



## Comparative Evaluation of the Accuracy of Locating the Minor Constriction in Single Rooted Teeth with Single Canal Using Radiovisiography, Cone beam computed tomography, Electronic Apex Locator and Tactile Sensation - An in Vitro Study

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### Abstract

**Background & Aim:** Determination of the working length is crucial for endodontic treatment success. The root canal morphology being complex makes this procedure harder for an endodontist. This study aimed to determine the most accurate method for the location of minor constriction in single rooted teeth.

**Methods:** A total of 45 freshly extracted human single rooted teeth with mature apex were selected for the study. All the teeth were subjected to all the methods for location of minor constriction. Two observers measured the distance of the minor constriction from the radiographic apex and the average value was considered. Radiovisiography [RVG], Cone Beam Computed Tomography [CBCT], Electronic apex locator, tactile sensation methods were used.

**Results:** One-way ANOVA showed statistically significant ( $p$ -value  $<0.05$ ) difference in measuring the minor constriction diameter using four different methods (RVG, CBCT, Electronic apex locator and tactile sensation). The Kappa statistics showed good agreement between the actual distance and the distance measured by CBCT which was statistically significant. (agreement good,  $p$ value  $<0.001$ )

**Conclusion:** CBCT was found the most reliable method among all the other methods.

**Keywords:** NIL

### Introduction

Endodontic treatment is considered challenging mainly due to the anatomic complexity of the root canals.(1) Proper knowledge about root canal configuration helps in making an outline of appropriate treatment plan and consequently results in a successful outcome and thus avoid treatment failure.(2)

Minor apical foramen is the narrowest part of the root canal. The location of the apical constriction is 1.5 mm coronal to the major foramen of the root canal(3). Present guidelines written in the Guide to Clinical Endodontics 6th Edition by American

Association of Endodontists (AAE) have been published in 2013. The distance between apical foramen and minor constriction has been found to be 0.4–1.2 mm and that of root apex and minor constriction is 0.5–1.01 mm, respectively.(4) Dummer et al classified the shape of the apical constriction mentioning four possible configurations types of the shape of the apical constriction. They are tapered, single, multi-constricted, and parallel.(5) The labiolingual dimension of the minor diameter was larger by 0.5 mm when was compared

mesiodistally.(4) Oval was the most commonly found shape of the minor constriction.(6)

The root end is a complex anatomical structure with distinct landmarks that helps in determination of the appropriate working length .(7),(8) According to Kuttler, the landmarks of the apical end consists of (a) cementodentinal junction, (b) apical foramen, (c) apical constriction, and (d) Anatomical apex.(11) Apical 3 mm of root canal is considered as the significant zone.(7),(8) The measurement, instrumentation, and filling of the root canal should be done properly to avoid encroachment and trauma of the periodontal ligament space.(9) According to several researchers, the best prognosis of the root canal treatment is achieved when the instrumentation and obturation terminates at the cementodentinal junction (CDJ).(10) Although the exact location of CDJ is immeasurable, apical constriction is an appropriate and reliable location as the terminus of root canal procedures.[10] Since the apical foramen is considered as nearest to the apical constriction Kuttler recommended that all endodontic procedures should be terminated 0.5 mm from the apical foramen.(11)

A technique to be used in working length determination of root canals of primary teeth should give precise and reproducible results. Although many clinicians still practice tactile perception as an adequate means to detect working length, it is generally difficult to use this technique in root canals with constricted canals, excessive curvatures, and root resorption.(12)

A study was conducted by Mousavi and Farhad et al (2018) (13) for the determination of apical constriction position in incisor and molar teeth. In the study, the sectioned roots were observed through a stereomicroscope. They concluded that in incisors, the mean distances between apical constriction [AC] and apical foramen [AF] were  $0.847 \pm 0.33$  mm in incisors and the mean distances between AC and AA were  $1.23 \pm 0.39$  mm.

No standardized size is advisable for the apical enlargement because in all tooth types, the diameters of the apical canals vary greatly. The use of three file sizes greater than the first file that binds in the apical region has been considered as the classic parameter for enlargement of the apical region at the working length. Although the concept behind this approach is

the first file to bind reflects the diameter of the apical canal, the instrument that binds does actually reflect the diameter of the canal in the apical region is lacking evidence. The canals instrumented to three sizes larger were not thoroughly cleaned have been confirmed by some of the histological studies.(5) Moreover, root canals are frequently elliptical in cross-section with narrow and large diameter and hence it is uncertain whether removing dentin from the wall of the recesses is always possible.

