EXTRAORAL RADIOGRAPHY: AN ALTERNATIVE TO INTRAORAL RADIOGRAPHY FOR ENDODONTIC (ROOT CANAL SYSTEM) LENGTH DETERMINATION

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Abstract

The objective of this study was to evaluate the accuracy of extraoral radiographic technique for determination of the working length and to determine the magnification error. This technique can be an additional supplemental tool that can be utilized as a reliable alternative for the intraoral periapical radiographs.

Eighty-five mandibular premolars were selected using convenience sampling. Medical & dental history of the patients was taken. The teeth were anesthetized and root canals were accessed, irrigated and dried. A file was cemented into the canal using Glass Ionomer Cement and handle was cut from the tooth reference point followed by extraoral radiograph taken by placing cone at -35 angles. Tooth was extracted to determine actual length and comparing with radiographic length. The ethical approval was obtained from the research ethics committee of the college.The accuracy of extraoral radiography is 94.5 $\pm$ 4.43% and magnification error (5.5 $\pm$ 4.3%) is not significant statistically. Extraoral radiographs (86 %) determined average tooth length precisely with magnification error of less than 10 %. The mean difference between the actual length and the extraoral radiographic length is 6.1 ± 5.1 % of the actual length.

The extraoral radiography is a valuable technique that is reliable (accuracy 94.6 ± 4.3% for measuring working length), useful and affective technique for clinical dentistry and endodontic working length determination particularly where use of intraoral radiography is difficult or impossible.

Keywords: Working Length, Root canal treatment, Premolars

Introduction

Determination of an accurate working root length is one of the most critical steps during endodontic therapy (Bramante and Berbert, 1974). The endodontic procedures such as cleaning, shaping and obturation cannot be accomplished accurately unless the working length has been determined precisely (Inoue and Skinner, 1985,Seidberg et al., 1975). Failure to accurately determine the length of the tooth may lead to complications such as ledge formation (Sinai et al., 1967), apical perforation and overextension of irrigates through the apical constriction (Kim-Park et al., 2003), leading to peri-redicular inflammation, pain and ultimately lower success rate (Sinai et al., 1967). Electric apex locator has been used widely for working length determination (Trope et al., 2006,Fouad and Reid, 2000,Chong and Pitt Ford, 1994), however it has certain limitations. For example, the presence of certain factors such as intact vital tissue, inflammatory exudates, open apexes, large periradicular lesion, complex canal morphology and/or blood may allow conduction of electric current and inaccurate readings (Jenkins et al., 2001,Pommer et al., 2002). Presence of debris and calcifications can also affect accurate working length determination with electronic apex locators (Aurelio et al., 1983). In addition, the use of apex locators in patients with cardiac pacemakers is controversial and having safety concerns (Wilson et al., 2006,Garofalo et al., 2002,Beach et al., 1996).

Radiography has been used to determine the working length (Zhang et al., 1995,Bhakdinaronk and Manson-Hing, 1981). Need for radiograph in all phases of endodontic therapy is well established (Folk et al., 2005,Newman and Friedman, 2003). Most of these aids rely on conventional intraoral radiography (Newman and Friedman, 2003). Generally accepted method for root canal length determination is intraoral radiographic interpretation of an instrument placed in the canal (Ingle, 2002). In intra oral technique the film is placed lingual to the tooth while X-ray cone is placed directly buccal to the tooth causing the X-ray beam passing through the tissue and exposing the film (Sinai et al., 1967). This technique although advantageous but is very difficult to be used in some patients such as mentally retarded, having exaggerated gag reflex, children, dental phobic and any lingual pathology interfering with the procedure. These cases are unable to tolerate the conventional intraoral technique (Newman and Friedman, 2003).

An alternative is extraoral radiographic technique that can be utilized while performing endodontic therapy for such compromised patients. In this technique the film is placed buccal to the tooth on the cheek and X-ray beam comes from the opposite side of the face, passing through the tissue and exposing the film. The angulations of the film would be

perpendicular to the X-beam and cone is adjusted at -35 angle from the horizontal plane. This technique can be utilized for both maxillary and mandibular teeth, without needing much patient cooperation and with or without rubber dam in place (Newman and Friedman, 2003,Harase et al., 2005).

