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ORIGINAL RESEARCH

Comparison of Working Length Determination using Apex Locator, Conventional Radiography and Radiovisiography: An *in vitro* Study

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ABSTRACT

Aim: The purpose of this study was to compare the working length determination done using three methods, namely, apex locator (Foramatron D-10, Parkell), radiovisiography (Planmeca) and conventional radiography (Prostyle intra, Planmeca).

Materials and methods: In this experiment, to determine the working length, 35 single-rooted teeth were selected and each tooth was subjected to all the three methods of the working length determination. This was compared with the actual working length measured utilizing ground sections of the individual teeth.

Results: The results revealed that all the three methods located the apex nearly as accurately as the actual root canal length obtained by histological ground sectioning, and among three methods apex locator being the closest to the actual root canal length.

Conclusion: The study concludes that all the three techniques are equally effective in determining working length.

Keywords: Working length, Apex locator, Radiography, Radiovisiography, *In vitro.*

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INTRODUCTION

An accurate and a reproducible working length is an important factor in root canal treatment. It establishes the apical limit of the canal preparation and demarcates the creation of an apical stop. It also enables thorough debridement of the canal, allowing it to be performed without overinstrumentation, trauma to the periapical tissues or destruction of the anatomy of the root apex. It establishes the apical limit for obturation. The success rate of conventional root canal treatment has been correlated with the length of the final root canal filling (Harry et al 1970).[1]

There are various methods of determining the working length. The use of conventional radiography remains the most common method of determining the working length. There are major disadvantages like the production of two-dimensional images, high radiation exposure and a cumbersome technique in developing the films with this method. Efforts have been made to improve the technique to locate the apical constriction and to determine working length without the need to irradiate the patient and to get a near accurate working length through newer methods. They are apex locators. However, they too have not been found to be ideal methods. They have remained adjuncts to conventional radiography.

In recent years, new imaging techniques have been developed with the aim of improving the clarity of the image while reducing the radiation dose. Among them is the radiovisiography, which is the most recently introduced method and is fast gaining widespread popularity. The advantage of radiovisiography is that there is a 60% radiation dose reduction[2] and production of an instant image which is enhanceable and modifiable.[1,3,4] The present article compares the diagnostic efficacy of three methods, namely apex locator, conventional radiography and radiovisiography in determining the working length in root canal systems *in vitro*.

MATERIALS AND METHODS

The materials and techniques tested in this studies are apex locator (Foramatron D-10, Parkell), radiovisiography unit (Planmeca), X-ray unit (Prostyle intra, Planmeca), X-ray film (E Speed, Kodak). Thirty-five freshly extracted human maxillary central incisors were collected from the outpatient

unit of the Department of Oral and Maxillofacial Surgery, SDM College of Dental Sciences and Hospital, Dharwad, India. The teeth were screened and X-rays were taken. If any of the following were noted, then those teeth were not included in the study.

- Incompletely formed apex
- Evident root fracture
- Dilacerated root
- Pulpal calcification.

Method of Collection of Data

The pulp chamber was accessed; root canals were located and irrigated with 3% sodium hypochlorite solution. Care was taken to maintain the standardization between samples while recording working length measurement in all the three techniques, namely apex locator, conventional radiography and radiovisiography.

A table on which geometric angulation was available was used for keeping the tooth for radiography, so that the angulation of the X-ray remained the same for all the samples. Tooth positioner and paralleling technique were used for standardization during exposure with radiography and radiovisiography. A constant distance of 3 inches was maintained between the cone head of the X-ray unit and the tooth positioner during radiographical and radiovisiographical methods for all the samples.

In order to reproduce the clinical conditions involved in the electronic measurement of root canal length, the specimens were kept with their roots immersed in normal saline. The labial clip of the apex locator was fixed to the edge of the saline bath all the time. A number 15 endodontic file was attached to the instrument clip and inserted into the canal. When the apex locator indicated that the file is at the apex, the file was held stationary and the rubber stopper was adjusted. Then, the file length was measured. This recording was noted as working length according to the apex locator.

Keeping tooth and file arrangement in the tooth positioner, which was described earlier, the conventional radiographic images of canal length measurement were obtained and working length was calculated as 1 mm short from the radiological apex. Radiovisiographic image was also taken using the same standard equipment and working length was calculated using the parameters of this system. Readings were noted as working length according to the radiographic method and the radiovisiographic method respectively.

To know the correct position of the dentinocemental junction (DCJ), the tooth was selectively ground sectioned in two different planes. This allowed elimination of the hard tissue which had prevented direct visualization of the most apical position of the root canal.

By this method of ground sectioning, it is possible to observe the relationship between the file tip and the anatomical apex. Utilizing the research microscope, the DCJ was observed and the distance between the file tip and DCJ was measured and the actual working length of root canal was measured and recorded.

This actual working length was compared with the working length obtained using the apex locator, conventional radiograph and radiovisiograph for individual tooth. Results were tabulated. Statistical analysis was performed using ANOVA test and Students' t-test, with a p-value of 0.05.

From Table 1, we can observe that there were no statistically significant difference between the groups in the determination of working length with an F value of 0.0420429 ($p > 0.05$). It implies that the root canal length determination in all the groups were similar. There is no statistically significant difference between the four groups as well as within the groups in locating the apex indicating that all the three methods are equally competent in locating the apex.

