Determination and Comparison of Maxillary First Premolar Pulp Chamber Landmarks Using Radio-Visio Graph and Cone-Beam Computed Tomography

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Abstract

Background: Information regarding anatomic location and dimension of pulp space are essential before cavity preparation and endodontic access preparation. It may minimize unwanted damage to healthy pulp during cavity preparation and possible mishaps during access preparation. Cone-Beam Computed Tomography (CBCT) is a three-dimensional imaging technique and high precision measurements are made. Hence the aim of this study is to determine and compare the pulp chamber landmarks of maxillary first premolar using radio-visio graph (RVG) and CBCT. Materials and method: A total of fifty intact two-rooted maxillary first premolars were collected and numbered. RVG radiograph and CBCT scan of fifty teeth were done and divided into two groups; RVG Group: 50 RVG images and CBCT Group: 50 CBCT images. Marking of landmarks and measurement between landmarks was done using GendewxVixWin™ Platinum software for RVG and Planmeca Romexis software for CBCT. Six measurements were taken in millimeter (mm); Measurement “P”: cusp to roof; “Q”: cusp to floor; “R”: cusp to furcation; “S”: floor to furcation; “T”: roof to furcation; and “U”: height of pulp chamber. The data obtained was analyzed using SPSS version 17. Results: Average measurements of P, Q, R, S, T and U for RVG group are 7.06, 10.02, 13.96, 3.94, 6.90 and 2.95 respectively and for CBCT group are 6.95, 9.58, 14.03, 4.45, 7.07 and 2.63 respectively. Measurement Q and U are statistically significant between two groups with p value of 0.01 and 0.03 respectively. Conclusion: Measurements made by RVG are comparable to that of CBCT, and in clinical scenario RVG can be routinely used.

Key words: Access cavity, cone-beam computed tomography, maxillary first premolar, pulp chamber, radio-visio graph.

Introduction

The Dental pulp is a soft connective tissue enclosed within the pulp chamber and root canals. Maintaining pulp vitality is necessary for neural activity and repair.1 Therefore, during cavity preparation, utmost care has to be taken for preserving a healthy pulp and maintaining pulpal vitality.2 Knowledge about pulp chamber measurement and its position prevents unwanted damage to a healthy pulp.

Access cavity is the initial entrance prepared that leads into the root canals.3 Before commencing access cavity, a sound knowledge related to pulp chamber position and dimensions helps in conservative preparation, preserving tooth structure which increases the resistance form of the tooth.4 This also aids the operator in instrument choice, direction and extent of cutting which prevents iatrogenic damage.5

Digital intraoral radiographic method, using the Radiovisiography system (RVG), is popular nowadays and is the most widely used method. This is because...
of an instant generation of high-resolution digital images, alteration of the captured image using basic features such as magnification, brightness and contrast available in a system for enhanced diagnostic performance, lower radiation dose, transmission, distant consultation and digital record keeping. A RVG image is a two-dimensional image of a three-dimensional object. The limitations of a two-dimensional image include enlargement, distortion, overlapping and misrepresentation of structures. The measurements taken from an RVG image varies considerably and may result in compromised access cavity preparation with iatrogenic damages. The Cone Beam Computed Tomography (CBCT) is a diagnostic imaging tool that provides a high-quality, accurate three-dimensional (3D) image. The clinical measurements taken from CBCT are highly accurate and reliable. It can greatly enhance the diagnosis and treatment planning of a variety of endodontic cases and may minimize mishaps during the access cavity preparation.

Though CBCT is the most significant advances in dentistry, it is not routinely used in everyday clinical practice. RVG remains the option as it has a low radiation dose and is cost-effective. The purpose of this in-vitro analysis is to determine the pulp chamber landmarks of maxillary first premolar using RVG and compare it with CBCT.

**Method:**
This study was conducted in the Department of Conservative Dentistry and Endodontics, People’s Dental College and Hospital, Kathmandu, from September 2016 to August 2017. Ethical clearance was taken from Institutional Review Board, Institute of Medicine, Tribhuvan University before conducting the study. A total of fifty maxillary first premolar teeth that were extracted for orthodontic reason were collected from the Department of Surgery, People’s Dental Hospital. A verbal consent was taken from the patients, regarding the utilization of their extracted tooth for research purposes.