The objective of this study was to evaluate the accuracy of extraoral radiographic technique for determination of the working length and to determine the magnification error. This technique can be an additional supplemental tool that can be utilized as a reliable alternative for the intraoral periapical radiographs for working length determinations.

Materials and Methods

Case selection: Eighty patients requiring extraction of lower premolar teeth were selected using convenience sampling technique. All patients were selected from the outdoor of de' Montmorency College of Dentistry/Punjab Dental Hospital Lahore and eighty five lower premolars were included in this study. The diagnostic criteria were based on clinical examination and detailed medical and dental history (Criteria used for selection of potential teeth are given in table 1). Complete protocol was explained and a written informed consent was obtained from each patient to participate in the study before completing detailed medical & dental history. The ethical approval was obtained from research ethics committe at college of dentistry.

Table 1. Case selection criteria

Inclusion Criteria	Exclusion Criteria
Adult patients	Patients contra indicated for X ray radiation
Mandibular premolars.	Obese patients.
Extractions for orthodontic treatment.	Mal-aligned teeth
Tooth with grade III mobility.	Grossly carious or damaged teeth
Tooth with straight root morphology	Teeth with curved or calcified canals.
Teeth with fully formed apices	Restorable teeth

Operative Procedure: The selected tooth was anaesthetized using (2% lignocaine) local anesthesia. Access cavity was prepared with the help of a 702 U tapering fissure bur in a high-speed contra angle hand piece. Subsequently the pulp tissue was removed using either barbed broaches or #20 Headstrom file (H-File). The canals were irrigated copiously with 2.5% sodium hypochlorite along with suction and excess was absorbed from the pulp chamber with a sterile cotton pellet and paper points (# 20) until fully dried. The root canals till the apical constriction was sealed using a K files (# 20) and glass ionomers cement. The

reference point was recorded on the clinical crown and file was left inside the canal by cutting off till the reference point.

Radiography: The extraoral oral radiographs were taken using the technique described by Newman (Newman and Friedman, 2003). Briefly, the patient was seated upright in the dental chair and film was placed on the external surface of the cheek directly buccal to tooth on the side of the face. The x-ray cone was angled at –35 degree from horizontal plane and perpendicular to the film on the opposite side of the face (Fig 1). The X-Ray equipment was set at 65 kVp, 10 mA and exposure was provided for 0.50 - 0.55 seconds E-speed periapical films (Agfa Dentus M2).

Figure 1: Angulation for extraoral radiography for lower premolars

The tooth was extracted carefully and sectioned longitudinally into two sections in bucco-lingual direction using oesteotome to access cemented file. The actual length of the tooth was determined with the same files cemented into the canal. A magnifying glass (2×) was used during determining the actual length of each tooth file. This file length was recorded on a millimeter scale as the “actual length” (assumed to be clinically important length) and compared with radiographic length from extraoral periapical radiograph for comparison.

Data analysis: The data was entered and analyzed using SPSS Version 10.0. The outcome of extraoral periapical radiographs and magnification error were listed. The sensitivity of the extra oral radiographic length measurements was determined within 10% of the actual length. Paired t-test was used to compare the difference between the extraoral radiographic length and actual length for each tooth. Correlation coefficient was also determined for the extraoral radiographs as compared to the actual length. ($p<0.05$ was considered significant).

Results

This is a clinical study conducted using non carious teeth extracted either for orthodontic or periodontal reasons. The actual working length of extracted premolars was compared with extra-oral radiographic lengths for accuracy and precision. All results are based on eighty five mandibular premolars using extraoral periapical radiography.

