Endodontic Working Length of Upper Premolars in a Sri Lankan Population

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Abstract— In order to achieve a successful endodontic treatment knowledge of the exact root canal length is of paramount importance. Although premolars are at a high risk of caries there is minimal research done on the working lengths of premolars. The study aimed to estimate the average endodontic working length of upper premolars in Sri Lankan patients in the context of no previous studies done in Sri Lanka. This was a cross-sectional study on 240 maxillary premolars in 208 patients, who attended the Restorative Unit B, in the Institute of Oral Health, Maharagama. The working lengths were assessed with the combination of the radiographical method and by using the apex locator. The results were presented using descriptive statistical measures. The majority of the study sample was 2nd premolars (136, 57%). Furthermore, the majority of maxillary premolars had two canals (214, 89.1%). The mean working length for 1st maxillary premolars is 19.74 (SD= 1.29). The 2nd premolar with 2 canals has a mean working length of 20.43 (SD=1.75), whereas the 2nd premolar with 1 canal has a mean working length of 20.07 (SD= 1.41). These findings could be considered as the baseline and carry out similar studies more comprehensively in other populations.

Keywords— Working lengths, Pre molars, Apex locator, Endodontic treatment.

I. INTRODUCTION

The importance of the exact location of the physiological apex of root canal cannot be neglected in order to achieve a successful endodontic treatment [1]. When the working length is not achieved properly and overfilling takes place, which will cause postoperative pain and also delay the healing [2]. Moreover, when a working length is established short, it may lead to insufficient debridement and also under filling of the canal which cause re-infection and pain [2]. This has been further supported by the study conducted by Sjogren and colleagues, who concluded that the root canal system must be filled completely in an attempt to prevent re-infection [3].

The working length could be defined as the distance from a coronal reference point to the point at which canal preparation and obturation should terminate [1]. Theoretically, the root canal terminus is considered to be the cemento-dentinal junction. However, this land mark cannot be detected clinically. For this reason, the minor foramen/ the apical constriction is used as the canal terminus. The average distance from the apical foramen to the apical constriction varies depending on the age. It is approximately 0.52 mm in young age groups and 0.65 mm in older age groups [4]. Furthermore, the apical foramen does not coincide with the anatomical root apex. It exists within 0.5 mm and 1.0 mm from the anatomical apex.

There are various methods to measure the working length out of which the most traditional is the radiographical method [5]. Most studies have been conducted on extracted teeth or radiographs [6]. Few other studies have used CBCT to measure root canal length [7]. Furthermore, a recent approach is using of electronic instruments like the apex locator which is widely used in endodontic practices today [8]. There are many studies which have shown the reliability of the apex locator over the radiographic methods [9]. When considering the vulnerability of teeth for caries, several studies show that molars are at the highest risk of getting caries [10]. Although there is minimal research done on the caries vulnerability of premolars, due to the close location of premolars to the molars, high caries presentation of premolars has been observed [11].

There are not many recent studies done on determining the working length of premolars per se. A study conducted by Black in 1897 which was one of the very 1st studies showed that lengths for maxillary first premolar and second premolar be 21 mm and 21.5 mm respectively in Caucasian populations [12]. Table 1 shows a summary of the findings of some studies conducted to explore the working lengths of premolars.

TABLE 1: Average working lengths of premolars from different studies

Tooth	Black (1897)	Grossman (1970)	Bjorndal et al. (1974)
First Premolar	21.0 mm	20.5 mm	22.3 mm
Second Premolar	21.0 mm	21.5 mm	22.3 mm

Furthermore, many morphological studies have found that maxillary first premolar teeth are either single-rooted, containing one or two canals, or double-rooted, with one canal in each root [13] [14]. The reported incidence of a single canal is low [15]. Although it is rare, several studies have also shown that the maxillary first premolar to has three canals ranging from 0.5% to 6% of the cases [16]. Some authors have reported the presence of two canals in 98.5% of cases while others find the incidence to be as low as 68.8% [17].

There are minimal studies done in this arena in Sri Lanka. A study was conducted by Peiris in 2008 to explore the root and canal morphology of Sri Lankan and Japanese permanent dentition. Two thousand Sri Lankan and 976 Japanese

permanent teeth were examined. The number of roots in premolars and molars was recorded [18].