![Exposure using RVG](image1)

The chosen teeth were mature, caries free teeth with two roots and intact cusps, without attrition and prosthesis. Those teeth were rinsed, cleaned with an ultrasonic scaler, and kept in a 10% formalin solution for seven days for disinfection. The teeth were stored in distilled water until use. To identify the teeth, each tooth was assigned a number. A number was written on the palatal surface of the crown of each tooth by using a permanent marker, from 1 to 50.

![Placement of teeth in Wax Rim; Scanning with CBCT](image2)

Cold cure acrylic blocks were used to stabilize the Rinn Endo Ray (EndoRay® II Film holder DENTSPLY), in such a way that, its arm was parallel to the floor. The tooth holder was made using two acrylic plates, separated from each other by five millimeters. Each tooth was placed in the space between the tooth holding two acrylic plates, in such a way that the proximal surface of tooth...
was in contact with the acrylic plates and the root apices were in contact with the acrylic block base. The RVG sensor was placed in a sensor holder of the Rinn Endo Ray in close contact with the acrylic plate. The tooth was then moved using a tweezer to align its long axis parallel to the RVG sensor.

An x-ray generator (Gendex 765DC Intra Oral X-Ray), operated at 65 kVp and 7 mA, was used to expose the tooth using a number 2-size digital sensor (GXS-700). The exposures were made with a focus-detector distance of thirty centimeter and an exposure time of 0.08 seconds (Figure 1). Each image was numbered and stored. The RVG images were named as RVG group.

Two horseshoe shaped wax rims were made measuring 23 centimeter length, 1 centimeter breadth and 2 centimeter height with modelling wax. Twenty five teeth, separated from each other by at least two millimeters, were placed in each wax rim by embedding the root portion (Figure 2A). The first wax rim had 1st to 25th numbered teeth and the second rim had 26th to 50th numbered teeth.

A metal stapler pin was inserted to one end of the wax rim, fifty millimeters away from the tooth. Both wax rims were kept on a bite mount of CBCT (Planmeca ProMax 3D Classic), in such a way that the second rim was over the first rim. The CBCT scan was performed using Planmeca ProMax 3D CBCT.

The machine performed scan at 90 kV voltage, 14 mA current, 200 µm voxel size and 90 * 150 mm field of view (Figure 2B). 3D digital scan was stored. Planmeca Romexis software was used to display the CBCT scan in the computer. Each image of fifty teeth was identified and numbered. The CBCT images were named CBCT group.

The labeling of four landmarks, X1, X2, X3 and X4, were done in image of both groups. The landmarks X1, X2, X3 and X4 were the mid-point of a line.

\[ P = X_1 \text{ to } X_2 \]
\[ S = R - Q \text{ (} X_3 \text{ to } X_4 \text{)} \]
\[ Q = X_1 \text{ to } X_3 \]
\[ T = R - P \text{ (} X_2 \text{ to } X_4 \text{)} \]
\[ R = X_1 \text{ to } X_4 \]
\[ U = Q - P \text{ (} X_2 \text{ to } X_3 \text{)} \]

