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HISTOLOGICAL EVALUATION OF WORKING LENGTH DETERMINATION USING RADIOGRAPHY, RADIOVISIOGRAPHY AND ELECTRONIC APEX LOCATOR METHODS – AN EXVIVO STUDY

Dental Science

Rajani Punna* Associate Professor, Kamineni Institute of Dental Sciences, Narketpally – 508254, Telangana state, India *Corresponding Author

Ravichandra Polavarapu Venkata Professor, Kamineni Institute of Dental Sciences, Narketpally

Harikumar Vemisetty Professor & HOD Kamineni Institute of Dental Sciences, Narketpally

Jayaprada Reddy Surakanti Professor, Kamineni Institute of Dental Sciences, Narketpally

Muppala Jaya Nagendra Krishna Associate Professor Kamineni Institute of Dental Sciences,Narketpally

Amulya Vanapatla Assistant Professor, Government Dental College, Hyderabad

ABSTRACT

The aim of this study was to relate the position of the cementodentinal junction (CDJ) and histologically evaluate the accuracy of three different working length determination methods. Sixty mandibular premolar teeth scheduled for therapeutic extraction were selected. Patients were divided into three groups (n=20) according to the method of working length determination.Access was prepared followed by the placement of file which was cemented to the reference point and the tooth was extracted. After extraction, apical Sections were prepared and observed under stereomicroscope at 4.5X magnification and photographed, which were then analyzed with Image J Analysis Software. Data was statistically analyzed using SPSS version 17 software. One-way analysis of variance with student-Newman-keuls method was carried out to compare the means. The lowest mean of difference was recorded in the EAL group **(0.227 ± 0.309)**. There was statistically significant difference between Radiographic and EAL group.

KEYWORDS

Apical constriction, Cementodentinal junction, Electronic apex locator, Radiographic length, Radiovisiography, Working length determination

INTRODUCTION

Successful endodontic therapy depends on the complete elimination of the micro-organisms from the root canal system and prevent further reinfection. One of the most important step in root canal treatment is the accurate working length determination which poses challenging for the operator in achieving thorough shaping and cleaning of the canals. Theoretically, the ideal physiological apical limit is cementodentinal junction (CDJ)[1]. However, CDJ is a histological landmark but not a morphological limit[2]. Clinically, minor apical constriction[3] is considered as a consistent anatomical feature described as the narrowest portion of the root canal system and is referred as the apical termination point for obturation.

Methods of determining WL include using radiographs, tactile sensation, radiovisiography (RVG) and electronic apex locators (EALs). The generally accepted method of working length determination is the radiographic method. Microscopic studies have shown that the minor diameter is located 0.5-0.75 mm coronal to the major diameter, which in turn is located about 0.5mm coronal to the apical terminus [5,6]. As a result, WL determined from radiographs is generally measured about 0.5–1 mm short of the radiographic apex. Pratten and McDonald showed that the assumption of the apical constriction being 1 mm short of the radiographic apex will result in an underestimation of WI[7]

Radiovisiography (RVG) offers some advantages over conventional film radiography. These include a lower patient dose per exposure, the ability to manipulate the image after acquisition, a reduction in time between the exposure and image interpretation, and the ability to electronically archive patient clinical and radiographic data in one electronic file[8]

The electronic apex locator (EAL) machine has attracted a great deal of attention because it operates on the basis of the electrical impedance rather than by a visual inspection. The EAL is one of the breakthroughs that brought electronic science into the traditionally empirical endodontic practice.

The possible variations between various methods of determining working length should be compared and analyzed to evaluate their accuracy. So this invivo/ exvivo study was done to determine the accuracy in measuring the working length of root canal using radiographic, radiovisiographic and electronic apex locator methods invivo and measuring the distance between the file tip to the cementodentinal junction, Invitro, after extraction.

MATERIALS & METHODS:

PART I: INVIVO STUDY

Sixty healthy, mandibular permanent premolars with mature apices that were to be extracted for orthodontic reasons were selected for the study. Informed consent was obtained from each patient in accordance with approval by the Institutional ethical committee. Age of patients ranged from 18-25 years. Teeth that are non carious, with adequate remaining tooth structure for rubber dam isolation,radiographically visible canals and fully formed root apices were included and teeth which are grossly decayed, with immature root apices,periodontal problems,excessive curvatures,developmental anomalies, resorption and any other defects were excluded.

Teeth preparation

Local anesthesia was administered, and the experimental teeth were isolated with rubber dam. Endodontic access was made with # 2 round bur. The access cavity is extended with Endo Z bur. Canal orifice was enlarged using sizes 2–4 Gates-Glidden drills in a low speed handpiece. The cusps were reduced using sterile high speed handpiece with a long tapered diamond burs to obtain fixed reference points. Gross pulp removal was performed with barbed broaches, and the canals were irrigated with 3% sodium hypochlorite followed by saline. Excess fluid was removed with paper points. Patients were divided into 3 groups of 20 patients, whose canal lengths were determined as follows:

Group I: Working length Determination by Radiograph (RG)
Group II: Working length Determination by Radiovisiography (RVG)
Group III: Working length Determination by Electronic apex locator (EAL)

Group I: WL determination by Radiograph (RG)

In first group (20 patients), the radiographic termination point for the canal was determined by the diagnostic radiograph. Working length was determined using Grossman's technique. After the radiographic apex was located, 0.5mm was subtracted and the first file that apparently binds at the working length (IAF) was repositioned to this point. File was then cemented in place using glass ionomer cement. The cement was allowed to set for at least 3 minutes and the file handles were cut with tapered diamond bur. Then the patient with the file cemented in the tooth was referred to the department of Oral and Maxillofacial surgery for atraumatic extraction.

Group II: WL determination by Radiovisiography (RVG)

In second group (20 patients), according to Grossman's technique, the file was placed 0.5 mm short of the apex and the digital image was recorded. After confirmation of the IAF short of 0.5mm in the RVG image, the same protocol like that of group I was followed.

Group III: WL determination by Electronic apex locator (EAL)

In third group (20 patients), the Root ZX was used to estimate the working length. The lip clip was attached to the patient's lip, and the electrode was connected to the IAF with a silicone stop. The file was advanced into the canal until the display indicated the apex. From this recorded length, 0.5mm was subtracted to determine the working length. The silicone stop was set on the nearest flattened cusp, and the length was measured. As in the previous groups, the file was then cemented in place, file handles were cut off, and the patient with the files fixed inside the canals at their determined positions, was referred to department of Oral and Maxillofacial surgery for extraction.

Part-II: Ex vivo Study

After the extraction, the tooth was collected and then placed in 3% sodium hypochlorite for 15 minutes to remove any remaining organic tissue from the root and then stored in a 0.2% thymol solution. The apical 4-5mm was trimmed with diamond discs and Sof-lex discs to gradually expose the inserted files, taking care not to disturb the apical anatomy.

The exposed file in relation to the cementodentinal junction of each tooth was examined under stereomicroscope at 4.5x magnification and photographed using digital camera fitted to the microscope. The distance between the file tip to the cementodentinal junction was measured using Image Analysis Software (Image J: 1.41 version).

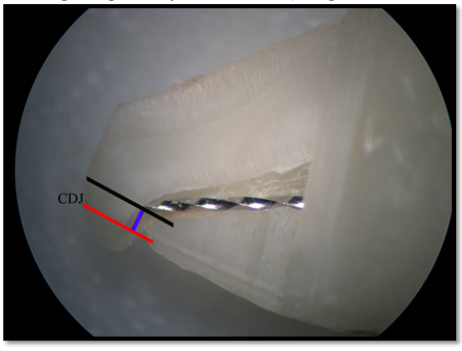

Figure: 1: Stereomicroscopic image of apical section - Group I

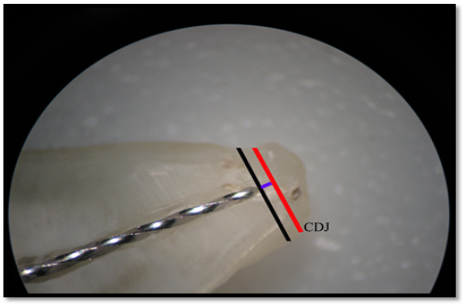

Figure 2: Stereomicroscopic image of apical section - Group II

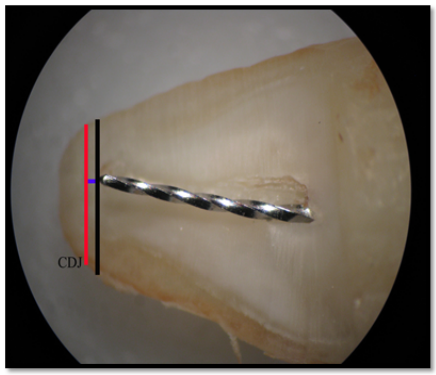

Figure:3: Stereomicroscopic image of apical section - Group III

STATISTICALANALYSIS

Data analysis includes descriptive statistics (Mean and standard deviation). One way analysis of variance with Student-Newman-Keuls method was carried out to compare the means of the study groups by using SPSS version 17 software.

RESULTS:

The data obtained after the image analysis of three study groups are given in the annexure. Correlation of the file tip to the CDJ in groups I, II, III is performed. The descriptive analysis is given in table 1.

TABLE 1: MEAN, STANDARD DEVIATION OF THE THREE STUDY GROUPS

Descriptive Analysis						
Distance between the file tip to the CDJ						
Group	N	Mean	Std. Deviation	Std. Error	Max	Min
I	20	0.711	0.411	0.0918	1.465	0.061
II	20	0.455	0.206	0.0460	0.897	0.167
III	20	0.309	0.227	0.0508	0.842	0.060

The lowest mean of distance between file tip and CDJ is observed in Group III – Working length determined with Electronic Apex locator (0.309) followed by Group II – Working length determined by Radiovisiography (0.455) and Group I – Working length determined by Radiograph (0.711).