This chapter appreciated the importance of knowing the correct root canal length to carry out a successful endodontic treatment on teeth including premolars. Moreover, it was realized that the available research in this arena with regard to premolars is minimal. Therefore, the objective of this study was to estimate the average endodontic working length of upper premolars in patients who attended one of the dental tertiary care units in Sri Lanka.

II. MATERIALS AND METHODS

Study Design

A cross-sectional study

Study setting

Restorative Unit B in Institute of Oral Health, Maharagama

Study Participants

Patients who attended the above study setting who were indicated for root canal treatment of upper premolars by the Consultant in Restorative Dentistry

Inclusion Criteria - Age range between 18-40 years
- Teeth with completely formed apices
- Teeth that have not been previously root treated
- Teeth without hypercementosis
- Teeth without root resorption and root fractures

Exclusion Criteria - Grossly broken teeth without an intact buccal cusp
- Teeth with occlusal wear/ fixed prosthesis/ restorations on the buccal cusp
- Teeth in which the apical third of the root canal could not be negotiated
- Pregnant patients
- Patients with cardiac pacemakers

Sampling Technique

Consecutive sampling technique

Sampling size

240 maxillary premolars in 208 patients

Data Collection

Data collection was carried out by the same dental doctor on all patients. The patients who were eligible were given the information sheet and informed consent was taken for the study. The selected tooth was anesthetized and isolated with a rubber dam. The endodontic access cavity was prepared. The pulp tissue was removed using either barbed broaches or a size 20 Hedstrom file (H- File). The root canals were irrigated copiously with 2.5% Sodium Hypochlorite. The excess irrigating solution was absorbed from the pulp chamber with a sterile cotton pellet and paper points were used to dry the canals.

The number of canals present for each premolar was recorded. The measurements were first achieved with an electronic apex locator. e buccal cusp tip was taken as the reference point in each instance. The measurements were taken with a standard size 15 or 20 K file, depending on the width of the root canal. The lip clip was attached to the patient's lip and the file holder was used to hold the hand file at the shaft. The file was advanced apically until the beeping sound was heard and the light emitting diode marked the "APEX" on the screen of the apex locator began to glow, indicating the tip of the file had reached the apex. Then the file was withdrawn with a slow counterclockwise turn until the reading on the screen showed 0.5. The silicon rubber stop in the endodontic file was adjusted to the reference point (buccal cusp tip) and the file was taken out. The distance between the rubber stop and the tip of the file was measured to the nearest 0.5 mm using the same graduated metal scale. Measurements were recorded in millimeters and registered as electronic apex locator readings.

Then the working lengths were radiographically verified using a 15/20 K-file at the determined length. Peri-apical radiograph with the paralleling technique was performed using E-speed films. In instances where there were multiple root canals two different sizes of K-files were placed within the root canals, or a K-file along with an H-file was used in order to differentiate the 2 files in the radiograph. The exposure factors, and the distance between the x-ray source and the film were standardized. The paralleling technique was used with a standard holder thus the film was positioned parallel to the long axis of the tooth.

Any apex locator reading within 1.0 mm of the radiographically assessed length, was regarded as a reliable initial working length. If the difference was more than 1 mm in the radiograph, the radiographic tooth length and the file length measurements were taken. Same measuring device was used for this purpose and the measurements were recorded in millimeters up to the nearest 0.5 mm. Then the root canal length was calculated using the below mentioned mathematical formula

$$\text{Working length} = \frac{\text{Inserted file length}}{\text{Radiographic file length}} \times \text{Radiographic tooth length}$$

When the difference between the calculated length and the apex locator reading was more than 3 mm, the radiograph was repeated at the calculated working length. After verifying the working length this was properly recorded in the data collection sheet.

Data Analysis

Data were entered and analyzed using the Statistical Package for Social Sciences (SPSS) version 16.0. The separate average working length values were calculated for each maxillary premolar, for individual canals of both premolars (buccal and palatal canals) and for premolars with single canals. The results were presented using descriptive statistical measures (mean, maximum, minimum, median value and mode).

Ethical Consideration

Patient's written consent was taken after providing an information sheet and a consent form. In addition the purpose

of the study was explained in simple terms to the patient prior to getting their consent. Furthermore, ethical approval was obtained from the Ethics Review Committee of Faculty of Medicine, University of Colombo.

