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Original Research

Radiographic estimation of pre & post-operative root canal wall thickness after using three NiTi rotary file systems- Protaper, RaCe and Mtwo – An in-vitro study

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ABSTRACT:
Introduction: To measure on a digital radiograph the pre and post-operative root canal wall thickness and to evaluate the differences between radiographic measurements and the actual canal width, by using three NiTi rotary systems. **Materials & methods:** Palatal roots of 30 human maxillary first molars free of decay and restorations were selected from a collection of freshly extracted teeth. The palatal roots were amputed at cemento-enamel junction using diamond disc of 0.25 mm thickness. Standardized digital radiographs were taken before preparation of the canal and the thickness of the root canal wall was measured on the left and right side of the canal in bucco-lingual and mesio-distal planes at three levels (coronal, middle & apical third) by using software XVa3. The root canals were prepared by using Protaper (Dentsply Sirona, Canada), RaCe (FKG, Lachaux-de-Fonds, Switzerland) and Mtwo (VDW, Munich, Germany) NiTi rotary systems. Standardized digital radiographs were taken again and dentin thickness measured in a similar manner after the preparation. Roots were sectioned horizontally at predetermined levels and actual root canal wall thickness was measured. The measurements were made blindly and the data were recorded using SPSS version 19 software (Microsoft, IL, USA). Results obtained were analysed using Paired "t" test, ANOVA & Pearson's Correlation coefficient. **Results:** Protaper had better cutting efficiency in all the planes whereas RaCe and Mtwo had varying results in different planes and locations. Radiographic measurements were higher as compared to the actual width. **Conclusion:** Digital radiography images overestimate the actual root canal wall thickness but Digital radiography has advantage over conventional radiography as it can measure the Root canal wall thickness in two-dimension for monitoring critical endodontic cases.
Keywords: Digital radiography, root canal wall thickness, rotary NiTi

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INTRODUCTION

Removal of necrotic or residual pulp tissue, elimination of debris and maintenance of the original canal anatomy during enlargement are the main objectives of root canal instrumentation and the success of endodontic therapy depends upon it. Over a period of time various hand and rotary methods have been devised to prepare root canals and manual root canal instrumentation was assumed to be superior to automated devices.[1,2] Since the last decade instrumentation using rotary nickel-titanium (Ni-Ti) instruments with various tapers is gaining popularity.

In fact, most of the endodontists are switching over to rotary instrumentation. With the introduction of Ni-Ti, there is less straightening of curved canals, less decentralization of the canal, and a rounder canal preparation even in severely curved root canals.[3,4] The access cavity, root canal preparation and post space preparation leads to an appreciable loss of dentin. The survival of root filled teeth depends upon the amount of residual dentin.[5] Various studies demonstrate a direct relationship between the loss of tooth structure and the possibility of fracture of the tooth crown or root after endodontic therapy.[6,7]

While preparing the root canal, the diameter of the preparation should be equal to one-third of the root diameter as observed on the radiograph.[8] At least 1 mm of root dentin should remain in all root aspects along its entire length after all intra-radicular procedures are completed.[9] The risk of fracture increases proportionally to the amount of dentin removed in endodontically treated teeth.[10] A study by Kutler *et al.* [11] in 2003 has shown that after instrumentation with rotary instruments there is a significant reduction in minimum canal wall thickness at each level (coronal to apical) of the root. Ideally, the more the rotary instrument remains canal centred the lesser the dentin removed resulting in preservation of the root canal wall thickness.[13,14] Shahriari *et al*. [15] evaluated the amount of dentine removed after canal preparation using stainless steel hand instruments or rotary ProFile instruments and concluded that ProFile rotary instrumentation prepares root canals with a greater conservation of tooth structure and greater amounts of dentin was removed mesially in all sections in hand instrumentation group. Weller *et al.*[16] undertook a study was to determine the remaining dentin thickness in the apical 4 mm following four cleaning and shaping techniques and found that there were significant statistical differences in remaining dentinal thickness among techniques at different levels and stressed for further study to determine any significant clinical difference in remaining dentinal thickness. Several studies have been conducted to evaluate root canal wall thickness after instrumentation with the rotary systems in the coronal and middle aspects of the root.[17-19] These studies have measured root canal wall thickness by using two dimensional radiographs or by actually measuring the canal width. Souza *et al.*[20] reported that Periapical radiographs overestimate root canal wall thickness during post space preparation.

