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Comparison of Accuracy of Two Apex Locators at 0 and 0.5 Readings and its Radiographic and Histologic Co-relation - A Scanning Electron Microscope

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Abstract: ***The success of an endodontic therapy is determined mainly by three factors: - Proper cleaning and shaping; Disinfection & 3-D obturation of the canal. To achieve the above factors the most important segment in endodontic treatment is determination of the accurate "Working length". Various methods for working length determination: - Manual method; Radiographic method and Electronic determination. Electronic apex locator reduce the number of radiographs required and helps in reduction of radiographic exposure. They are also helpful in locating the Major diameter (apical foramen) from the radiographic apex. Aim: To evaluate the Accuracy of two Apex locators (ROOT ZX & RAY PEX 6) at 0 and 0.5 Readings and Its Radiographic and Histologic Co-relation with Scanning Electron Microscope. Materials and Methods: Forty single-rooted teeth were selected. Pre-Radiograph images were taken and the actual length (AL) was calculated. The Standard access cavities were prepared. The samples were then embedded in alginate model and the electronic measurements were determined and recorded. Results: The results obtained when compared two different apex locators with A.L; Radiographic evaluation showed that at 0 reading Root ZX was accurate in 100% and Ray pex 6 was accurate in 96%. At 0.5 reading Root ZX was accurate in 75% and Ray pex 6 was accurate in 25%.By histologic evaluation at 0 reading Root ZX was accurate in detecting C.D.J 100% and Ray pex 6 was accurate in detecting C.D.J 96%. At 0.5 reading Root ZX was accurate in detecting C.D.J 75% and Ray pex 6 was accurate in detecting C.D.J 25%. Conclusion: The apex locators detect the major foramen accurately than the minor foramen when compared to AL, radiographically and histologically.***

Keywords: Working length; Actual length (AL); Apex locators; Major foramen; Scanning Electron Microscope.

1. Introduction

The success of an endodontic therapy is determined mainly by Proper cleaning and shaping; Disinfection & 3-D obturation of the canal. The thorough cleaning, shaping and obturation of the root canal system cannot be Accomplished accurately unless the working length (WL) is determined accurately. WL has been defined as, "the distance from a coronal reference point to the point at which canal preparation and obturation should terminate."[(1)] Anatomically, the apical constriction (AC), also called the minor apical diameter or minor diameter (Kuttler 1955), is a logical location for working length (WL), as it often coincides with the narrowest diameter of the root canal (AAE 2003) [(2)]. Locating the AC clinically is problematic. Dummer *et al*[(3)] concluded that it is impossible to locate the minor foramen clinically with certainty, because of its position and topography. The cemento-dentinal junction (CDJ) has also been suggested as the location for WL as it represents the transition between pulpal and periodontal tissues. (Grove 1931) the location of the CDJ is widely accepted as being 0.50-0.75 mm coronal to the apical foramen, but as with the AC, the exact location of the CDJ is impossible to identify clinically (4). Various methods for establishing root canal length include the use of manual sensation and radiographs. As the above methods have limitations. To overcome the limitations and the search for a more accurate and predictable method of determining root canal length led to the invention of the electrical method .The usage of electronics to determine WL

Was introduced in 1918 by Custer [(5)]. An investigation by Suzuki in 1942 [(6)]reported that the electrical resistance between the periodontal ligament and the oral mucosa in vivowas a constant value of 6.5 KΩ. This led to the development of the first electronic apex locators (EALs) by Sunada in 1962 [(7)]. The aim of this study is to evaluate the Accuracy of two Apex locators (ROOT ZX & RAY PEX 6) at 0 and 0.5 Readings and Its Radiographic and Histologic Co-relation with Scanning Electron Microscope.