TABLE 2: COMPARISION OF MEAN DISTANCE OF THE THREE STUDY GROUPS USING ONE-WAY ANOVA TEST

ANOVA					
Mean Distance					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.65	2	0.827	9.45	0.0003
Within Groups	4.99	57	0.0875		
Total	6.64	59			

The mean difference is significant at the 0.05 level.
The difference in mean values of distance between file tip and CDJ are statistically significant (p – 0.0003).

Table 3: analysis of difference in the mean values of distances of the groups using student-newman-keuls method

Group	Group	Mean Difference	P<0.05
I	III	0.402	Yes
I	II	0.256	Yes
II	III	0.146	No

- There was statistically significant difference between the Group I (WL determination using RG) and Group III (WL determination using EAL) and also between Group I and Group II (WL determination using RVG).
- There was no statistically significant difference between Group II and Group III (0.146).

DISCUSSION:

The establishment and maintenance of the apical limit of instrumentation is undoubtedly an important step of the cleaning and shaping procedure. An accurate working length contributes to a safe and effective instrumentation[9,10]. It is a crucial step to the success of root canal treatment. It is the distance from a coronal reference point to

the point at which canal preparation and obturation should terminate[3].

The cementodentinal junction has been recommended as an ideal apical termination for root canal preparation[10]. The position of this histologic entity varies around the internal circumference of the canal by ranges from 0.5 to 3mm short of the anatomical apex[1,5]. An apical constriction (AC) usually occurs in the region of the dentin-cementum junction and often forms a natural apical matrix. It is the narrowest portal of entry of the pulpal vasculature from the periapical tissues and would be the smallest wound following pulp removal[11]. The topography of the apical constriction is variable[2] and is undetectable radio graphically.

Radiographic method, traditionally the most popular and trusted way for length measurement in the field of endodontics, has advantages like direct observation of the anatomy of the root canal system, the number and curvature of roots, the presence or absence of disease, and in addition acts as an initial guide for working length estimation. But these radiographs are subjected to distortion and magnification. Other shortcomings of radiography include technique sensitivity and subjectivity[12,13], the danger of ionizing radiation, and errors of superimposition caused by producing a two-dimensional representation from a three-dimensional object.

Radiovisiography (RVG) offers some advantages over conventional film radiography. These include a lower patient dose per exposure, the ability to manipulate the image after acquisition, a reduction in time between the exposure and image interpretation, and the ability to electronically archive patient clinical and radiographic data in one electronic file[14].

With the increasing concern about radiation exposure, the introduction and development of the electronic apex locator has been received with enthusiasm by clinicians performing endodontic procedures. It helps in the accurate and predictable working length determination[15]

In most studies carried out to date, the accuracy of working length determination by radiography or apex locator has been evaluated invitro, which has been compared with direct

method. However, in extracted teeth, out of the oral cavity environment, precise simulation of working length determination with radiography or EAL is difficult. The use of in vivo models in which PDL is present will increase the accuracy of results. Invivo accuracy studies more closely reflect the reality of conditions in clinical practice.

In this study, the working length was determined by Grossman's technique (0.5mm short of radiographic apex) in group I and II and (0.5mm short of anatomic apex) in group III.

In group I and II the tooth was exposed using bisecting angle technique as many digital radiographic techniques do not easily permit obtaining endodontic working films with the long-cone paralleling technique, which necessitates using the bisecting angle method[16] and this technique is used more often and the results can be extrapolated more easily to routine daily practice[17].

In the present study Root ZX was used to evaluate the working length in group III, because studies have shown that it yields the best results[18]. It uses the ratio method to locate the minor foramen by the simultaneous measurement of impedance using two frequencies. It works in the presence of electrolytes and non electrolytes.

This study showed a statistically significant rate of acceptable results in the EAL group, which is in agreement with previous studies [19,20,21]. Elayouti et al[9] have shown that electronic apex locators can prevent over instrumentation, even when the working length seems within the acceptable range on radiography. Considering that root canal treatment without preoperative and postoperative radiographs is below the standard of care [83], this clinical study supports the use of electronic apex locators as an adjunctive but not a substitute of radiography for root canal treatment.

CONCLUSION:

To draw the final conclusion, no individual technique is truly satisfactory in determining endodontic working length. The CDJ is a practical and anatomic termination point for the preparation and obturation of the root canal and this cannot be determined radio graphically. Modern electronic apex locators can determine this position with accuracies of greater than 90% but still have some limitations. Knowledge of apical anatomy, prudent use of radiographs and the correct use of an electronic apex locator will assist practitioners to achieve predictable results.

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