Thus, it is important to highlight that periapical radiograph remains the most reliable clinical tool used for determining the root canal wall thickness. As compared to conventional radiography, direct digital radiography with its low exposure to radiation and time saving procedure offers an advantage and has a limited effect on the diagnostic accuracy.[22,23] Three dimensional digital radiography such as Cone Beam computed tomography or Micro-computed tomography may be used for the purpose but due to its high cost and unavailability its use is limited. Thus, an endodontist has no option but to rely on two dimensional digital radiography which has numerous advantages over conventional such as image storage, enhancement and calibrations. If root canal wall thickness is measured using calibration tools of direct digital radiography at every stage of root canal preparation would help clinicians to avoid weakening of the roots. So far, a comprehensive study using direct digital radiography to estimate root canal wall thickness on the mesio-distal and bucco-lingual aspects in the coronal, middle and apical aspect of the root has not been conducted.

Taking into consideration the above facts, this study was designed to compare the difference in root canal wall thickness before and after instrumentation with the rotary instruments by using direct digital radiographs and actual measurements were then compared with radiographic measurements.

MATERIALS AND METHODS

Palatal roots of 30 human maxillary first molars free of decay and restorations were selected from a collection of freshly extracted teeth. The palatal roots were amputed at cemento-enamel junction using diamond disc of 0.25 mm thickness. The roots with an average length of 8 mm and round cross section were considered for the study.

The roots were randomly divided into three groups (n= 10).

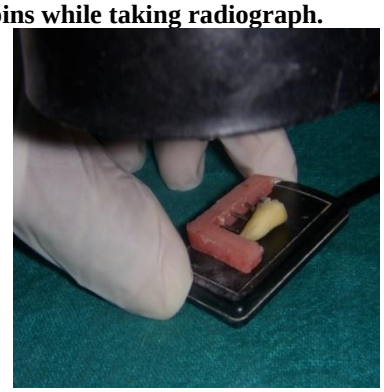
GROUP I : Protaper (Dentsply Sirona, Canada)

GROUP II : RaCe (FKG, Lachaux-de-Fonds, Switzerland)

GROUP III : Mtwo (VDW, Munich, Germany)

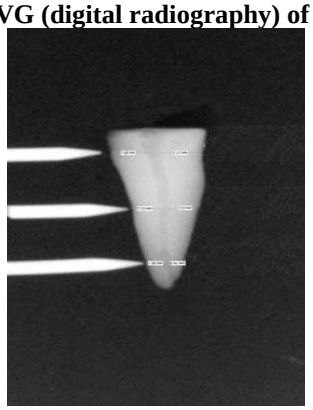
The mesial, distal, facial and palatal surfaces were marked for identification. Each root was stabilized on an acrylic mould having pins at definite distance from each other horizontally, marking the point at which the measurements are to be taken. (Figure.1)

Figure 1: Root stabilized on an acrylic mould having pins while taking radiograph.



