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An *in vitro* study to predict effect of root canal curvature on accuracy of apex locator

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Abstract
Background: Inaccuracy in determining and maintaining working length (WL) may result in length being too long leading to apical perforation The present study was conducted to predict effect of root canal curvature on accuracy of apex locator
Materials & Methods: The present study was conducted on 90 mandibular molar teeth of either gender. The degree of root canal curvature was determined by Schneider's method. Samples were divided into three groups. Group I were with mild canal curvature (< 20°), group II were moderate canal curvature (20-36°) and group III were severe canal curvature (>36°).
The actual root canal length was determined using a no. 8 or no. 10 file into the canal until the tip of the file emerged through the major apical foramen. Differences between EWL and AWL were calculated.
Results: Group I teeth were with root curvature < 20°, group II with 20-36° and group III with >36°. Maximum difference was observed in group III, followed by group II and group I. In group I, the difference was 0.178±0.14 mm, in group II was 0.20±0.22 mm and in group III was 0.24±0.24 mm. The difference was significant (P<0.05).
Conclusion: Curvature of the canal has a small but significant contribution on the accuracy of the EAL tested.

Keywords: Apex locator, canal curvature, working length

Introduction
An ideal root canal treatment should be limited to the root canal system. Any procedure beyond or less than this point may increase the risk of treatment failure.
As a result, working length (WL) determination is a crucial factor in successful root canal therapy. The apical constriction (AC) is suggested as the end-point of root canal treatment [1, 2]. This anatomical landmark is a point where pulpal and periodontal tissues reach together and is identified as minor apical foramen. It is generally accepted to be located at 0.5-1 mm coronal to the radiographic apex. Failure to accurately determine and maintain working length (WL) may result in length being too long leading to apical perforation, overfilling or overextension and increased post-operative pain with prolonged healing period and a lower success rate.[1] A WL too short of the apical constriction can lead to incomplete cleaning and under filling causing persistent discomfort, and continued periradicular infection. The apical constriction (AC) is suggested as the end-point of root canal treatment [2]. This anatomical landmark is a point where pulpal and periodontal tissues reach together and is identified as minor apical foramen. It is generally accepted to be located at 0.5-1 mm coronal to the radiographic apex. AC might be located on one side of root at a distance up to 3 mm from the anatomical apex. Moreover, the position and topography of minor foramen varies between teeth, making it difficult to determine clinically [2].
Electronic foramen locators (EFLs) were designed to overcome the limitations of radiographs. Electronic apex locators have been used clinically for over 30 years as an aid in deciding where canal preparation and obturation should terminate. Suzuki[3] in 1942 first studied the flow of current through teeth. He found that a constant electric resistance was obtained between an electrode attached to a root canal instrument and one applied to the oral mucous membrane. In 1962, Sunada[4] determined this constant electrical resistance to be 6.5 kilo ohms and stated that it is possible to use this value of resistance in the estimation of root canal length. The present study was conducted to predict effect of root canal curvature on accuracy of apex locator.

Materials & Methods

The present study was conducted in the department of Endodontics. It comprised of 90 mandibular molar teeth of either gender. The study protocol was approved from institutional ethical committee.

Working length was determined using no.10 K file which was inserted into the mesio-buccal canal of each tooth and IOPAR was taken. The degree of root canal curvature was determined by Schneider's method. Samples were divided into three groups.

Group I: mild canal curvature (< 20°),
Group II: moderate canal curvature (20-36°) and
Group III: severe canal curvature (>36°).

The actual root canal length was determined using a no. 8 or no. 10 file into the canal until the tip of the file emerged through the major apical foramen. The stopper was adjusted to correspond to the flat reference surface. A digital caliper was used to measure the length between the stopper and the tip of the file to the nearest of 0.01 mm. This was taken as the actual working length (AWL). The file clip of apex locator was attached to the file and the file inserted until the "Apex" reading was reached in Root ZX. This was the electronic working length (EWL). Differences between EWL and AWL were calculated. Positive values indicated measurements that were long of the apical foramen, negative values indicated measurements that were short of the apical foramen and 0.0 values were considered coinciding measurements. The collected data was analyzed by Kruskal-Wallis test followed by Mann-Whitney test.

