Evaluation of the Distance of Apical Constriction from Anatomic and Radiographic Apices in Extracted Maxillary Second Premolars Using the Clearing Technique

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Abstract

Objective: Precise knowledge regarding the topography of the tooth apex and location of the apical assessing the constriction are necessary for good and efficient root canal treatment and its long term prognosis. Since radiography is among the most commonly used methods for termination point, it is essential to be able to determine the exact location of apical constriction by radiography. The aim of this study is to evaluate the distance of apical constriction from anatomic and radiographic apices in extracted maxillary second premolars using clearing technique. It also compared the reliability of radiographic results with that of histologic findings.

Methods: In this in-vitro experimental study, 50 extracted maxillary second premolars of patients presenting to various dental care centers in Tehran were selected. After cleaning and disinfecting the root surfaces and preparing the access cavity, 2% methylene blue was injected into the canals along with the use of negative pressure. Then, demineralization and clearing process were done using 5% nitric acid and methyl salicylate. Samples were evaluated under stereomicroscope at X16 magnification. In order to evaluate the distance between apical constriction and radiographic apex, a #10 file was fixed at the apical constriction under the stereomicroscope. Covering the apices with sealer, radiographs were taken from all samples. The reliability of radiographic results was compared with that of histologic findings.

Results: The mean distance of apical constriction from the anatomic and radiographic apices was 0.9 and 1.05 mm, respectively. Sensitivity, specificity, positive and negative predictive values of radiographic results were 87.8%, 88.8%, 93% and 62%, respectively. The likelihood ratio for positive and negative radiographic results was 7.9 and 0.1%, respectively. The diagnostic odds ratio was 57.6% which is indicative of the acceptable accuracy and validity of the radiographic results in assessing the distance of apical constriction from the anatomic apex.

Conclusion: This study demonstrated that the distance of apical constriction from the anatomic and radiographic apices in the maxillary second premolars was approximately 1 mm and therefore, the process of cleaning, shaping and obturation should end at this point. This study emphasizes on the accuracy of radiographic findings and importance of having sufficient anatomic knowledge for achieving a good treatment outcome in a clinical setting.

Key words: Anatomic apex, Apical constriction, Maxillary second premolar, Radiographic apex

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Introduction:

The main route connecting the dental pulp and periodontal ligament in all teeth is through the apical and lateral foramen or foramina. Successful root canal therapy depends on cleaning all the pathways of the pulp which cannot be achieved without the exact
determination of the working length.

In normal root canals, the most apical part of the canal narrows and forms the apical constriction. Past this constriction, the canal widens again and forms the major foramen (1). Major foramen is usually deviated laterally and is located approximately 0.5 to 2 mm coronal to the anatomical apex (2, 3).

Apical limit of root canal instrumentation and obturation during an endodontic treatment has always been a subject of controversy. Researchers have evaluated the periradicular tissues after root canal therapy and concluded that the best prognosis would be achieved when the canal preparation terminates at the cementodentinal junction (CDJ). However, determining its exact location is not possible. Therefore, apical constriction can serve as a safe and appropriate end point for endodontic treatment (4). Contemporary methods for determining the working length like the electronic apex locator also consider the apical constriction as the appropriate end point for canal preparation and filling (5). Since it is not possible to see the exact location of apical constriction and apical foramen on a radiograph, radiographic apex would be a more reliable reference point for determining the root canal therapy end point. Employing various conventional methods for determining the exact location of the canal preparation end point results in a more accurate biologic working length and decreases the risk of injuring the periodontal ligament. Consequently, rate of endodontic failures will decrease. Studies evaluating the prognosis of endodontic treatments have also confirmed that success of endodontic treatments is affected by the proper working length (6,7). Therefore, more knowledge about the anatomy of the teeth apices can be very helpful.

Various methods are employed for determining the canal preparation end point and measuring the working length. In this respect, radiography as the most common method has the advantage of direct observation of the root canal and its curvatures, presence or absence of disease and estimating the initial working length (5). This study aimed at evaluating the distance of apical constriction from the anatomic and radiographic apices using clearing technique in extracted maxillary second premolars.