The central pin was placed at the centre of the root and the next two pins were placed at a distance of 2 mm from the central pin coronally and apically. (Figure.1) The root were radiographed mesio-distally and bucco-lingually using direct digital radiography (RVG, Suni Ray Systems, USA) and X-ray machine Evolution X 3000 (New Life Radiology, Italy) 70kv 8ma with target- sensor distance of 30cm. (Figure.2)

Figure 2: RVG (digital radiography) of root

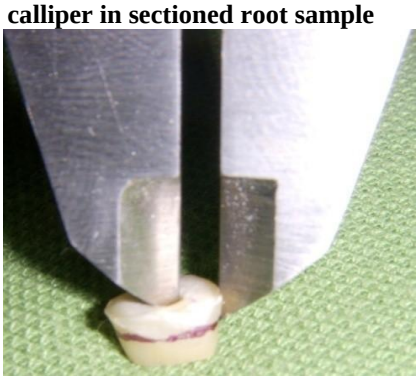


The pre-operative root canal wall thickness was measured at coronal, middle and the apical third , mesiodistally and faciolingually , using calibrating software XVA3 (Version 3.5)

Subsequently working length of each root was determined visually and radiographically using # 10 K-file. The roots were stabilized temporarily on a vice for ease of preparation. Preparation of root canals for all the three groups was completed using crown down technique. During canal preparation each instrument was rotated at a definite rpm (as recommended by the manufacturer - 300-350 rpm for Protaper, 300-600 rpm for RaCe and M two) and torque of 1-4 N cm, using X Smart motor (Dentsply). During root canal preparation each canal was thoroughly irrigated with 5.25% of sodium hypochlorite. After preparation of the canals the roots were again radiographed both mesio-distally and bucco-lingually and the root canal width was again measured at coronal, middle and apical third, mesio -distally and bucco - lingually.

All the measurements were recorded and tabulated. Then the roots were sectioned horizontally at the three pre-marked reference points and actual dentin thickness was measured using digital vernier calliper. (Figure 3)

Figure 3: Dentin thickness measured using digital vernier calliper in sectioned root sample



Differences between anatomic and radiographic measurements were recorded in millimetre. The results were then subjected to statistical analysis and conclusions were drawn.

RESULTS

Statistical tools used were Paired "t" test, ANOVA & Pearson's Correlation coefficient.

The Hypotheses tested were -

HYPOTHESIS 1

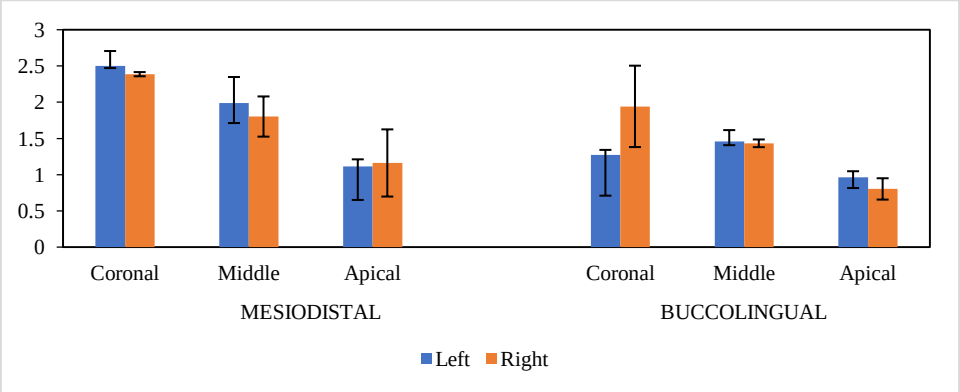
Different instrumentations have different cutting efficiency based on:

i. Minimum or no significant difference in left and right side measurements of root canal wall thickness in the coronal, middle and apical third:-

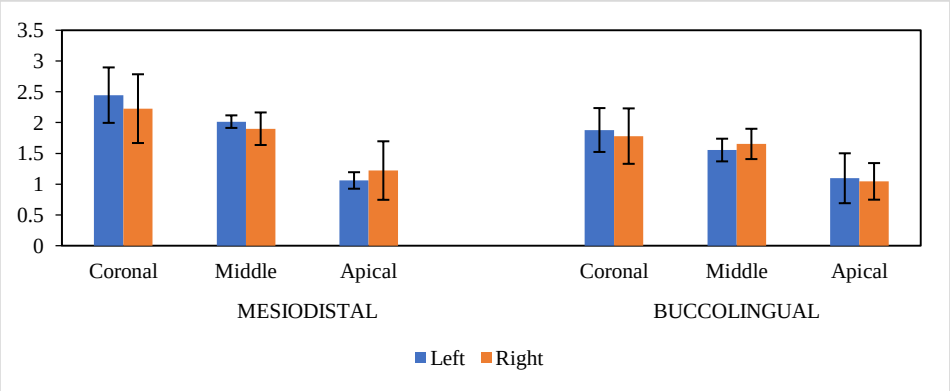
Comparison of left and right side values after preparation would give an idea about the symmetrical cutting – *i.e.* minimum differences in left and right sides after cutting would determine the accuracy/precision of cutting.

From the values and graphs obtained, it can be inferred that apart from Protaper in Buccolingual Apical plane, all the instruments showed symmetrical accuracy. [Graph 1(a), 1(b), 1(c) and Table 1]

Graph 1 (a)



Graph 1(b)



Graph 1(c)

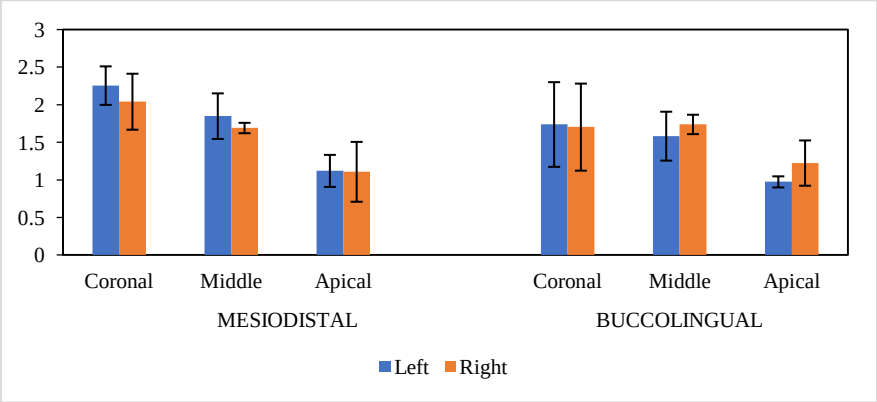


Table 1: Table depicting left and right-side measurements of root canal wall thickness in the coronal, middle and apical third

SNo.	Group	Plane	Left Side n = 5		Right Side n = 5		Statistical Significance	
			Mean	SD	Mean	SD	"t"	"p"
1	Protaper	MD - Coronal	2.498	0.206	2.385	0.029	1.370	0.242
		MD - Middle	1.988	0.358	1.801	0.277	1.663	0.172
		MD - Apical	1.114	0.097	1.161	0.463	-0.262	0.807
		BL - Coronal	1.271	0.070	1.941	0.561	-2.718	0.053
		BL - Middle	1.459	0.155	1.432	0.053	0.469	0.664
		BL - Apical	0.962	0.085	0.803	0.147	2.921	0.043
2	RaCe	MD - Coronal	2.444	0.450	2.225	0.558	2.606	0.060
		MD - Middle	2.014	0.102	1.899	0.264	0.814	0.461
		MD - Apical	1.059	0.134	1.220	0.475	-0.777	0.481
		BL - Coronal	1.878	0.356	1.779	0.450	0.435	0.686
		BL - Middle	1.553	0.184	1.652	0.246	-0.650	0.551
		BL - Apical	1.095	0.405	1.044	0.297	0.360	0.737
3	M-2	MD - Coronal	2.255	0.256	2.041	0.372	0.835	0.450
		MD - Middle	1.849	0.303	1.691	0.069	1.084	0.339

		MD - Apical	1.121	0.213	1.109	0.398	0.067	0.950
		BL - Coronal	1.738	0.563	1.703	0.579	0.088	0.934
		BL - Middle	1.583	0.325	1.739	0.129	-0.973	0.386
		BL - Apical	0.975	0.074	1.225	0.301	-2.005	0.115

ii Minimum of 1 mm dentin remaining on both the sides in the coronal, middle and apical third :
Comparison of percentage change in different groups will show the cutting efficiency of groups.
From the values obtained it is contingent that Protaper had the better cutting efficiency in all the planes while cutting efficiency of RaCe and Mtwo had been varying in different planes and locations. [Graph 2 and Table 2]

Graph 2

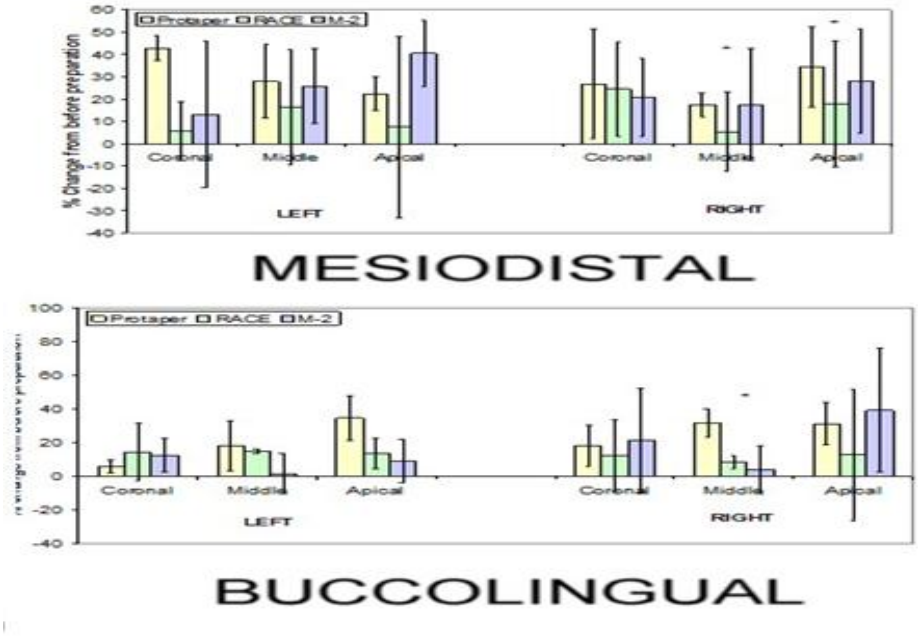


Table 2: Comparison of percentage change in different groups

S.No.	Group	Plane	Left (n=5)				Right (n=5)			
			Mean	SD	"F"	"p"	Mean	SD	"F"	"p"
1	Protaper	Coronal	5.791	3.995	0.729	0.503	17.914	12.091	1.467	0.269
	RaCe		14.236	17.061			16.659	21.103		
	M-2		12.329	9.836			-3.958	30.832		
2	Protaper	Middle	18.007	14.838	0.942	0.417	31.808	8.350	11.099	0.002
	RaCe		8.985	1.344			3.587	3.848		
	M-2		16.371	12.082			10.902	14.330		
3	Protaper	Apical	34.497	13.427	3.533	0.062	30.984	12.657	1.731	0.219
	RaCe		17.524	8.873			-2.731	39.136		
	M-2		16.777	12.936			-0.020	36.725		

HYPOTHESIS 2

There is a significant difference in canal width of prepared root viewed radiographically and that of actual width viewed after section cutting.

Comparison of mean values of left and right side in radiographic view after preparation and in actual view after preparation will reveal whether there exists a difference between radiographic and actual view.