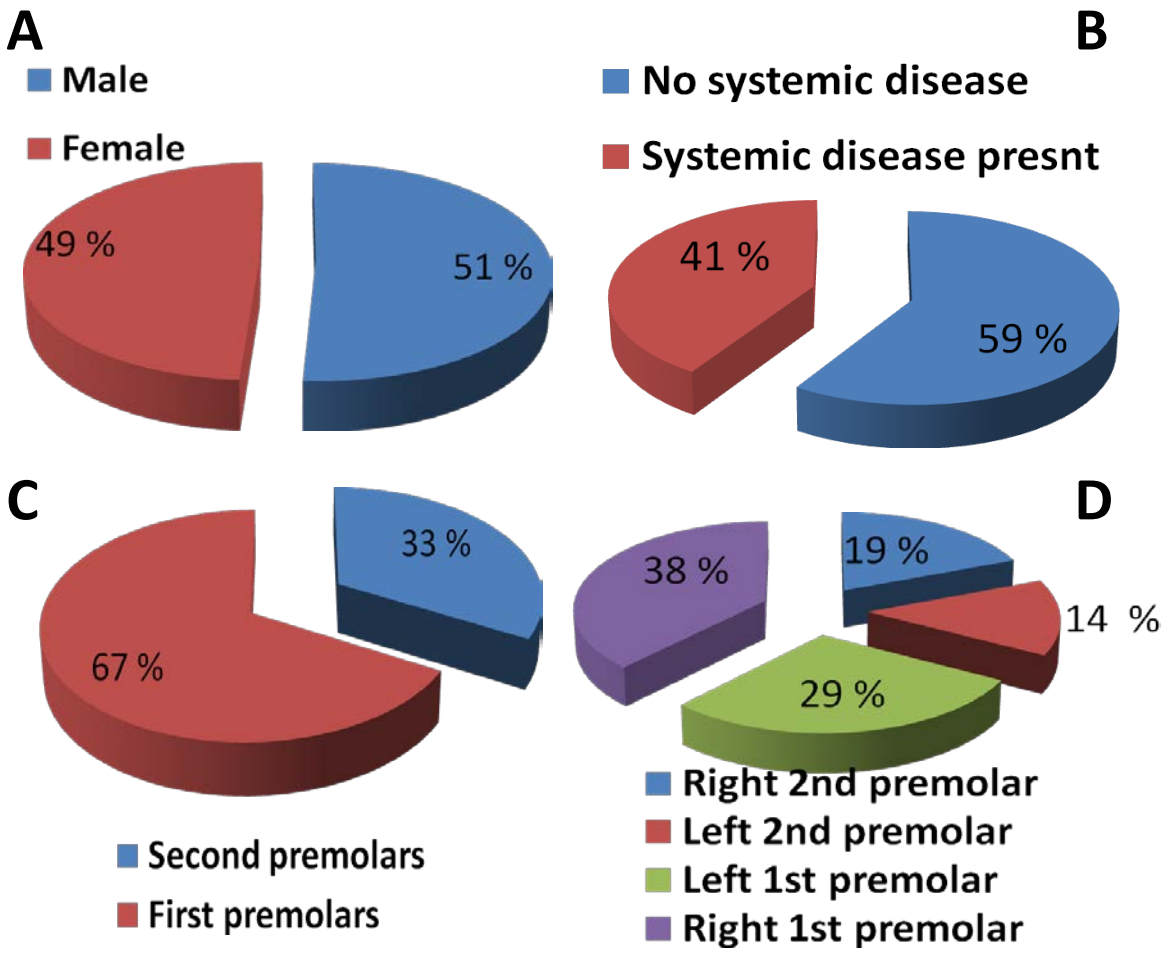

Figure 2: The proportion of teeth included in the study based on
A)- Gender, B) - Presence of systematic disease, C) and D)- premolars distribution

Extraction of premolars has been the most favorable extraction choice for orthodontic reasons (Proffit, 1994). There was more proportion of first premolars (67 %) compared to second premolars (33 %) with almost equal number of male (51 %) and female (49 %) patients (Fig. 2).

There was no medical problem in 47 patients (59 %) while remaining half (41 %) had medical problems such as hypertension, diabetes mellitus or cardiac problem.