DISCUSSION

Ideal length determination at the onset of treatment initiation ensures thorough cleaning and shaping and obturation. However, locating the appropriate apical position has always been a challenge in clinical endodontics. In theory, the apical extent of the endodontic instrument should be at the DCJ (Kuttler 1955).[1] However, the literature suggests two valid positions for terminating obturation: At the DCJ (Burch and halen 1972)[1] or at the apical foramen (Altman et al 1970).[1] Till now, no method has been developed which is capable of reliably locating either of these two anatomical points (Hedrick et al 1994).[1,5] The cementodentinal junction, where the pulp tissue changes into apical tissue, is the most ideal physiologic apical limit of working length (Kim DCNA 2004).[6]

Table 1: Comparison of four groups by ANOVA test

SV	*SS*	*df*	*MS*	*F*	*p-value*	Significance
Between groups	0.2753907	3	0.0917969	0.0420429	>0.05	NS
Within groups	296.9435	136	2.1834081			
Total	297.21889	139				

There are various methods for determining working length, but none of these are ideal, so as to be considered as the perfect method. Each method has got its own advantages and disadvantages. The usual methods followed are radiography, apex locators, radiovisiography.[7,8] While using radiographic method in most cases the DCJ does not coincide with the point 1 mm short from the radiographic apex because of cementum deposition. Also, it simply provides reliable information on the location of the radiographic apex (Kuttler 1955) .[1] The anatomical apex may or may not coincide with the apical foramen. In most of the cases (50-98% of all roots) the foramen deviate from the long axis of the tooth. The mean distance between the anatomical apex and the foramina is generally 0.5 to 1.0 mm (Palmer et al 1971, Chunn et al 1981 and McDonald and Horland 1990).[1] Considering that the apical foramen frequently does not coincide with the radiological apex, positioning of the file at the radiological apex will often lead to under- or overinstrumentation.

In recent years, electrical devices have been developed for determining the length of the tooth without resorting to radiography. This is one of the breakthroughs that brought electronic science into the traditionally empirical endodontic practice. This method helps to reduce the treatment time and the radiation dose.[1]

Radiovisiographic method is the most recent and upcoming method of measuring working length. Their advantages over conventional radiographs are the speed of image acquisition, reduced patient radiation dosage and the possibility of image editing (Sherer et al 1990, Ellingsen et al 1995).[3,4]

Different studies have compared these devices of working length measurement (Shearer et al 1990, Hedrick et al 1994, Ellingsen et al 1995, Martinez Lozano et al 2001).[1,3-5] A study conducted by Martinez Lozano et al (2001)[1] concluded that there was no significant difference between these techniques. According to Kobayishi and Suda (1994)[9] the apex locator showed a similar precision as other methods and that if working lengths were determined electronically before obtaining X-rays, the number of radiographic exposures would be reduced as a result (Brunton PA et al 2002).[2]

Clinical endodontics usually depends heavily on information from radiographs for diagnosis and treatment. Therefore, any advancement in radiography may be of interest to dental surgeons who undertake endodontic therapy. Particularly, a study suggested that radiovisiography is of as equal value as conventional film radiography for imaging root canal system *in vitro* (Shearer et al 1991).[4] The potential of the RVG for direct measurement of root canal length has raised interest. A study by Ashraf F Fauld et al (2000)[12] showed that using an electronic estimate before radiographic verification enhances length control throughout the treatment. It also improves the length of obturation and reduces the number of radiographs. Study by Rushton et al (1995)[4] compared 10 radiographic methods for assessing root length. They suggested that all radiographic methods have equally reliable value in assessing working length. Radiographic visualization is influenced by a number of physical and technical factors (Ellington et al 1995, Ong and Pittford 1995)[3,10,11]

In the present study, the methods that were used to determine working length were apex locator, radiovisiography and conventional radiography. All the three techniques showed equal efficiency in determining accurate working length. Out of these three methods, the apex locator was closer to the accurate value but, was not statistically significant than the other two methods. The results of the present study compared with those of the previous studies conducted Martinez-Lozano MA et al (2001),[1] Brunton PA et al (2002),[5] and Kaufman A et al (2002).[12] The investigators observed reduced patient inconvenience with the use of electronic apex locator. The investigators concluded that the determination of working length using a combination of an electronic apex locator and radiography is more accurate than radiographs alone.

So, it can be said that the accurate determination of working length will be dependent on the ability of the clinician to read radiographs, correct assumption of apical constriction with the help of apex locator, handling and using a combination of all methods, application of logic, knowledge of anatomy and tactile sense. The best prognosis for root canal treatment is adequate instrumentation and homogeneous obturation till the apical constriction. The worst prognosis for root canal treatment is under- or overinstrumentation or filling short or beyond the apical constriction. So, combining proper usage of instruments with the knowledge, skill and experience of the operator will determine the outcome of each technique.

CONCLUSION

Thus, while all methods are equally effective, the skill, knowledge and expertize of the clinician assumes paramount importance in correctly understanding and utilizing these technological advances, so as to best determine the accurate working length, which forms the basis for successful endodontic therapy. The more diligently the clinician becomes adept with these techniques, the better the holistic success of the endodontic therapy. The conventional X-ray, though accurate, has the disadvantages of increased

radiation and being time consuming. The RVG overcomes these by reducing the radiation and time requirement and also eliminating processing variables. The apex locator, however, completely eliminates radiation and has the advantage of time and convenient chairside access. So, we can conclude the clinical significance of this study as that all the three methods located the apex nearly as accurately as the actual root canal length obtained by histological ground sectioning, and among three methods apex locator being the closest to the actual root canal length. Thus, further research and advances may make this the technique of choice in working length determination or a combination of the RVG and apex locator may be the future in endodontics.

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