In a study by M.-K. Wu, D. Barkis et al, they determined whether the first file that binds at the working length corresponds to the canal diameter and within the limitations of that study, they concluded that neither the first K-file nor the first Light- speed instrument that bound at the working length accurately reflected the diameter of the apical canal in cases of curved mandibular premolars. Thus, it is not certain whether dentine can be removed from the entire circumference of the canal wall by filing the root canal to three sizes larger than the file that binds first.(7)

Conventional radiographic method described by Ingle has been one of the most popular diagnostic tools for determining working length in routine endodontic practice but this method only provides a two-dimensional (2D) image of the 3dimensional structure. The presence of lateral canals/foramina or an apical constriction may not be identified accurately by this technique. One cannot rely on a 2D image in primary teeth where the physiological root resorption is mostly oblique and not horizontal in nature.(12) Recent technological advances have turned digital radiography into a viable option for the determination of endodontic working length. The reliability of digital radiography is seemingly comparable to or even better than that of conventional radiography.(14) Other studies, however, reported that conventional radiography is more accurate in comparison to older digital radiographic systems.(15)

According to previous studies, conventional radiography yields an 82% precision, but in a study done by Olson et al,(16) electronic measurement is closer to 95%. Apex locators were found to be more accurate and more reliable than radiography for the determination of working length when these two techniques were compared because of the fact that

electronic measurement being an objective technique was found to be more accurate and the conventional radiography is a subjective technique. This was proven as early as 1983 in the study by Gelfand et al (17) in which almost 22% of operators disagreed with themselves while examining a set of X-rays for the second time.

Cone-beam computed tomographic (CBCT) imaging provides an accurate, high-quality, 3-dimensional (3D) representations of hard tissues, and thus results in a more accurate diagnosis of many dental hard tissue conditions. CBCT imaging may be considered when it has been decided that radiographic images are yielding limited information although it is not indicated for the initial evaluation of dental morphology, and that further details are required for diagnosis and treatment planning.(1) Many studies have simply used CBCT imaging as the reference method or have used both Periapical Radiographs and CBCT imaging to identify Root canal curvature in different populations with no gold standard .(18) However, without comparing CBCT analysis with a gold standard can underestimate the complexity of RCC to assume that the CBCT scanning is accurate enough to diagnose root canal configuration (RCC). Thus, the biases and precision of RCC frequency-based studies cannot be estimated due to the lack of knowledge of the accuracy of CBCT imaging in detecting RCC.

There are many studies about the most reliable method for the determination of working length, but to the best of our knowledge, the present study is the first study where the most accurate method of locating the minor constriction of single rooted teeth with single root canal has been evaluated using RVG, CBCT, tactile sensation and electronic apex locator. Present guidelines are written in the Guide to Clinical Endodontics 6th Edition by American Association of Endodontists (AAE), published in 2013.

Based on this context, this present study aimed to determine the accuracy of Locating the Minor Constriction in Single Rooted Teeth with Single Canal Using Radiovisiography, Cone beam computed tomography, Electronic Apex Locator and Tactile Sensation.

The Objectives for the present study are

1. To determine the most accurate method for location of minor constriction in single rooted teeth with single canal.
2. To measure and determine the location of minor constriction in single rooted teeth with single canal using radiovisiography (RVG), CBCT, tactile sensation and electronic apex locator.
3. To comparatively evaluate the distance of apical constriction or minor apical diameter in freshly extracted anterior teeth using RVG, CBCT, tactile sensation and electronic apex locator
4. To assess and compare the accuracy of these available and commonly used techniques in determining the accuracy of location of apical constriction.

### Materials and Methods

The present study was conducted in the Department of Conservative Dentistry and Endodontics, Guru Nanak Institute of Dental Sciences and Research, the West Bengal University of Health Sciences, West Bengal, India, after getting clearance from the Institutional Ethics Committee.

### Sample Size determination

For this in-vitro cross-sectional study, a sample size of 45 was estimated with an alpha error of 0.05, power of 95%, and effect size of 0.45 using G Power Version 3.1.9.2 (Universität Kiel, Kiel, Germany) software. A total of 45 freshly extracted human single rooted teeth with mature apex were selected for the study.

### Preparation of the samples

Teeth were disinfected with 5.25% sodium hypochlorite solution followed storage in 10% formalin solution till sample preparation. The presence of single canal in each specimen was confirmed by Cone Beam Computed Tomography imaging. The specimens were decoronated at the cemento enamel junction (CEJ) using a diamond disc for standardization and access to the root canal and obtain a wide occlusal landmark.

### Measurements

All the teeth were subjected to all the methods for accuracy of location of minor constriction. Two observers measured the distance of the minor constriction from the radiographic apex and the average value was considered.