2. Materials and Methods

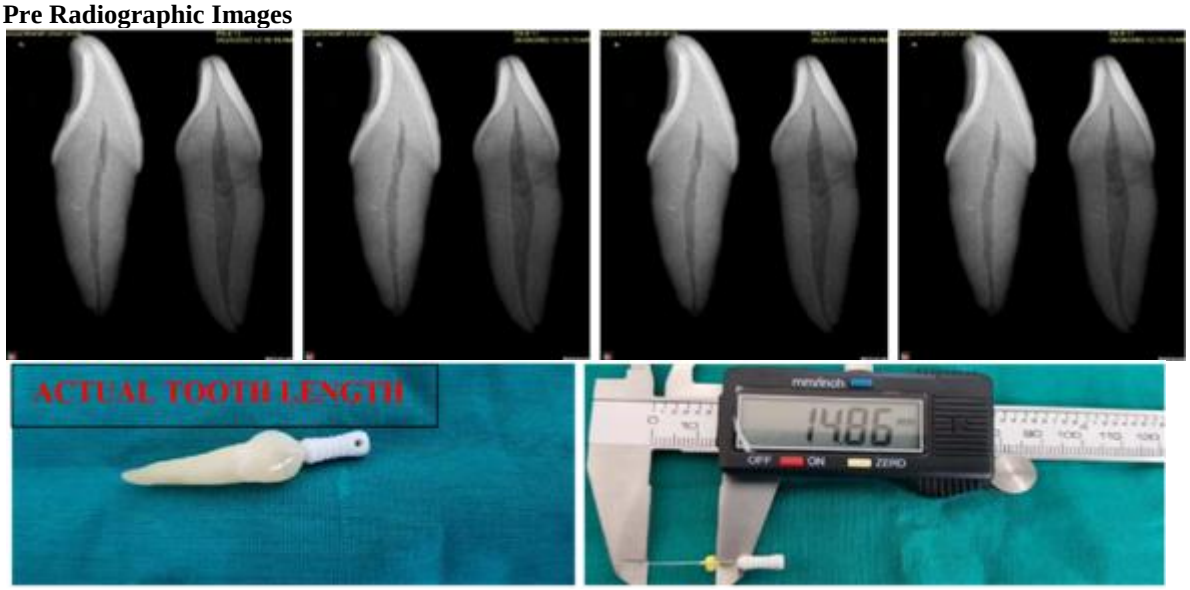
Forty single-rooted, caries-free teeth (Mean age: - 20-40 years of age) were collected from the Department of Oral maxillofacial surgery P.M.N.M Dental college Bagalkot; Karnataka India. Teeth were inspected for root fracture, two canal; fused root, necrotic pulp, incompletely formed apex were exclude from the study.

Pre-Radiograph images are taken with the help R.V.G 5200 machine to evaluate the canal morphology and tooth structure. Actual tooth length had measured such that the file should flushed with apical foramen by using magnifying glass. The silicone stopper had adjusted and the file is measured with Digital Vernier calliper to determine the actual tooth length. Later the samples were conformed with Radiographic evaluation at 0 and 0.5 reading. The samples were then embedded in alginate model and the electronic measurements were determined by using two different apex locators (Root Zx and Ray pex 6) determined the working length at 0 and 0.5 reading. The file were cemented within the canal with the help of Glass-ionomer cement and samples were visualized under Scanning electron microscope for determining the location of C.D.J histologically.

Apex Locators

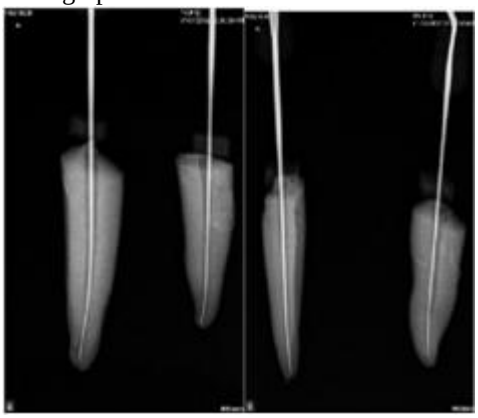
Armamentarium

Pre Radiographic Images



Decornated Teeth

Radiographic Evaluation



Root ZX at 0 Reading

Root ZX at 0.5 Reading

Ray Pex 6 at 0 Reading

Ray Pex 6 at 0.5 Reading

3. Results

Intergroup comparisons were carried out using the Wilcoxon Signed Rank Test and comparison of mean percentage of two different apex locators were carried out using McNemar's Test.

Descriptive for Actual tooth length measurements (in mm) among study samples

N	Mean	SD	Min	Max
40	12.83	2.03	8.30	17.50

Comparison of mean difference between the values obtained with each Apex locator and the Actual Length using Wilcoxon Signed Rank Test

EAL	N	Mean	SD	Mean Diff	Min	Max	Z	P-Value
Root Zx	40	0.45	0.28	-0.40	0.0	1.0	-3.548	<0.001*
Ray Apex	40	0.85	0.68		-0.4	2.6		

Comparison of mean Tooth length by Actual measurement, Radiographic and Root ZX EAL at 0 & 0.5 mm using Wilcoxon Signed Rank Test

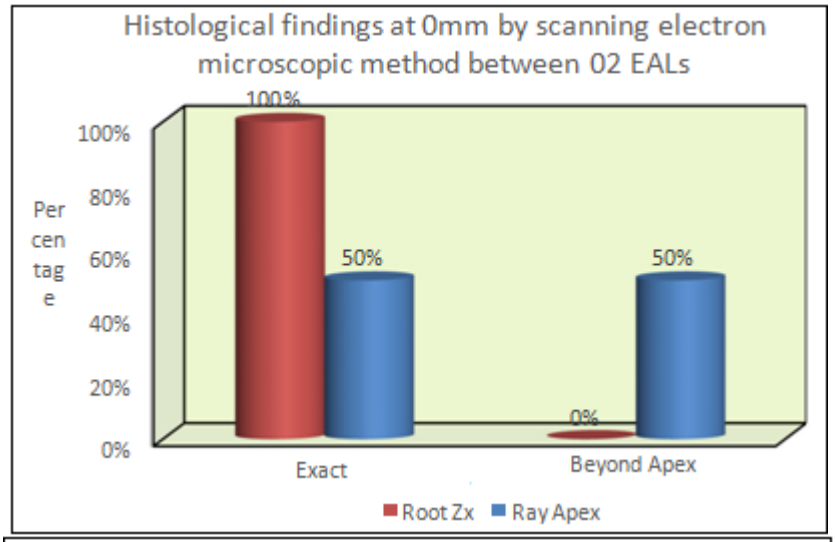
Distances	Method	N	Mean	SD	Mean Diff	P-Value
0 mm	Actual length	40	12.83	2.03	0.45	<0.001*
	Radiographic	40	12.38	1.94		
0 mm	Actual length	40	12.83	2.03	0.45	<0.001*
	Root ZX	40	12.38	1.94		
0 mm	Radiographic	40	12.38	1.94	0	1
	Root ZX	40	12.38	1.94		
0.5 mm	Radiographic	40	11.75	1.95	-0.09	0.29
	Root ZX	40	11.84	2.05		

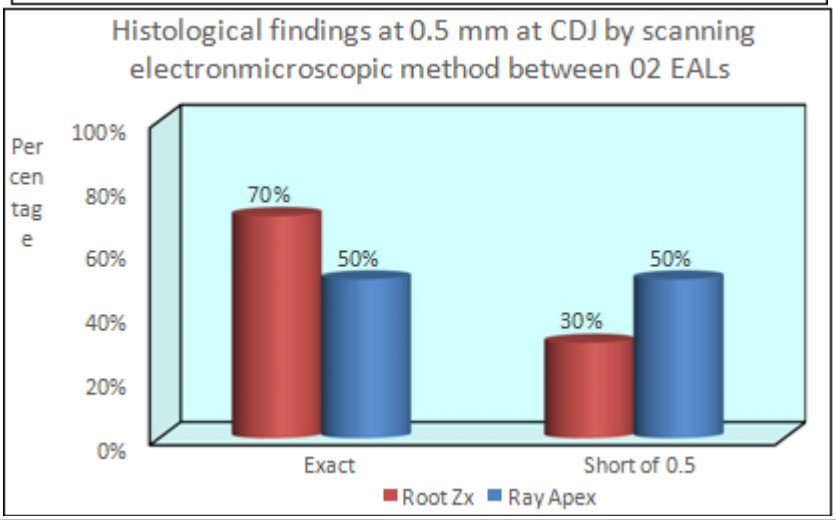
Comparison of mean Tooth length by Actual measurement, Radiographic and Ray Apex EAL at 0 & 0.5 mm using Wilcoxon Signed Rank Test

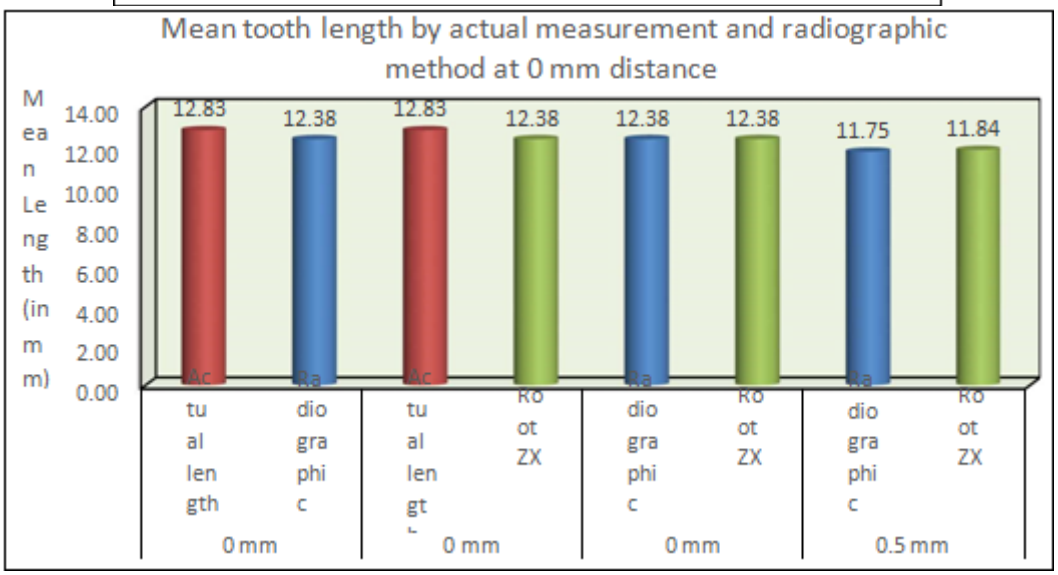
Distances	Method	N	Mean	SD	Mean Diff	P-Value
0 mm	Actual length	40	12.83	2.03	0.45	<0.001*
	Radiographic	40	12.38	1.94		
0 mm	Actual length	40	12.83	2.03	0.85	<0.001*
	Ray Apex	40	11.98	2.08		
0 mm	Radiographic	40	12.38	1.94	0.4	<0.001*
	Ray Apex	40	11.98	2.08		
0.5 mm	Radiographic	40	11.75	1.95	0.65	<0.001*
	Ray Apex	40	11.1	2.1		

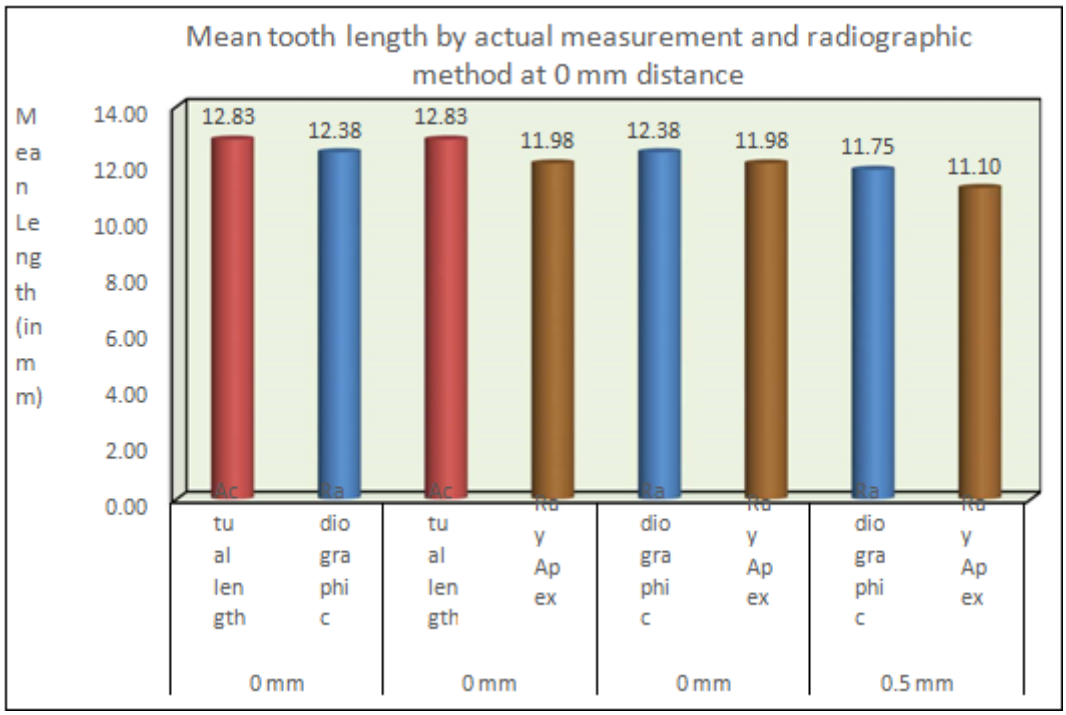
Comparison of the histological findings by scanning electronic microscopic method between 02 EALs using McNemar's Test

Points	Findings	Root Zx		Ray Apex		McNemar's Value	P-Value
		n	%	n	%		
At 0 mm	Exact	10	100%	5	50%	7.351	0.06
	Beyond Apex	0	0%	5	50%		
0.5 mm reading at CDJ	Exact	7	70%	5	50%	2.672	0.5
	Short of 0.5	3	30%	5	50%		









Scanning Electron Microscopic Images

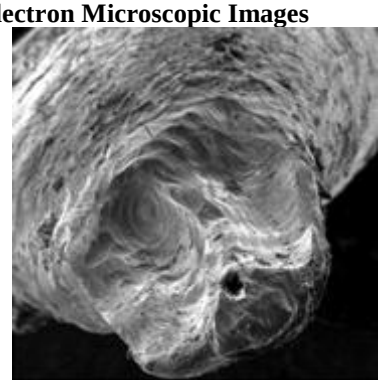


Figure A: Normal apicalforamen

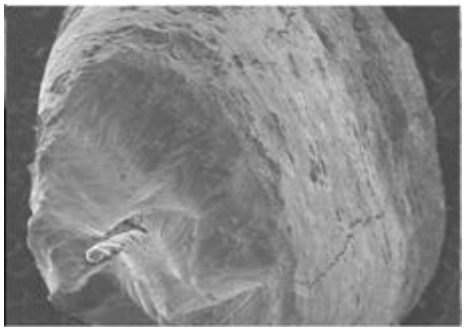


Figure B: ROOT ZX at 0 reading

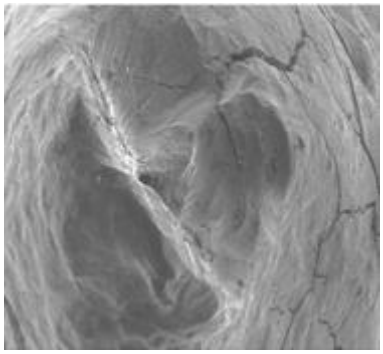


Figure C: ROOT ZX at 0.5 reading

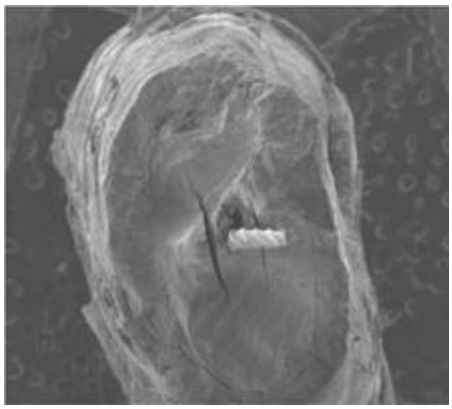


Figure D: RAY PEX 6 at 0 reading

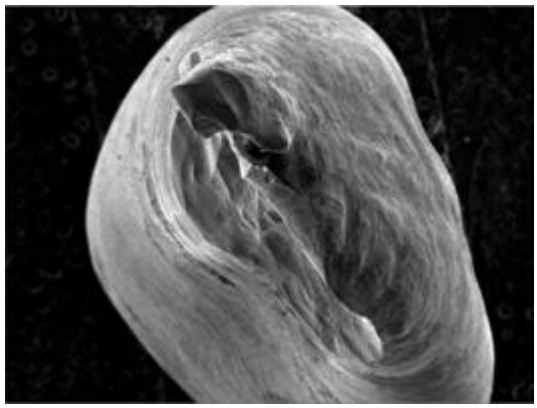


Figure E: RAY PEX 6 at 0.5reading

The mean Actual length was measured as 12.38mm, whereas Comparison of mean tooth length at 0 & 0.5 using Wilcoxon Signed Rank Test Root ZX and Ray pex 6 measured the length was 0.40 and 0.70 respectively.

The results of this study showed that comparison of two different apex locators with Actual Length; Radiographic evaluation at 0 reading Root zx accurately detected the

major foramen 100% of the samples and Ray pex 6 accurately detected the major foramen 96% of the samples. At 0.5 reading Root zx accurately detected minor foramen accurately 75% of the samples and Ray pex 6 detected minor foramen accurately 25% of the samples. The Pvalue obtained was 0.001 between Actual length; radiographic and apex locators.