Table 1 - Comparison of the morphological measurements from RVG and CBCT

<table>
<thead>
<tr>
<th>Measurements</th>
<th>RVG (mean ± sd)</th>
<th>CBCT (mean ± sd)</th>
<th>Mean diff.</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-point of line connecting two cusp tips to pulp chamber roof (P)</td>
<td>7.06 ± 0.64</td>
<td>6.95 ± 0.64</td>
<td>-0.112</td>
<td>0.387</td>
</tr>
<tr>
<td>Mid-point of line connecting two cusp tips to pulp chamber floor (Q)</td>
<td>10.02 ± 0.95</td>
<td>9.58 ± 0.84</td>
<td>-0.439</td>
<td>0.01*</td>
</tr>
<tr>
<td>Mid-point of line connecting two cusp tips to the furcation (R)</td>
<td>13.96 ± 1.58</td>
<td>14.03 ± 1.44</td>
<td>0.062</td>
<td>0.838</td>
</tr>
<tr>
<td>Floor of pulp chamber to furcation(S)</td>
<td>3.94 ± 1.78</td>
<td>4.45 ± 1.64</td>
<td>0.501</td>
<td>0.148</td>
</tr>
<tr>
<td>Roof of pulp chamber to furcation(T)</td>
<td>6.90 ± 1.58</td>
<td>7.07 ± 1.44</td>
<td>0.174</td>
<td>0.567</td>
</tr>
<tr>
<td>Height of pulp chamber (U)</td>
<td>2.95 ± 0.77</td>
<td>2.63 ± 0.75</td>
<td>-0.327</td>
<td>0.05*</td>
</tr>
</tbody>
</table>

*statistically significant.
connecting two cusp tips, lowest point on roof of the pulp chamber, highest point on floor of the pulp chamber and the point of complete separation at furcation respectively. Four flat parallel lines were drawn from each landmark. The six measurements termed as P, Q, R, S, T and U was made between these lines. The measurements were made in millimeters (mm). The measurements P, Q, R, S, T and U are the distance between X1 to X2, X1 to X3, X1 to X4, X3 to X4, X2 to X4 and X2 to X3, respectively (Figure. 3A).

The data was entered and coded using Microsoft excel. The data was then exported to Statistical Package for Social Sciences (SPSS) version 17.0 for statistical analysis. The various anatomic landmarks of the premolars were summarized with the help of descriptive statistics like mean, standard deviation. The mean difference in measurements between RVG and CBCT was compared using independent t-test. The level of significance was set at 5%.

**Result**

The average measurement of P, Q, R, S, T and U obtained from RVG group image was 7.06 ± 0.64 mm, 10.02 ± 0.95 mm, 13.96 ± 1.58 mm, 3.94 ± 1.78 mm, 6.90 ± 1.58 mm and 2.95 ± 0.77 mm, respectively. (Table 1)

The average measurement of P, Q, R, S, T and U obtained from CBCT group image was 6.95 ± 0.64 mm, 9.58 ± 0.84 mm, 14.03 ± 1.44 mm, 4.45 ± 1.64 mm, 7.07 ± 1.44 mm and 2.63 ± 0.75 mm, respectively. (Table 1)

The mean values of measurement Q and U obtained from RVG was longer than CBCT. This result was significant with p value of 0.01 and 0.03, respectively. (Table 1)

**Discussion**

Knowledge and information regarding pulp chamber anatomy and the measurement related to it, such as depth and width is indispensable before commencing endodontic treatment so as to prevent undesirable mishaps during an endodontic access cavity preparation. The literature review shows the use of sectioning method, intra-oral periapical radiograph, bite wing radiograph and CBCT to measure anatomic landmarks of pulp chamber. Also, there are very few studies related to maxillary first premolar pulp chamber landmarks measurement. Only one study has been done in Nepal so far by Joshi N et al. Hence, the present study was conducted to determine and compare the measurements of maxillary first premolar pulp chamber landmarks using RVG and CBCT.

Both RVG and CBCT are digital radiographic technique. RVG was used to obtain high-resolution, two-dimensional magnified images. This image can be further enhanced by using the brightness and contrast feature. This helped in better selection and pointing of the landmark. CBCT is a three-dimensional imaging technique which allowed selecting a specific plane for measurement. Moreover, CBCT provides highly accurate anatomic information, which makes the measurement more precise, accurate and realistic. Cavity preparation in deep caries is challenging, as we have to remove caries without altering the healthy pulp located within the pulp chamber. Complete caries excavation depends on its extension and is guided by internal pulp chamber. Also, in endodontic access cavity preparation, internal anatomy of the pulp chamber dictates the external outline of access cavity. The periphery of the internal pulp chamber is the landmark that needs to be identified before commencing treatment. This prevents unwanted damage to the healthy pulp during cavity preparation and prevents access related mishaps like gouging, perforation during access cavity preparation. Therefore, the landmarks in present study included midpoint of line connecting two cusp tips (X1), lowest point on roof of the pulp chamber (X2), highest point on floor of the pulp chamber (X3), and complete separation at furcation (X4). These landmarks selection was in accordance to the similar study done by Deutsch et al. In another study done by Venkateshbabu N et al., landmarks selected for measurements in maxillary furcated bicuspids were buccal cusp tip, roof and floor of the pulp chamber and complete separation at furcation.

