Original Article

Determination of Working Length of Root Canal

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Abstract

Background: This study was undertaken to determine the working length of root canal by microprocessor controlled impedance quotient apex locator and conventional radiographic method.
Methods: Patients whose teeth were to be extracted were selected for this study. A total of 100 teeth in the same or different patients were identified. Biomechanical preparation of the canal was done for smooth negotiation of the entire canal. The electrode of the Root ZX™ was attached to the selected file and the length adjusted till the beep of the Root ZX™ indicated the apical foramen. The electrode was removed but the file was stabilized with the help of soft gutta percha. An intraoral periapical (IOPA) radiograph was taken using basic guidelines. The tooth was then extracted under local anaesthesia along with the file in the tooth. A window was cut on one surface of the root apex approximately 4mm from the apex to expose the root canal. The file tip was identified. The distance of the file tip from the apex was measured under 3X magnification and the reading recorded. Similarly the distance from the file tip to the radiographic apex was measured on the radiograph under magnification and the reading recorded. All the readings were tabulated. The actual distances measured between the extracted tooth, the electronic apex locator and on the radiograph were compared using a paired 't' test to determine the accuracy of each method in relation to the minor diameter.
Result: It was observed that the radiographic method had a significant variation from the electronic method when compared to the actual measurement on the extracted tooth.
Conclusion: The electronic method is a more accurate method as compared to radiographic method for determination of working length of the root canal.

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Key Words : Working length; Root canal; Cementodentinal junction; Electronic apex locators

Introduction

The explicit location of the physiological apex of root canal is a prerequisite for a successful endodontic therapy. Working length is defined in the endodontic glossary as the distance from a coronal reference point to the point at which canal preparation and obturation should terminate. According to Kuttler (1955), the narrowest diameter of the canal is definitely not at the site of exit of the canal from the tooth but usually occurs within the dentin, just prior to the initial layers of cementum. According to Ricucci and Langeland, the apical constriction is the narrowest part of the canal with the smallest diameter of blood supply, thus creating the smallest wound site and best healing condition [1]. This anatomical landmark can be called the minor diameter of the canal. However, the cemento-dentinal junction (CDJ) and apical constriction do not always coincide, particularly in senile teeth as a result of cementum deposition, which alters the position of the minor diameter [2]. The minor diameter represents the transition between the pulpal and the periodontal tissue, located in the range of 0.5 to 1.0 mm from the external foramen or major diameter on the root surface [3]. A working length established beyond the minor diameter may cause apical perforation and overfilling of the root canal system. This may increase postoperative pain and delay or prevent healing. Alternately, a working length established short of the minor diameter may lead to inadequate debridement and underfilling of the canal. Retained pulp tissue may persist and cause prolonged pain. In addition, microleakage into the canal space may result in impaired healing [4]. The generally accepted method of working length determination is the radiographic method but the apical constriction cannot be accurately determined radiographically. The electronic apex locator has attracted a great deal of attention as it operates on the basis of electronic principles rather than by a visual inspection. The electronic apex locator is one of the breakthroughs that brought electronic science into the traditionally endodontic practice [5]. Electronic apex locators are particularly useful when the apical portion of the canal is obscured by anatomic structures, such as impacted teeth, tori, the zygomatic arch, excessive bone density,

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overlapping roots or shallow palatal vaults. Electronic apex locators currently are being used to determine the working length and as an important adjunct to radiographs. Electronic apex locators reduce the radiation dose and treatment time. The earlier apex locators were based on the principle of resistance and impedance type. The newly developed apex locators are based on the impedance of a given circuit that is substantially influenced by the frequency of the current flow. These devices are called frequency dependent apex locators [6]. These apex locators are based on the principle that there is a maximum difference of impedance between electrodes depending on the frequencies used. The major advantages with these apex locators are that they operate in an electroconductive environment in the presence of pus and pulpal tissue remnants. The aim of this study was to compare the accuracy of frequency based electronic root canal length measurement device-Root ZX™ and conventional radiographic method in working length determination under clinical conditions (Fig. 1).