On comparing histological evaluation obtained by scanning electron microscope The distance from the file tip to the most coronal border of the foramen was calculated with the aid of a software for image analysis (Soft-imaging software GmbH, v. MVP 2.1, Mtinster, Germany) at 0 reading Root Zx accurately detected C.D.J 100% of the samples and Ray pex 6 accurately detected C.D.J 96%.At 0.5 reading Root Zx accurately detected C.D.J 75% and Ray pex 6 accurately detected C.D.J 25%

On applying Wilcoxon Signed Rank Test analysis between the AL; radiographic and both electronic measurement groups, the *p* value obtained was 0.001 for the Root zx and Ray Pex 6 groups respectively. This shows a very strong correlation between the electronic measurement methods and radiographic and Actual length.

4. Discussion

Accurate determination of root canal length is an important factor that enhances the outcome of root canal therapy. The use of electronic devices to determine the WL has gained increasing popularity in recent years, particularly after the introduction of the apex locators [(8)]. The development and production of electronic devices for locating the canal terminus has been a major innovation in root canal treatment. The electronic method has shown equal or higher accuracy compared with the radiographic method in determining root canal length in *in vivo* studies and also reduced the total number of radiographs needed and thus the radiographic exposure[(9)].

All EALs function by using the human body to complete an electrical circuit. One side of the apex locator's circuit subsequently is connected to the oral mucosa through a lip clip and the other side to a file. When the file is placed into the root canal and advanced apically until it is tip touches periodontal tissue at the apex, the electrical circuit is completed. The electrical resistance of the EAL and the resistance between the file and oral mucosa are now equal, which results in the device indicating that the apex has been reached [(10)]

The most extensively researched apex locator is the Root ZX, by the company J. Morita, Japan which is considered as the gold standard against, which the newer apex locators. The Root zx third generation electronic apex locators uses multiple frequencies method to determine the distance from the end of the canal. These units have more powerful micro-processors and are able to process the mathematical quotient and algorithm calculation required to give accurate readings. Since the impedance of given circuit may be substantially influenced by the frequency and the current flow[(10)]. Ray pex 6 apex locator is 6th generation apex locator has an advantage of adaptive apex locator which helps in eliminating necessity of drying and moistening of the canal. Adaptive apex locators continuously define humidity of the canal and immediately adapts to dry or wet canal.

In this study, the actual canal length was determined by introducing the file into the canal up to the major foramen by using magnification glass. The major foramen (Apical foramen) was used since it could be located consistently and reducing 0.5 mm from the length of the major foramen leads us to a point just before or at the minor diameter (Apical constriction) and prevents the operator from any over instrumentation. Later the samples were conformed with Radiographic evaluation at 0 and 0.5 reading. Kaufman and Katz proposed the alginate model for the electronic measurement by apex locators as it very well mimics the electric impedance of the human periodontium and has since then has been used in numerous *in vitro* studies for WL determination[(11)]. By using two different apex locators (Root Zx and Ray pex 6) determined the working length at 0 and 0.5 reading. The file were cemented within the canal with the help of Glass-ionomer cement and the samples were visualized under Scanning electron microscope for determining the location of C.D.J histologically. The results of this study showed that comparison of two different apex locators with Actual Length; Radiographic evaluation at 0 reading Root zx accurately detected the major foramen 100% of the samples and Ray pex 6 accurately detected the major foramen 96% of the samples. At 0.5 reading Root zx accurately detected minor foramen accurately 75% of the samples and Ray pex 6 detected minor foramen accurately 25% of the samples. On comparing histological evaluation obtained by scanning electron microscope at 0 reading Root Zx accurately detected C.D.J 100% of the samples and Ray pex 6 accurately detected C.D.J 96%. At 0.5 reading Root Zx accurately detected C.D.J 75% and Ray pex 6 accurately detected C.D.J 25%. There was no statistically significant difference between the two apex locators.

In the previous study done by Gabriella Pagavino (1998) [(12)] on the performance of the Root ZX apex locator in unprepared vital teeth had reported a clinical accuracy rate of 96.2% located major foramen accurately. A previous study Veiyra et al(2010) assessed the accuracy of Root ZX in vital teeth the tolerance limit of locating A.F 82.75-96.2%.

The Histologic co-relation of apical foramen with scanning electron microscopy (S.E.M) is needed to corroborate the precision of electronic endodontic devices.

5. Conclusion

Within the limitations of this study it can be concluded that the apex locators detect the major foramen accurately than the minor foramen when compared to AL, radiographically and histologically. From this study we can draw an inference that the apex locators should be used to detect the apical foramen and then the operator can reduce a length by 0.5 to 1 mm and cleaning & shaping, obturation procedure should be terminated to achieve maximum success rate.

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