Methods:

In this in-vitro experimental study 50 extracted maxillary second premolars with mature apices and no or minimal caries were collected during one year from several clinics in Tehran. For disinfection, the teeth were placed in jars containing 10% formalin until the initiation of laboratory studies. Age and sex of patients and reason of extraction were not known. The teeth were cleaned by scaling and polishing and soft tissue debris, bone chips and calculus were removed. Access cavity was prepared for each tooth using 008 diamond bur (Tizkavan, Iran) and high speed hand piece (Kavo, West, Germany). Orifices of the canals were evaluated using DG16 endodontic explorer (Hu Freiday, Chicago, IL, USA). To achieve clearing, samples were stored in 5.25% sodium hypochlorite solution (Golrang, Pakshou, Tehran, Iran) for 48 hours at room temperature (20°C) to solve the debris and the remaining pulp tissue. All samples were then rinsed and soaked in running water for 4 hours to remove debris.

In the next phase, methylene blue 2% was injected through the access cavity into the canals using a 27 gauge insulin syringe (Supa, Tehran, Iran) while applying negative pressure at the apex using central suctioning system with the approximate pressure of 25 mmHg. In order to ensure that the dye remains in the canals, the second phase of dye injection was done through the access cavity and without suctioning. Finally, temporary filling material (Coltosol, Ariadent 37g) was placed and the margins of the cavity and tooth were covered with nail varnish. The samples were then ready for decalcification and clearing.

For demineralization, all samples were stored in nitric acid solution 5% for 6 days at room temperature (20°C). The solution was stirred 3-4 times a day and exchanged daily. In order to ensure demineralization, tooth softening was checked by inserting a sharp point instrument into the tooth crown and comparing the control
radiograph with that of the intact tooth. After completion of the 6-day period and washing the samples for 4-6 hours under running water, dehydration process was accomplished using 100% ethyl alcohol (Ararat, Tehran) for 2 hours. Samples were then placed in methyl salicylate (Merck, Darmstadt, Germany) for another 2 hours for complete clearing and then evaluated under stereomicroscope (SZX-1LLB200, Olympus, Japan) at X16 magnification and 0.1 mm precision to determine the distance of apical constriction from the anatomical apex (Figure1).

Figure 1- Microscopic view of the maxillary second premolar apex (X16), apical constriction (AC), anatomic apex (AA) and apical foramen (AF)

In order to measure the distance of apical constriction from the radiographic apex, a #10 file (Dentsply Maillefer, Ballaigues, Switzerland) was inserted into each canal until the tip of the file was just seen at the apical constriction under aX16 stereomicroscope. The file was fixed in the canal by filling the coronal access with adhesive wax. All apices were covered with AH Plus sealer (Dentsply GmbH 78467, Konstanz, Germany) so that they would appear radiopaque on a radiograph. After completion of the sealer setting time, the teeth were radiographed directly from their buccal surface. We put a distance between the cone of X-ray unit and the film. If more than 1 canal was present, X-ray central beam would be aimed 20 degrees mesially. Primax RDX-58E (Primax, Berlin, Germany) E-Speed size 2 dental film and MYRAY UNTUS High Frequency (225 KHz) X-ray unit with x-ray tube length of 25 cm were used. The exposure settings were 0.6 mA and 60 kVp. After exposure, the radiographs were processed in an automatic processor with fresh processing solutions (Gendex Clarimat 300, England) in order to match the conditions for all samples. For each tooth, the vertical distance between the file tip and the center of radiographic apex was measured with a calibrated ruler with tenth of a millimeter precision. All phases were done by one clinician. Histologic findings were compared with radiographic results using reliability tests.

Results:

This study was performed on 36 single-canal and 14 two-rooted maxillary second premolars. The mean distance of apical constriction from the anatomic and radiographic apices was measured in millimeter (Table 1).