Results

Table 1: Distribution of teeth

Groups	Group I	Group II	Group III
Root curvature	< 20°	20-36°	>36°
Number	30	30	30

Table 1 shows that group I teeth were with root curvature < 20°, group II with 20-36° and group III with >36°.

Table 2: Number of canals showing difference between AWL and EWL

Difference	Group I	Group II	Group III
>1	0	0	0
0.5-1	1	1	1
0.01-0.5	5	2	2
0	0	0	0
−0.5-−0.01	12	14	15
−1-0.5	1	2	2
−1	1	0	0

Table 2 shows that maximum difference was observed in group III, followed by group II and group I.

Table 3: Comparison of difference between groups

Groups	Mean± S.D.	P value
Group I	0.178±0.14	0.01
Group II	0.20±0.22	
Group III	0.24±0.24	

Table 3, shows that in group I, the difference was 0.178±0.14 mm, in group II was 0.20±0.22 mm and in group III was 0.24±0.24 mm. The difference was significant (P< 0.05).

Discussion

Radiographs have been useful for determining the working length for many years but the studies on the apical root morphology show that radiographic interpretation alone cannot be relied upon to establish the working length accurately. Electronic foramen locators (EFLs) were designed to overcome the limitations of radiographs. Initial devices determined WL by calculating electrical resistance between the periodontal ligament and oral mucosa, which is the constant value of 6.5 k7 [5]. The first EFLs did not exhibit sufficient accuracy for measuring the WL and were influenced by various root canal irrigation solutions [6]. The subsequent EFLs have overcome this problem and are capable of measuring the canal length in the presence of electrolytes. The Root ZX measures the impedance ratio of two different frequencies (0.4 and 8 kHz) for determining the tip of the file in the canal, regardless of the type of electrolyte, and requires no calibration [7]. The accuracy of this device between the *in vivo* and *in vitro* models is not different. The development of EAL has helped in making the assessment of working length more accurate and predictable [8].

The present study was conducted to predict effect of root canal curvature on accuracy of apex locator.

In present study, we included 90 mandibular molars. Group I teeth were with root curvature < 20°, group II with 20-36° and group III with >36°. Santosh *et al*. [9] conducted a study on sixty mandibular posterior teeth were decoronated. A number (No.) 10 file was inserted into the mesiobuccal canal and radiographs were taken to determine the degree of curvature by Schneider's method. Samples were divided into three groups of mild (<20º), moderate (20-36º) and severe curvature (>36º). After enlarging the orifice, the actual canal length was determined by introducing a file until the tip emerged through the major foramen when observed under 20X magnification. The teeth were embedded in an alginate model and the Root ZX was used to determine the electronic length. The difference in measurement of Actual and Electronic working length was statistically significant between group 1 and 2 (P<0.05) as well as between group 1 and group 3 (P<0.05) with group 1 showing the lowest difference.

Present study revealed that maximum difference in AWL and EWL was observed in group III, followed by group II and group I. Table 3, shows that in group I, the difference was 0.178±0.14 mm, in group II was 0.20±0.22 mm and in group III was 0.24±0.24 mm. The difference was significant (P<0.05). Saatchi *et al*. [10] in their study, one hundred and ten extracted mandibular molars were selected. Access cavity was prepared and coronal enlargement of mesiobuccal canal was performed. A #10 Flexofile was inserted into the mesiobuccal canal, and a radiography was taken to measure the degree of curvature by Schneider's method. The accuracy of Root ZX within ±0.1 mm and ±0.5 mm was 38.2% and 94.6%, respectively. There was no correlation between the distance from the EWL to the AWL and the degree of root canal curvature.

Till date only few studies had been published who took curvature into consideration as an influencing factor and found that there was a significant difference between electronic and actual canal lengths for curved canals which was in accordance with the present study. The greater inaccuracy of EAL in the study could be due to the use of Raypex 5 apex locator which is considered as the fourth generation EAL and Root ZX has been proven to be more accurate than Raypex 5 [6, 11].

Conclusion

Apex locator found to be more accurate for the mild curvature group than moderate and severe groups.

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