III. RESULTS

There were 208 study participants, out of which majority (172, 71.7%) were females and 68 (28.3%) patients were males. The selected basic description about the premolars in the study is presented in table 2.

TABLE 2: The selected basic description about the premolar teeth in the study

Name of the premolar	Number (%)	No. of canals	
		1 canal	2 canals
1st premolar	104 (43%)	0	104(100%)
2nd premolar	136 (57%)	26 (19.1%)	110 (80.8%)
Total	240 (100%)	26 (10.8%)	214 (89.1%)

Table 2 depicts that the majority of the study sample was 2nd premolars (136, 57%). Furthermore, the majority of maxillary premolars had two canals (214, 89.1%).

The endodontic working length of the maxillary premolars, for each tooth separately is given in Table 3.

TABLE 3: The Average working length values for maxillary premolars

Tooth	Total number of root canals	Mean (mm)	Standard deviation
1st Premolar (104)	208	19.74	1.29
2nd Premolar with 2 canals (110)	220	20.43	1.75
2nd Premolar with 1 canal (26)	26	20.07	1.41

According to Table 3 the mean working length for 1st maxillary pre molars is 19.74 (SD= 1.29). The 2nd premolar with 2 canals has a mean working length of 20.43 (SD=1.75), whereas the 2nd premolar with 1 canal has a mean working length of 20.07 (SD= 1.41).

The working length values for individual root canals of each maxillary premolar is given in Table 4.

TABLE 4: Average working length values for individual canals for each premolar

Tooth	Canal	No of canals	Mean (mm)	Standard deviation
1st Premolar (104)	Buccal	104	19.57	1.39
	Palatal	104	19.91	1.48
2nd Premolar (110)	Buccal	110	20.32	1.84
	Palatal	110	20.52	1.76

The table 4 depicts mean root canal length in buccal canals of the maxillary 1st premolars as 19.57mm (SD= 1.39) and the palatal canals measured on average 19.91mm (SD=1.48). The mean root canal lengths in buccal canals of maxillary 2nd premolars were 20.32mm (SD= 1.84) and palatal canals were 20.52 mm (SD=1.76). Moreover, the median values were also higher for both palatal and buccal canals of 2nd premolars than for first premolars.

IV. DISCUSSION

Summary of Findings

Out of the total of 208 study participants, the majority (172, 71.7%) were females and 68 (28.3%) patients were males. The majority of the study sample was 2nd premolars (136, 57%). Furthermore, the majority of maxillary premolars had two canals (214, 89.1%). The mean working length for 1st maxillary premolars is 19.74 (SD= 1.29). The 2nd premolar with 2 canals has a mean working length of 20.43 (SD=1.75), whereas the 2nd premolar with 1 canal has a mean working length of 20.07 (SD= 1.41). The mean root canal length in buccal canals of the maxillary 1st premolars is 19.57mm (SD= 1.39) and the palatal canals measured on average 19.91mm (SD=1.48). The mean root canal lengths in buccal canals of maxillary 2nd premolars were 20.32mm (SD= 1.84) and palatal canals were 20.52 mm (SD=1.76). Similarly, the median values were also higher for both palatal and buccal canals of 2nd premolars than for the first premolars.

Method

Since there was no study done in Sri Lanka of this nature selecting a descriptive study design is most appropriate. Furthermore, the selection of the premolar tooth for the study is well justified through the study conducted by Loto in 1998 where the mere fact that the premolars are situated near molars that are at the highest risk of caries increases the susceptibility of premolars for caries[11].

There are several reasons for the design of an in vivo study in this research. It is difficult to find an adequate number of teeth if extracted teeth were to be used. On the other hand, the data acquired from extracted teeth or methods using radiographic pictures can be useful for studies on anatomical form, size and root length, but it is not useful to decide the length of instrumentation during endodontic treatment in the actual clinical scenario. The main purpose of this study was to measure the endodontic working lengths and not the lengths of teeth hence an in vivo study was designed.

The usage of a combination method of the traditional radiographic method and the apex locator method is a strength of this study. The radiographic method is usually employed to determine the working length of the root canal. Abbot has highlighted that radiographs can be inaccurate because of the morphological variations of root canal systems [19]. Furthermore, the anatomical root apex does not always coincide with the canal terminus [20]. The usage of combination methods to measure working lengths has been recommended by Simon and his colleagues [21]. Furthermore, using only one operator for the study is a strength of this study since the inter-operator bias is not present.