Sequence of determination of minor constriction:

1. Radiovisiography
2. CBCT
3. Electronic apex locator
4. Tactile sensation

For Radiovisiographic analysis the minor constriction of each specimen was determined on the monitor and the distance from the radiographic apex was measured with the RVG measuring grid.

For CBCT analysis, Samples were scanned by using CBCT. Determination of minor constriction in orthogonal slicing, curved slicing and oblique slicing was done and the mean value was considered. The minor constriction of each specimen was determined on the monitor and the distance from the radiographic apex was measured with measuring scale in the CBCT software.

For determination of minor constriction by Electronic Apex Locator, an in vitro model was developed in which the samples were mounted in a plastic case in an alginate. In accordance with the manufacturer's instructions, the meter screen of Electronic Apex Locator for working length indicating minor Apical Constriction, the K-file was inserted in the root canal until the meter screen showed that it has reached the electronic apex.

For Tactile sensation, the 10 and 15 k file was used of determination of the minor constriction. After the initial binding of the file in the canal, a radiograph was taken. Then the distance of the file tip from the radiographic apex was measured with the measuring grid in the RVG

Outcome

Detection of the most accurate method in precisely locating the minor constriction in single rooted teeth with single canal.

### Statistical Analysis

SPSS Statistics V.23.0 for Windows was used for data analysis. The measurement data are expressed as mean  $\pm$  standard deviation ( $\bar{x} \pm S$ ). Statistical tests were performed using a one-way ANOVA and Tukey's multiple comparison test for comparison between groups, intraclass correlation coefficient (ICC) of the different methods to determine the minor constriction diameters. P-value  $< 0.05$  was considered statistically significant.

### Results

Among 45 single rooted teeth there were 12 (26.6%) maxillary incisor, 7(15.5%) mandibular incisor, 6 (13.3%) maxillary canine, 9 (20%) mandibular canine, and 11 (24.4%) mandibular premolar.

### Minor constriction diameter (mm)

Table1 shows the mean and standard deviation of ABL using different types of methods. In one way ANOVA showed statistically significant (p-value  $<0.05$ ) difference in measuring the minor constriction diameter using four different methods (RVG, CBCT, Electronic apex locator and tactile sensation)[Table2]. Similarly Tuckey's multiple comparison test showed significant (p-value  $<0.05$ ) result as well [Table 3]. Comparison between the different methods to measure the minor constriction diameter also showed significant result (p-value  $<0.05$ ).[Table 4]

### Distance of minor apical constriction from AF(mm)

Table 5 shows the shows the mean and standard deviation of ABL using different types of methods. We did not get significant (p-value $<0.05$ ) result running the one-way ANOVA for the distance of the minor apical constriction or the Tuckey's multiple comparison test which showed sample correlation using different methods. Similarly, there were no significant correlation found between the actual minor constriction diameter with the different methods used in the study. The Kappa statistics showed good agreement between the actual distance and the distance measured by CBCT which was statistically significant. (Table 5).

### Discussion

Determination of the working length is crucial for endodontic treatment success. The root canal morphology being complex makes this procedure harder for an endodontist. Several studies are there describing the most reliable method for the determination of the working length; however to the best of our knowledge ours is the first study where the most accurate method of locating the minor constriction of single rooted teeth with single root canal has been evaluated using RVG, CBCT, tactile sensation and electronic apex locator.

Subramaniam et al(19) reported an in vitro study comparing the tactile sense technique, apex locators, and conventional and digital radiography with the stereomicroscopy to determine the working length in primary single rooted teeth where statistically significant differences was not found after comparing all the techniques. However in the present study significant differences was found after comparing the four techniques using one-way ANOVA. The intra class correlation among the different methods also showed statistically significant difference in the present study.

One study done by Sousa et al. (1) aimed to assess the diagnostic accuracy of periapical radiography (PR) and cone-beam computed tomographic (CBCT) imaging in the detection of the root canal configuration (RCC) of human premolars. They concluded that, PR presented low performance in the detection of RCC in premolars, whereas CBCT imaging showed no difference compared with the gold standard. Canals with complex configurations were less identifiable using both CBCT and periapical radiography. This result was consistent with the present study where we compared four methods to determine the minor constriction diameter and the distance between the apical foramen and the minor constriction using RVG, CBCT, Tactile sensation and electronic apex locator. According to the present study, findings CBCT was the most reliable method to measure the minor constriction diameter and the distance between the apical foramen and the minor constriction.

One study was done by Abdullah et al.(12). They aimed to evaluate the effectiveness of two different varieties of electronic apex locators and radiovisiography (RVG) for working length determination in primary teeth. Their study concluded that, Radiovisiography and apex locators are equally effective in determining working length in primary teeth. This result is consistent with our study. Our study did not show any remarkable difference between the process done by RVG and electronic apex locator. Our study showed the significant reliability of CBCT.

In a study conducted by Pratten et al(20) to compare the ability of radiographic and electronic methods for determination of the location of the apical constriction. The working length of root canals in

human cadaver teeth in that study was determined by positioning an endodontic file at the apical termination point as indicated by an apex locator. The radiographs of the same teeth were taken at various angles with the file in place and were evaluated by five examiners to determine a radiographic termination point for each canal. In that study they found that method using the apex locator was slightly more reliable. In this study, the inter observer reliability was not measured which is a limitation of this study.

### Conclusion

In conclusion, CBCT imaging showed the highest reliability in measuring the diameter of minor constriction as well as measuring the distance of minor constriction from the apical foramen among all the methods we used (RVG, CBCT, Tactile sensation, electronic apex locator). However, Although CBCT imaging appears to be the most effective imaging examination applicable clinically for measuring the diameter of minor constriction as well as measuring the distance of minor constriction from the apical foramen, clinicians should always respect the indication criteria and be aware of the limitations of CBCT imaging in displaying the configurations in some cases.

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**Table1. Descriptives Statistics: Mean and SD of ABL of different types of methods (N=45)**

Methods	Samples (Total N=45)	Frequency n (%)	Mean	Std. Deviation
RVG	Maxillary Incisor	12%	0.3710	0.06082
	Mandibular Incisor	7%		
	Maxillary Canine	6%		
	Mandibular Canine	9%		
	Mandibular Premolar	11%		
Electronic apex	Maxillary Incisor	12%		
	Mandibular Incisor	7%		

locator	Maxillary Canine	6%	0.2885	0.05214
	Mandibular Canine	9%		
	Mandibular Premolar	11%		
tactile sensation (tip diameter of file used)	Maxillary Incisor	12%	0.2383	.06252
	Mandibular Incisor	7%		
	Maxillary Canine	6%		
	Mandibular Canine	9%		
	Mandibular Premolar	11%		
CBCT	Maxillary Incisor	12%	0.4267	0.06270
	Mandibular Incisor	7%		
	Maxillary Canine	6%		
	Mandibular Canine	9%		
	Mandibular Premolar	11%		

**Table2. One-way ANOVA comparing the various techniques**

ANOVA						
		Sum of Squares	df	Mean Square	F	P-value
RVG	Between Groups	.098	4	.024	14.944	.000
	Within Groups	.065	40	.002		
	Total	.163	44			
Electronic apex locator	Between Groups	.076	4	.019	17.381	.000
	Within Groups	.044	40	.001		
	Total	.120	44			
tactile sensation (tip diameter of file used)	Between Groups	.096	4	.024	12.762	.000
	Within Groups	.076	40	.002		
	Total	.172	44			
CBCT	Between Groups	.074	4	.018	7.418	.000
	Within Groups	.099	40	.002		
	Total	.173	44			

p- value is considered significant when <0.05

**Table 3. Tukey’s multiple comparisons test showing the samples correlations using the different methods**

Tukey’s multiple comparisons test	Mean difference	P value	Paired Samples Correlations	P value
RVG Vs Electronic apex locator	.01374	.032	.740	.000
RVG Vs Tactile sensation	.06391	.000	.529	.000
RVG Vs CBCT	-.12442	.000	.550	.000
Electronic apex locator Vs Tactile sensation	.05017	.000	.582	.000
Electronic apex locator Vs CBCT	-.13817	.000	.532	.000
Tactile sensation Vs CBCT	-.18833	.000	.498	.001

p-value is considered significant when <0.05

**Table 4. Comparison (interclass correlation coefficient [ICC]) of the different methods to determine the minor constriction diameters**

Methods	ICC	95% Confidence Interval		P-value
		Lower Bound	Upper Bound	
RVG Vs Electronic apex locator	0.845	0.718	0.915	0.000
RVG Vs Tactile sensation	0.692	0.439	0.831	0.000
RVG Vs CBCT	0.710	0.471	0.840	0.000
Electronic apex locator Vs Tactile sensation	0.728	0.506	0.851	0.000
Electronic apex locator Vs CBCT	0.687	0.430	0.828	0.000
Tactile sensation Vs CBCT	0.669	0.390	0.816	0.000

p-value is considered significant when <0.05



**Table 5. Measure of Agreement (Kappa Statistics)**

Methods	Kappa Value	Strength of agreement	P-value
RVG	-.023	No agreement	0.287
Electronic apex locator	-.024	No agreement	0.279
CBCT	.791	Good	0.000

p-value is considered significant when <0.05