Before exposure of samples with RVG, Endo Ray was stabilized and tooth holder was fabricated. Blocks
of cold cure acrylic resin were used to stabilize the Rinn Endo Ray, and to make its arm parallel to the floor. The paralleling principle reproduces the total length of the tooth more accurately, without any distortion. The average mesio-distal width of maxillary first premolar is seven millimeters. So, the tooth holding acrylic plates were separated from each other by five millimeters. This made the tooth to be held firmly mesiodistally in between the acrylic plates without any movement. All the parameter for taking the RVG was made constant to produce images of the same quality. The exposure of the tooth was done in a proximal (mesio-distal) view, which displayed two cusp tips and the furcation area in a single image. As the present analysis is in-vitro, a proximal view was chosen. Although this view is not feasible in clinical scenario, it best enabled landmarks selection and making direct measurements between these landmarks.

For CBCT scan, two wax rims were made to mount all the teeth, so that all the teeth were scanned in a single exposure. Metal stapler pin was inserted in a wax rim, fifty millimeters away from tooth for identifying the tooth placement sequence without producing artifact and affecting image quality. Study by Nardi C et al., has found no metal artifacts in CBCT scan when the metal was placed five centimeters away from the site of interest.

In the present study, the CBCT section for measurement was selected in accordance to the study done by Azim et al. The measurements were made in the coronal section as it displayed both the cusp tips and the furcation area. The best coronal section was selected by adjusting the axial and sagittal views. Moving the axial view corono-apically and apico-coronally, the desired landmarks were selected accurately.

The findings of present study for the measurement of P and U, either from RVG or CBCT, are consistent with the findings of Venkateshbabu N et al. and Deutch et al. In contrast, measurement of R, S and T, either from RVG or CBCT, are longer than the findings of Venkateshbabu N et al., and Deutch et al.

Comparing the results of the RVG digital image from present study with the result of Deutch et al., measurement P, R, S, T and U appeared to be 0.12 mm, 2.41 mm, 2.09 mm, 2.29 mm and 0.19 mm longer, respectively. Comparing the results of CBCT digital image from present study with the result of Deutch et al., measurement P, R, S and T appeared to be 0.01 mm, 2.48 mm, 2.6 mm and 2.46 mm longer, respectively and measurement U appeared to be 0.13 mm shorter. This difference may be due to the difference in study population race since the study conducted by Deutch et al. was in a Tennessee population, whereas the present study was done in a Nepalese population.

Comparing the results of the RVG digital image from the present study with the result of Venkateshbabu N et al., measurement P, R, S, T and U appeared to be 0.13 mm, 2.37 mm, 2.15 mm, 2.24 mm and 0.68 mm longer, respectively. Comparing the results of the CBCT digital image from present study with the result of Venkateshbabu N et al., measurement P, R, S, T and U appeared to be 0.02 mm, 2.44 mm, 2.66 mm, 2.41 mm and 0.36 mm longer, respectively. This difference may be due to the difference in landmark selection.

On comparing the measurements made by RVG and CBCT, measurements P, R, S and T showed statistically non-significant and comparable mean measurement, whereas measurements Q and U showed significantly longer measurement made by RVG when compared to CBCT. There is a possibility to have difference in the measurement taken from an RVG radiograph image and the anatomic measurement because of the limitations of a two-dimensional image.

**Conclusion**

Since the majority of measurements made by RVG and CBCT are comparable, it can be concluded that RVG is a reliable method for measuring the maxillary first premolar pulp chamber landmarks. In clinical practice, the bur marked approximately at ten millimeters will lessen damage to the pulpal floor and in case of calcification, marking the bur less than fourteen millimeters will reduce the possibility of perforation into the furcation.
References