While measuring the working lengths all attempts were made to minimize bias. The paralleling technique was engaged using holders to minimize the errors due to variations in the angulations of the X-ray beam. The aim of all working length determination techniques is the correct measurement from the file tip to the coronal landmark. Weiger et al. recommended that a definite coronal reference point should be determined/ prepared and suggested the use of stable silicone stops in taking a mean of repeated measurements [22]. As the buccal cusps of premolars were taken as the reference point and teeth with no intact buccal cusps were not taken to the study. Furthermore, teeth with occlusal wear, and buccal restorations

were also excluded. The teeth with metallic restorations were excluded as electronic apex locators give erroneous values when in contact with metallic objects. The present study is based on electronic apex locators, and radiographs were an in vivo study different to previous studies. This may also have contributed to the differences in average working length values between the present study and the published data.

Results

Out of the minimal literature available the studies on the Caucasian population have reported average working lengths of maxillary first premolar and second premolar to be 21 mm and 21.5 mm respectively. These are higher than the current study findings [12]. Although people in this part of the world are regarded as a Caucasian population, greater physical differences exist between the two groups. According to the present study, the average working length of the maxillary first premolar was 19.7 mm and the average working length of the maxillary second premolar was 20.4 mm. Although these values were numerically lesser than their recognized Caucasian counterparts, they were in close approximation to those in previous studies (Table 1). It should, however, be noted that Weine (1976) published the data for average tooth lengths in North Americans measured using the radiographic method, which is usually an overestimation of the actual working length[23]. The present study is based on electronic apex locators, and radiographs was in vivo study different from previous studies. This may also have contributed to the differences in average working length values between the present study and the published data.

Although a difference between the lengths of buccal and palatal canals was observed in multi-rooted teeth, the mean root lengths showed that this difference was very little between the roots of the same tooth. This is in agreement with the reviewed literature which reports that both buccal and palatal canals of premolar teeth most often are of the same length [24].

Present study findings are more or less closer to those as all the first premolars had two root canals. The presence of 2 canals in the non-Caucasian populations showed different values like 87% in the mongoloid, and a range of 79-92% in Caucasoid origin [25]. First premolar teeth with single canals or three root canals could not be found within the study sample.

The present study's second premolars had two canals in 88.88% of the cases. This is at variance with the studies of Green and Vertucci et al in which the maxillary second premolars were reported to have one canal in 72% and 75% of cases respectively [26] [27]. However, it is in support of an earlier study of Chima and Percora in which maxillary second premolars had two root canals in 71.5% and 67% of maxillary second premolars to be 58.6% and the incidence of single canals to be 40.3% [28] [29]. Although it is very rare in 1% of cases maxillary second premolars are found to have three canals [30].

The study finding are also in consistent with the findings of Peiris in 2008, who reported that Sri Lankan maxillary first and second premolars displayed a higher incidence of two root canals [18]. Not a single maxillary second premolar with three root canals was found in the selected study sample. These differences in study findings are mainly due to the heterogeneity in conducting the studies.

The inevitable limitations of this study could be mentioned as, since the study had only one operator there could be humane errors caused due to fatigueness. Moreover any measurement bias that could have been created when measuring the root lengths have not been accounted for.

V. CONCLUSIONS

The following conclusions were achieved based on the findings and analysis

1. The average endodontic working length of upper first premolar was 19.7mm (SD= 1.29). All upper first premolars used in the study were having 2 canals.

2. The average endodontic working length of upper second premolar with two canals was 20.4 mm (SD= 1.75).

3. The average endodontic working length of upper second premolar with a single canal was 20.07mm (SD= 1.41).

4. The mean length of buccal canals of upper first premolars was 19.57 mm (SD= 1.39).

5. The mean length of palatal canals of upper first premolars was 19.91 mm (SD= 1.48).

6. The mean length of buccal canal of upper second premolar was 20.31 mm (SD=1.84)

7. The mean length of palatal canal of upper second premolar was 20.51 mm (SD = 1.75).

Recommendations

Being the 1st study on Sri Lankan population, it is recommended to consider these findings as the baseline and carry out similar studies more comprehensively in other populations.

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