From the values obtained, it seems that direct digital radiographic measurements for left and right sides were higher as compared to the actual width. [Graph 3 and Table 3]

Graph 3

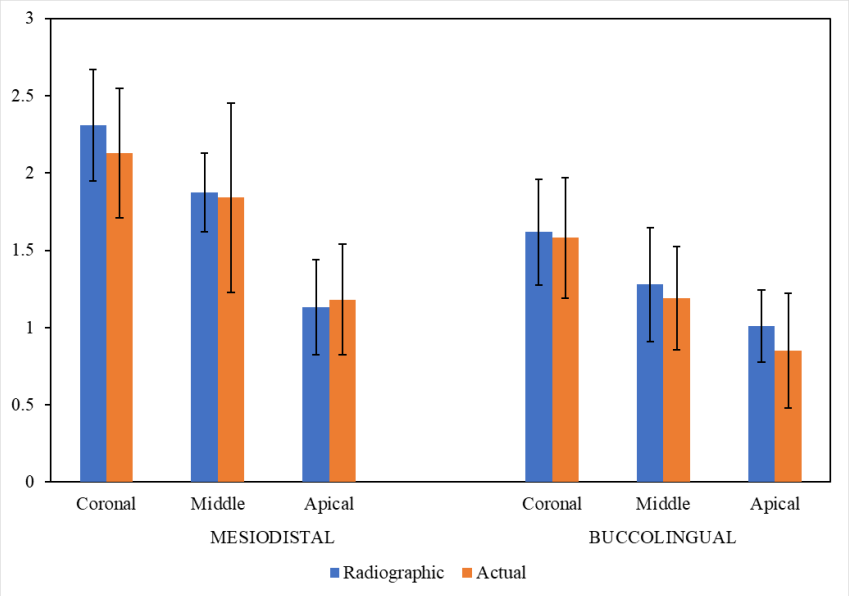


Table 3: Comparison of mean values of left and right side in radiographic view after preparation and in actual view after preparation

SN	Plane	Radiographic [after preparation] (n=30)		Actual (n=30)		Statistical Significance	
		Mean	SD	Mean	SD	"t"	"p"
1	MD - Coronal	2.308	0.360	2.129	0.418	1.782	0.080
2	MD - Middle	1.874	0.255	1.842	0.612	0.261	0.795
3	MD - Apical	1.131	0.308	1.181	0.358	-0.584	0.561
4	BL - Coronal	1.618	0.341	1.581	0.388	0.399	0.691
5	BL - Middle	1.278	0.366	1.191	0.336	0.959	0.341
6	BL - Apical	1.011	0.233	0.85	0.370	1.335	0.193

HYPOTHESIS 3

A correlation might be seen between radiographic and actual canal width:

A correlation between after preparation radiographic view and after preparation actual view will reveal the extent of correlation between radiographic and actual view and whether a constant can be derived to determine the actual values on the basis of radiographic viewing.

A poor correlation (r= 0.3 to 0.5) was seen between Actual Measurements and Radiographic measurements which was also significant statistically. Radiographic measurements are arbitrary and do not correlate well. [Graph 4 and Table 4]