Accuracy and magnification measurement: The validity of extra oral periapical radiographic technique for working length determination was assessed by calculating

accuracy and estimated magnification. Formula used to calculate the accuracy of this technique is given here (Equations 1 and 2)..

$$\text{Accuracy (\%)} = \frac{\text{Actual working length}}{\text{Radiographic working length}} \times 100 \quad (1)$$

While

$$\text{Magnification (\%)} = 100 - \text{Accuracy} \quad (2)$$

Paired t-test was used to compare the difference between the extra oral radiographic length and actual length for each tooth and p-value ($p<0.05$) was considered significant. The accuracy of this technique was calculated 94.5 ± 4.34 % and radiographic magnification was calculated 5.5 ± 3.01 % (n=85), strongly suggesting that extraoral periapical radiographic technique is a valid procedure for working length determination (Fig 3).

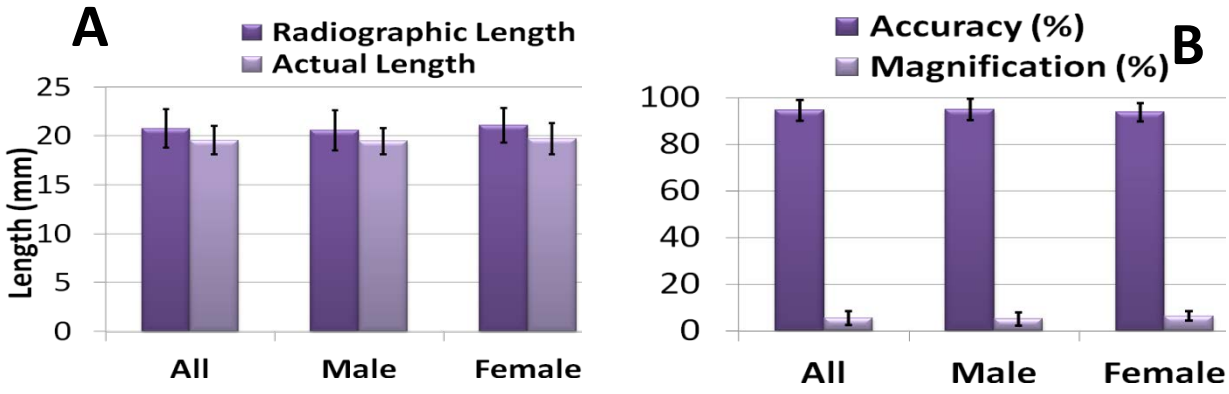

Figure 3: Extraoral radiography. A) - Comparison of actual tooth length and extraoral radiographic length B) - Accuracy and magnification of the technique *(n=85)*

The extraoral radiographic and actual lengths were compared for premolar obtained from male and female patients (Fig 3). In male patients, the average length measured using extraoral radiographic method was 20.58 ± 2.06 mm while the mean actual working length was 19.47 ± 1.34mm hence an estimated magnification of 5.04 ± 2.77 % was observed. In female patients, the mean tooth length calculated using extraoral radiographic method was 21.06 ± 1.77 mm; compared to actual tooth length (19.73 ± 1.60 mm) with an estimated magnification error was 6.26 ± 2.04 % (Fig 3). The magnification error was found to be statistically insignificant for both male and female patients. A majority of extraoral radiographs (86 %) determined average tooth length precisely with magnification error of less than 10 %. The mean difference between the actual length and the extraoral radiographic length is 6.1 ± 5.1 % of the actual length using the paired t-test within the confidence interval ($p>0.05$).

Discussion

Working length determination is a crucial step for successful endodontic treatment. It is accepted generally that the preparation of the root canal should ideally be carried out to the Cemento-dentinal Junction or the apical constriction and radiography is vital to achieve this goal (Travassos et al., 2003). Discrepancies in working length can result in failure or complications during endodontic treatment. For example, over instrumentation could force infected pulp tissue or dentinal chips into the periapical tissue and may cause a persistence inflammatory response and post operative pain or trigger the foreign body reaction (Nehammer, 1985,Seltzer et al., 1968). This kind of apical leakage allows microorganisms to invade the root canal system and affects the prognosis of periapical healing (Wang et al., 2005). Intraoral radiography is a well developed tool for accurate endodontic length measurement and treatment assessment. This study has mentioned the benefits and accuracy of using extraoral radiography as an adjunct tool to help patients who cannot tolerate intraoral radiography.

This is a unique study and first of its kind where extraoral radiographic length of tooth was compared with extracted teeth. The concept of extraoral radiography is not new as Fisher (Fisher, 1974) used extraoral radiography for obtaining the image of 3rd molars using occulusal films. However it received a lot of criticism for using high value of input voltage (kVP) and this issue can now be resolved using high speed F-films that needs a very low amount of radiations compared to D-speed films (Jones and Burton, 1992).

In a previous study (Sadeghi and Esmi, 2007), the accuracy of extraoral and intraoral radiography was compared for working length for molar teeth. They found a correlation between two techniques ($r>0.59$, $p<0.001$) with 75% magnification accuracy. The results are better in the current study due to the direct comparison of extraoral radiography with tooth itself. In contrast, the results obtained by Sadeghi et al (Sadeghi and Esmi, 2007) were based on comparing two radiographic images. The present study has revealed extraoral radiography for lower premolars has an accuracy of 95.4±4.34 % with a magnification of just 5.5±4.34 % and resulting in magnification error of <10 % for 86 % teeth. However, we agree with Sadeghi et al (Sadeghi and Esmi, 2007) that the extra oral radiographic technique with conventional periapical film could be effective in patients who were unable to tolerate or sensitive to periapical film.

The rubber dam isolation is a vital requirement during endodontic procedures and likely to affect the ease and accuracy of the radiographs particularly in molar region. Similarly anatomical parameter such as rigid or high palate (in case of maxillary molars) is

another example that can make intraoral radiography a challenging task in clinics (Chee and Neo, 1990). The present study also shows that the extra oral radiography can easily be carried out even in the presence of rubber dam in place. There would be no need for the removal of the rubber dam. These results show that it can effectively be used in the patients having lingual trauma, those who are mentally retarded, children and dental phobic patients.

Newman and Friedman (Newman and Friedman, 2003) used extra oral radiography effectively in selected population of patients and found a slight decrease in the resolution however not affecting the diagnostic quality of the images. In addition, patients tolerated the procedure well and preferred extraoral radiography to the conventional intraoral radiography.

These results are comparable a previous study (ElAyouti et al., 2002) where intraoral radiography was found to be 95 % accurate in measuring working length of premolars. Another complicating factor is the location of apical foramen; that is located laterally in 78% to 93% of the cases (Green, 1956). An apical foramen located short of the radiographic apex on the facial or lingual aspects of the root makes it generally difficult to identify the position of the apical reference point on the radiograph.

Lamus et al (Lamus et al., 2001) compared digital and conventional film intraoral radiography with gold standard of extracted teeth and found no significant difference in the accuracy of both techniques. Both conventional film and direct digital images had a difference of less than 1mm from the extracted teeth; whereas in present study (using of extraoral radiography) this difference of measurements between radiograph and extracted teeth is 1.16 mm suggesting that the extraoral radiographic technique can be used effectively in clinical practice.

The magnification always remains an issue for radiographic images. For intraoral radiography a magnification error was described 5.4 % using standardized radiographs and right angle paralleling technique (Vande Voorde and Bjorndahl, 1969). The magnification error calculated in this study is 5.5 % (where $n=85$) that is not significantly different to intraoral radiography having 94.5% mean accuracy. These all result strongly suggest that extraoral radiographic can be a reliable, useful and affective technique for clinical dentistry and endodontic working length determination particularly where use of intraoral radiography is difficult or impossible (Such as gag reflex, mentally retarded patients, limited mouth opening).

Conclusion

The extraoral radiography is a valuable technique that is reliable (accuracy 94.6 ± 4.3% for measuring working length), useful and affective technique for clinical dentistry and

endodontic working length determination particularly where use of intraoral radiography is difficult or impossible (Such as gag reflex, mentally retarded patients, limited mouth opening). In addition, this technique is well tolerated by patients and can be used along rubber dam/endodontic instruments in place. The risk of operator errors for intraoral radiography is high (9-26 %) especially in patients prone to gagging (Sewerin, 1984) that can significantly be reduced using extraoral radiography technique. There are certain limitations for extraoral radiography such as inability to apply for anterior teeth due to poor access. Future work is required to standardize extraoral radiography technique and to overcome the limitations.

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