Material and Methods

Patients whose teeth were to be extracted were selected for this study. A total of 100 teeth in the same or different patients that were asymptomatic and without any periapical infection were identified. An access cavity was prepared and the pulpal contents were removed from the pulp chamber as well as the canals. Biomechanical preparation of the canal was done for smooth negotiation of the entire canal. A root canal file was selected corresponding to the canal size and inserted in the canal. The electrode of the Root ZX™ was attached to this file and the length adjusted till the beep of the Root ZX™ indicated the apical foramen (Fig. 2). The electrode was removed but the file was stabilized with the help of soft gutta percha. An intraoral periapical (IOPA) radiograph using ORIX-65™ (Ardex, Italy, 65 Kvp-8mA- 520 VA. Focal spot: mm 1x1, Inherent filtration: 0.8 mm AL, Total filtration : 2.5 mmAL) was taken using basic guidelines. The tooth was then extracted under local anaesthesia along with the file in the tooth. Care was taken that the tooth was extracted in one piece without fracture of the root, although there were 11 fractures of roots in the study. These 11 cases were removed from the study group and fresh cases were incorporated to complete the sample size. Care was also taken that the file stabilized in the root canal was not disturbed. After extraction the tooth was placed in hydrogen peroxide for two minutes and washed under flowing water. A window was cut on one surface of the root apex approximately four mm from the apex to expose the root canal. The file tip was identified. The distance of the file tip from the apex was measured under 3X magnification and the reading recorded. Similarly the distance from the file tip to the radiographic apex was measured on the radiograph under magnification and the reading recorded. All the readings were tabulated. It may also be clarified here that while taking radiographs, long cone technique was used rather than the short cone, as the latter leads to elongation of the image and more discrepancy.

In six cases the apical opening was 1-2 mm short of the apical tip of the root. Since this would have affected the result because the radiographic measurements were made from the radiographic tip of the root, these six cases were not considered in the study. It may be reiterated here that only those cases were considered where the apical foramen coincided with the apical tip of the root.

Results

The purpose of the present study was to compare the accuracy of frequency based apex locator Root ZX and conventional radiographic method under clinical conditions. The accuracy of the apex locator was compared using single canal single rooted teeth (incisor, canine and lower premolar teeth) that were to be extracted for periodontal or orthodontic reasons.

The actual distances measured between the extracted tooth, the electronic apex locator and on the radiograph were compared using a paired samples 't' test to determine the accuracy of each method in relation to the minor diameter. It was observed that the radiographic method had a significant variation from the electronic method when compared to the

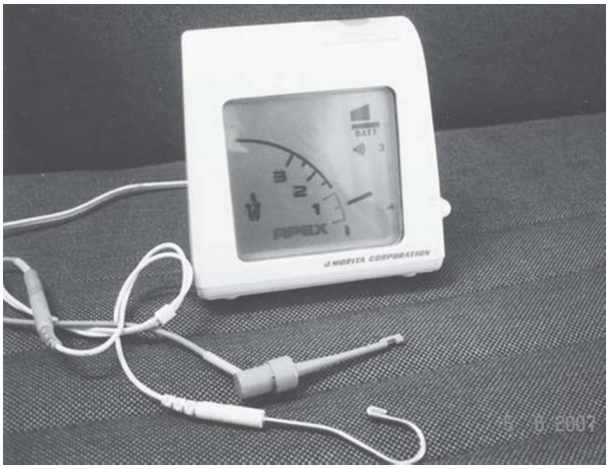

Fig. 1 : Root ZX with probe.

Fig. 2 : Root ZX probe attached to file to determine working length of root canal.

actual measurement on the extracted tooth. It was thus concluded that the electronic method is a more accurate method as compared to radiographic method for determination of working length of the root canal.

Discussion

Most experts agree that the canal preparation should terminate at the CDJ. However, the term "CDJ" is a histological term and a microscope is needed to find it. Clinically this is not practical. In the early days of endodontics, when radiographs were not being used in dentistry, working length was approximated to where the patient experienced pain. This obviously led to multiple errors. If vital tissues were left in the canal, the calculation would be too short. If a periapical lesion were present, the calculation would be long.

Radiographs in dentistry came about in 1899. However, the thought at that time was that the dental pulp extended through the tooth, past the apical foramen, into the periapical tissue and that the narrowest portion of the tooth was at the extreme apex. The radiographic apex was thought to be the correct site to terminate the canal preparation. In the 1920's, Blaney and Coolidge offered information that indicated that filling slightly short of the root tip gave the best results.

In 1955, Kuttler gave the most comprehensive anatomic microscopic study of the root tip. He studied several thousand teeth. Not everyone embraced his ideas initially but over the past 40 years his ideas are still practiced. In individuals between the age group of 18-25 years, the average distance between the minor and major diameters was 0.524 mm. In older individuals the average distance was 0.659 mm. Therefore Kuttler felt that it was an unwise clinical procedure to fill to the radiographic apex because it caused postoperative pain and lowered the success rate. Many studies have followed and supported Kuttler's findings.

In 1957, Ingle used the pre-treatment radiograph in a mathematical procedure for determining working length. The original tooth image was measured on the pre-treatment radiograph, following substraction of a standard 2-3 mm from that length to compensate for distortion. There are several ways to determine the working length of the root canal viz radiographs, electronic apex locators, tactile sense, patient response, knowledge and experience, predetermined normal tooth length, use of paper points, mathematical equations etc. Accuracy in length determination is necessary to avoid damage to the apices of teeth and to the periapical tissues during instrumentation, thus providing better conditions for healing after endodontic treatment. As with anything that is open to interpretation, variation exists in the radiographic determination of endodontic file length.

The advantage of apex locators are that they are supposedly accurate, easy, fast and reduce exposure to radiation. Artificial perforation can be recognized and it is the only method that can measure length to the apical foramen and not the radiographic apex. The disadvantages are that it requires a special device and accuracy is influenced by electrical condition of canal. Most of the disadvantages come from the fact that the magnitude of the impedance of the canal is influenced by the electrolytes present inside the canal. This disadvantage has been almost totally overcome by the new apex locators such as the Endex and the Root ZX™. Electronic apex locators have limitations in teeth with wide open apex. Root ZX™ uses the ratio method for measuring the root canal length. Ratio method measures the impedance of two different frequencies, calculates the quotient of the impedances and expresses this quotient in terms of the position of the electrode (file) inside the canal. The quotient is hardly affected by the electrical condition inside the canal. With the Root ZX™ a microprocessor corrects the calculated quotient so that the position of the file tip and the meter readings are directly related. No calibration is needed. Like the Endex™, Root ZX™ can perform with high accuracy in the presence of sodium hypochlorite solution, blood, water, local aneasthesia and pulpal tissue. With this device one can use fine endodontic files without the need to precalibrate the circuit before locating the apical foramen. Metallic restorations and heavily calcified canals interfere with electrical conductivity. With heavily calcified canals, patency of the canal needed to be established before determining the electronic signal of the apical foramen. With an electronic method one can always detect electrically the point where the file tip is in contact with the periapical tissue (tissue fluid) even if the apical foramen is located away from the anatomic apex. To keep the canal enlargement within the canal, the actual working length is slightly less than the measurements. The best working length is found by subtracting approximately 0.5 mm from the length obtained with the apex locator.

It is important to know that there is potential for interference of an electronic apex locator with a patient's cardiac pacemaker function. It depends on the specific type of pacemaker placed and the patient's dependence on it. It is best to consult the patient's cardiologist before the treatment.

Conclusion

From the results of the present study it may be concluded that

1. The use of electronic apex locators is a reliable method of determining root canal length.

2. The Root ZX electronic device was able to predictably locate the minor diameter to within 0.6 mm (in 95% of cases) more than the radiographic method.
3. The results show that the electronic root canal length measurement devices are a useful adjunct to endodontic practice. Further studies should be performed to evaluate the effect of diameter of apical foramen on the electronic root canal length measurement devices and also the ability of these devices to locate apical constrictions, perforations, horizontal and vertical fractures.
4. Within the limitations of the study the radiographic method was standardized and the long cone was used but some element of variation may have been there in the radiographic readings which may have influenced the results.
5. Further studies using a larger sample size and standardized radiographic methods are recommended.

Conflicts of Interest

This study has been funded by research grants from the O/o DGAFMS.

Intellectual Contribution of Authors

Study Concept : Maj Gen V Arora, VSM, Col MC Sharma
Drafting & Manuscript Revision : Col MC Sharma
Statistical Analysis : Col MC Sharma
Study Supervision : Maj Gen V Arora, VSM, Col MC Sharma

References

1. Ricucci D, Langeland K. Apical limit of root canal instrumentation and obturation, part 2. A histological study. International Endodontic Journal 1998; 31: 394-409.
2. Kim Euiseong, Seung Lee. Electronic Apex Locators. Dental Clinics of North America 2004; 55: 35-54.
3. Spangberg SF. Instruments, materials and devices. In: Cohen S, Burns RC, editors. Pathways of Pulp: 8th edition. St Louis, Missouri: Mosby, 2002; 521-72.
4. Ingle IB, Bachanan S. Endodontic cavity preparation. 4th edition.Endodontic Maloern, Philadalphia: William & Wilkins 1994; 92-227.
5. Pagavino G, Pace R, Baccetti T. A SEM study of in vivo accuracy of the Root ZX electronic apex locator. Journal of Endodontics 1998; 24: 438-41.
6. Blank LW, Tenca JI, Pelleu GB Jr. Reliability of electronic measuring devices in endodontic therapy. Journal of Endodontics 1975; 1: 141-5.

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