Graph 4

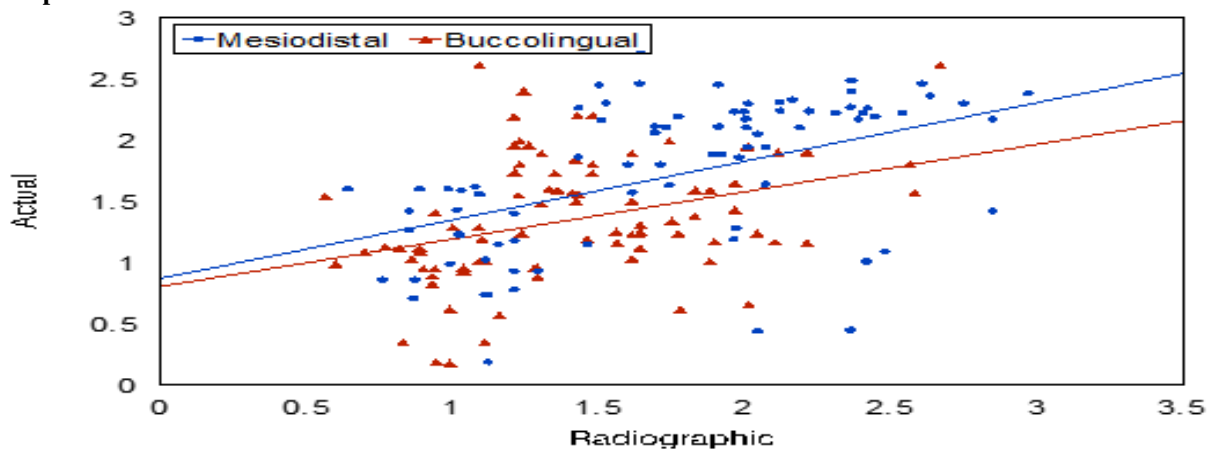


Table 4: Table showing correlation seen between radiographic and actual canal width

S.No.	Plane	"r"	"p"
1.	Mesiodistal	0.45	<0.001
2.	Buccolingual	0.35	<0.001

DISCUSSION

In endodontics radiography is the most commonly used method to study the anatomy of the root,[14] and the amount of dental tissue pre and post instrumentation.[20] Thus for the estimation of root canal wall thickness after root canal instrumentation with hand or rotary system's direct radiography is a useful tool as compared to CR.[15,16] Some of the studies have demonstrated that the radiographic estimation is actually higher than the anatomical root canal wall thickness measurements; however, none of the studies have neither estimated the root canal wall thickness in two planes i.e. bucco-lingual and mesio-distal nor measured the root canal wall thickness on the left or right of the canal which will give a comprehensive two-dimensional view of the root canal wall thickness remaining after instrumentation.

In the present study, the root canal wall thickness was measured pre and post instrumentation on the left and right side both on mesio-distal and buccolingual planes of the root canal which is possible only by using direct digital radiography. These measurements gave the clue as to how much dentin remained after preparation of the root canal and also revealed the centering ability of the rotary instrument. The radiographic overestimation was calculated, with the percentage changes along the left and right side for each particular plane. Direct digital radiographic measurements for left and right sides were higher as compared to the actual width ($p>0.05$). Different instruments lead to distinct amounts of dentine removal, which might influence the root canal wal thickness observed radiographically. Apart from Protaper in Buccolingual Apical plane ($p<0.05$), all the instruments showed symmetrical accuracy. However, a pattern of radiographic overestimation was observed regardless of the instrument used.

Efficiency of rotary NiTi system on root canal wall thickness was also evaluated in this study; especially the cross-section of NiTi instruments. Because it directly determines the strength characteristics to the different stresses and the ability to cut the dentine is determined by the shape of the blades. Rotary NiTi instruments with triangular cross sectional instruments cut with greater efficiency. Hence the dentin removal in cases of Protaper was more as compared to RaCe and Mtwo. This study endorses the studies which found that Protaper rotary instruments have the better cutting efficiency in all the plane,[24] since percentage change observed on both the left and right side was significant as compared to RaCe and Mtwo.

The magnitude of degree of relationship between actual measurements and radiographic measurements after canal instrumentation was measured and a poor correlation ($r= 0.3$ to 0.5) i.e. $r < 1$ was seen, which was also highly significant statistically ($p<0.001$).

Further research particularly clinical trials are required to confirm the advantages of rotary instruments with regard to the tissue conservation. This study did not consider variables such as age, various degrees of root curvature and properties of dentin which would affect the results to some extent. Moreover, with the dawn of latest technologies like Micro-computed tomography allowing measurements with greater number of cross sections it may be more appropriate to conduct such measurements using Micro-computed tomography.

CONCLUSION

Through this study we may conclude that though direct digital radiography images overestimate the actual root canal wall thickness, a clinician can at least apply its software to measure the root canal wall thickness in two-dimension and monitor the critical endodontic cases. It would also help the clinician in selecting a rotary endodontic system from the plethora of rotary instruments with different designs and specifications.

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