lengths measured. Additionally, this study did not separate the tooth regions and the periapical radiograph technique. Further research should take these factors into consideration.

Conclusions

This study's results indicate no statistical difference in vertical distortion between estimated clinical tooth length and tooth length measurements on the sampled radiographs.

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Declaration of Interest

The authors declare no potential conflicts of interest concerning this article's research, authorship, and publication.

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