Table 1- The mean distance of apical constriction from the anatomic and radiographic apices of maxillary second premolars in mm

<table>
<thead>
<tr>
<th>Total mean</th>
<th>Two-rooted teeth (n=14)</th>
<th>Single canal teeth (n=36)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Palatal canal</td>
<td>Buccal canal</td>
</tr>
<tr>
<td>0.9</td>
<td>1 ± 0.26 0.6 1.33 1.1 ± 0.4 0.53 1.93</td>
<td>0.8 ± 0.2 0.53 1.46</td>
</tr>
</tbody>
</table>

Distance of apical constriction from the anatomic apex
Distance of apical constriction from the radiographic apex
The mean distance of apical constriction from the anatomic and radiographic apices in the single-canal maxillary second premolars was 0.8±0.2 and 0.9±0.1 mm, respectively. These rates were 1.1±0.4 and 0.3±0.3 mm, respectively in the buccal canal of two-rooted teeth and 1±0.26 and 1.2±0.3 mm in the palatal canal of two-rooted teeth, respectively. The total mean distance of apical constriction from the anatomic and radiographic apices in maxillary second premolars was 0.9 and 1.05 mm, respectively. When comparing the histological results with the radiography, Pearson’s correlation coefficient found a significant correlation between the two in terms of the distance of apical constriction from the anatomic and radiographic apices (P=0). Accuracy and validity of radiographic results indicated acceptable sensitivity, specificity, positive predictive value and negative predictive value of 87.8%, 88.8%, 93% and 62%, respectively. The likelihood ratio for positive and negative radiographic results was 7.9 and 0.1, respectively. The diagnostic odds ratio (true positive to false positive) for radiographic results was 57.6 which indicates the high accuracy and validity of radiographic results in determining the distance between apical constriction and anatomic apex.

Discussion:

Successful endodontic treatment requires complete knowledge about the anatomy and morphology of the teeth and root canals. Anatomy of the root canals and apex can be studied using various methods like the laboratory techniques i.e. injection of methylene blue (8), Black India ink (9), or Hematoxylin staining (10), metal or plastic casting (11), radiopaque gel infusion and radiography (12) and in-vitro root canal therapy. Tooth clearing technique is a precise method for this purpose which has complex laboratory phases. This method was also used by Vertucci et al, in 1984 (10) and has the advantage of thorough observation of canals, apical foramen and apical constriction using dye injection. Various studies have determined the distance of apical foramen from the anatomic apex in different teeth and especially maxillary premolars. In studies by Green in 1960 (3), Burch in 1972 (13), Arora in 2009 (14), and Martos in 2009 (15), this distance has been reported to be 2, 0.59, -2.91, 0.052 and 0.69 mm, respectively. Since during the endodontic treatment and perioperative radiographic assessments the reference point for measuring the working length is the apical constriction from one side and the radiographic apex from the other, it is necessary to determine the distance of apical constriction from the radiographic apex in order to achieve a complete endodontic treatment. The present study is among the few evaluating the distance of apical constriction from the anatomic and radiographic apices instead of the distance of apical foramen from the anatomic apex among the Iranian population. In this study, the mean distance between the apical constriction and the anatomic apex was 0.9 mm in maxillary second premolars which was in accord with Dummer study in 1984 (16) and different from the results obtained by some similar studies (3, 13, 15). Also, the mean distance of apical constriction from the radiographic apex was approximately 1 mm (1.05 mm) which was not in accord with Melius et al, finding in 2002. They calculated the distance of apical constriction from the anatomic apex using digital radiography and reported it to be 0.59 mm. They reported this rate to be 0.49 mm using conventional radiography (17). This difference can be due to the study design and method of evaluations or the race of the understudy population. Our study demonstrated a significant association between the distance of apical constriction from the anatomic apex and its distance from the radiographic apex. This furthers supports the use of radiography for determining the location of apical constriction.

Inserting a file at the apical constriction under the microscope and obtaining a radiograph resulted in a high precision in measuring the distance of apical constriction from the radiographic apex which is among the advantages and strength points of this study.

Conclusion:

Considering the study results regarding the distance of apical constriction from the anatomic and radiographic apices in maxillary second
premolars we can conclude that radiography has high accuracy in determining the position of apical constriction which is located in approximately 1mm distance from the anatomic apex. Endodontic treatments have a better prognosis when canal preparation and filling are terminated at the apical constriction. Therefore, it seems that the closest end point to the apical constriction would be at 1 mm distance from the radiographic apex in maxillary second premolars.

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References: