Comparative evaluation of three methods to measure working length - Manual tactile sensation, digital radiograph, and multidetector computed tomography: An in vitro study

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Abstract

Aim: Compare the measurement of working length with three different methods manual tactile sensation, digital radiography and Multidetector computed tomography(MDCT).

Materials and Method: 40 human premolar extracted for orthodontic purpose were selected. Teeth were store in sodium chloride (0.9%) during the study. Access cavity was prepared and canal patency was seen with no 10 file in each tooth. Manually no 15 K file was inserted from access cavity until the tip was visible at the foramen, a silicon stopper was adjusted to the corresponding buccal cusp tip and the root canal length was measured. After that in each tooth with no-15 K file inserted from access cavity with stop at tip of buccal cusp until tip appear at foramen and x-ray was taken with digital radiograph (RVG,Satelac) and canal length was measured. After that all teeth are mounted in wax block,MDCT scan was done and in the scan images of teeth, root canal length is measured from buccal cusp tip to root end. After taking measurement of working length with all three methods and the data was stastically analyzed with One Way Analysis of variance (ANOVA) followed by Turkey’s Test.

Results: ANOVA and turkeys test showed that there was no significant difference in the measurements by the three procedures (p>0.05).

Conclusion: Working length measurement with MDCT scan and other two conventional methods does not show significant difference in measurement. Use of newer 3D imaging technique is useful in root canal treatment for measuring working length.

Keywords: Digital radiograph; multidetector computed tomography; root canal; tactile sensation; working length

INTRODUCTION

Working length determination is an important step in endodontic therapy. Success of endodontic treatment depends on perfection in the negotiation of working length. Conventionally, working length of a tooth means “the distance from a coronal reference point to that point at which canal preparation and obturation should terminate.” Hence, cement-enamel junction and apical constriction are two most crucial anatomical landmarks of a tooth a clinician must negotiate to achieve success in endodontic treatment.

Various methods are used to determine endodontic working length. Manual tactile sensation, being the oldest and most common technique in working length determination, requires a learning curve to achieve expertise. Conventional intraoral imaging is another commonly used modality for working

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length determination, however, has its own shortcomings such as two-dimensional replication of a three-dimensional object, possibilities of size and shape distortion; most recently, introduction of digital intraoral imaging though reported to be superior by providing the operator convenience and reducing patient radiation exposure, accuracy of the modality still remains a controversy.[3] According to the study conducted by Martínez-Lozano et al. proved in their study, accuracy of conventional and digital imaging was 50.6% and 61.4%, respectively, in establishing the true working length.[3]

Determination of working length by apex locator has also been reported to have met with great success, and it also omits the need of radiation and thereby its hazards. Smadi in his study concluded that apex locators are capable of producing working length without any statistical difference from the radiographic method and thereby useful for working length determination.[4,5]

Through past few decades, the field of modern medical imaging is changing their dimension from conventional sectional imaging to advanced cross-sectional and volumetric imaging. Adaptation of these advanced imaging in the field of maxillofacial sciences has also been reported to have met with great success in diagnosis and treatment. In the field of endodontics, advanced radiological modalities such as micro-computed tomography (CT) and cone beam CT have proved their potential superiority in usefulness in the determination of working length without the need of any surgical modification of the tooth and thereby reducing the patient compliance.[4,5]

Thereby, we would like to conduct an *in vitro* study to compare the accuracy of multidetector CT (MDCT) with conventional radiography and manual tactile sensation in the determination of working length.

**MATERIALS AND METHODS**

Forty human premolars extracted for orthodontic purpose were selected for this study. Teeth were cleaned and stored in sodium chloride (0.9%). Access cavity was prepared, and canal patency was seen with no. 10 K-file in each tooth.

Working length of each tooth is measured with three different methods:
- Manual tactile sensation
- Digital radiograph
- MDCT.

Manual tactile sensation method - in this method, no. 15 K-file was inserted from access cavity until the tip was visible at the foramen, a silicon stopper was adjusted to the corresponding buccal cusp tip, and the length was measured (from buccal cusp tip to apical foramen) [Figure 1]. Digital radiograph (RVG: radio visual graphy) method - in this method, no. 15 K-file was inserted from access cavity with rubber stop at tip of buccal cusp until it appears at foramen in each tooth and radiograph was taken (RVG, Satelec, Germany). Canal length was measured in the same way [Figure 2].
MDCT - in MDCT method, all teeth were mounted in wax block and MDCT scan was done. In scan images of teeth, root canal length was measured from buccal cusp tip to root end with different slice at all levels (slice thickness - 0.625 mm) [Table 1 and Figures 3, 4].

After taking measurement of working length with all three methods, statistical analysis was performed (with the help of Epi Info™ 3.5.3.) (Epi Info is a trademark of the Centers for Disease Control and Prevention [CDC] Atlanta, GA, USA, 2011).

**Statistical analysis**

Statistical analysis was performed with the help of Epi Info™ 3.5.3 (Epi Info is a trademark of the CDC.)

Descriptive statistical analysis was performed to calculate the means with corresponding standard deviations. One-way analysis of variance (ANOVA) followed by Tukey’s test was performed with the help of critical difference or least significant difference at 5% and 1% level of significance to compare the mean values. \( P \leq 0.05 \) was considered statistically significant.

**RESULTS**

ANOVA showed that there was no significant difference in the measurements by the three procedures \( (F_{2,123} = 3.05; P > 0.05) \). Tukey’s test confirmed that there was no significant difference in the mean values of the measurements of the three methods \( (P > 0.05) \) [Tables 2, 3 and Figure 5].

**DISCUSSION**

Improper working length determination often meets with the failure of root canal therapy and may even cost the patient with sacrificing the tooth. Hence, determination of working length is vital in order to achieve the best outcome of the therapy.

### Table 1: All measurements with three methods

| Specimenblock-1 | Manual tactile sensation (mm) | Digital radiograph (mm) | MDCT (mm) |
|-----------------|------------------------------|-------------------------|-----------|
| 1               | 24                           | 23                      | 23.125    |
| 2               | 20                           | 20                      | 19.375    |
| 3               | 26                           | 25                      | 23.75     |
| 4               | 20                           | 20                      | 19.375    |
| 5               | 22                           | 22                      | 20.625    |
| 6               | 21                           | 20                      | 19.375    |
| 7               | 23                           | 23                      | 21.875    |
| 8               | 21                           | 21                      | 20        |
| 9               | 23                           | 23                      | 21.875    |
| 10              | 24                           | 24                      | 23.75     |
| 11              | 21                           | 21                      | 20.625    |
| 12              | 22                           | 22                      | 21.25     |
| 13              | 22                           | 22                      | 21.25     |
| 14              | 21                           | 21                      | 20.625    |
| 15              | 21                           | 21                      | 20.625    |
| 16              | 20                           | 20                      | 19.375    |
| 17              | 22                           | 22                      | 20.625    |
| 18              | 21                           | 21                      | 21.875    |
| 19              | 21                           | 21                      | 20.625    |
| 20              | 22                           | 22                      | 21.25     |
| 21              | 20                           | 19                      | 19.375    |
| 22              | 24                           | 23                      | 23.625    |
| 23              | 22                           | 22                      | 22.125    |
| 24              | 23.5                         | 24                      | 23.625    |
| 25              | 24                           | 23                      | 23.625    |
| 26              | 26                           | 25                      | 25.625    |
| 27              | 22                           | 22                      | 21.250    |
| 28              | 24                           | 24                      | 24.125    |
| 29              | 22.0                         | 22                      | 21.875    |
| 30              | 20                           | 20                      | 20        |
| 31              | 24                           | 24                      | 23.875    |
| 32              | 21                           | 21                      | 21.125    |
| 33              | 24                           | 24                      | 24.125    |
| 34              | 22                           | 21                      | 21.875    |
| 35              | 24                           | 24                      | 24.250    |
| 36              | 23                           | 23                      | 23.375    |
| 37              | 22                           | 21                      | 21.875    |
| 38              | 22                           | 22                      | 22.125    |
| 39              | 22                           | 22                      | 22.250    |
| 40              | 23                           | 23                      | 23.125    |

MDCT: Multidetector computed tomography

### Table 2: Mean±standard deviation, median, and range of measurements by the three methods

| Values of descriptive statistics | Mean±SD Manual tactile sensation measurement | Mean±SD Digital radiograph measurement | Mean±SD MDCT measurement |
|----------------------------------|---------------------------------------------|--------------------------------------|--------------------------|
| Mean±SD                          | 22.30±1.58                                  | 22.00±1.46                           | 21.50±1.47               |
| Median                           | 22.00                                       | 22.00                                | 21.25                    |
| Range (minimum-maximum)          | 20.00–26.00                                 | 19.00–25.00                          | 18.75–25.00              |

SD: Standard deviation, RVG: Radiovisography, MDCT: Multidetector computed tomography

### Table 3: Analysis of variance table

| Source              | df | Sums of squares | Mean sum of squares | F     | P     |
|---------------------|----|-----------------|---------------------|-------|-------|
| Between groups      | 2  | 13.91           | 6.95                | 3.05  | >0.05 (NS) |
| Residual            | 123 | 260.08          | 2.27                | 6.62  | <0.05 |
| Total               | 125 | 293.99          | -                   |       |       |

df: Degrees of freedom, F: F-statistics, NS: Statistically not significant

![Figure 4: Working length in multidetector computed tomography scan image](image-url)
length holds the key to achieve optimal healing and thereby successful endodontic treatment. Hamed Saeed has found it often difficult to identify and prepare the anatomical landmark accuracy where obturation actually terminated. According to Huang, anatomical factors affect the success rate of endodontic treatment. Neena et al. also commented that accuracy in determination of working length is one of the determining factors for success in root canal treatment.

Manual working length determination is an age-old method. Dohaithem had shown in his block randomization trial study that treatment outcome may vary between working length determination by tactile sensation and radiographic method, where tactile sensation turned out to be a more accurate method. Yet, it should also be considered that accuracy in tactile working length determination requires a learning curve and may vary depending on operator tactile perception as well as the morphology of the root canal system.

Alternatively, conventional radiographic working length determination though remains the most common method practiced till date, also necessitates radiation exposure to patients as well as it is technique sensitive. Introduction of digital technologies in intraoral radio imaging has helped us to overcome some shortfalls of conventional imaging such as lesser radiation exposure to the patient, elimination of film processing, modification of image by operator with ease, and by keeping the accuracy comparable to the conventional imaging. However, technical sensitivity and thereby accuracy remains still controversial.

Use of electronic apex locator for endodontic working length determination eliminates many disadvantages of radiographic method in terms of accuracy, ease, and patient convenience. Andrian in his comparative analysis study came to a conclusion that apex locators have highest accuracy in determination of working length as compared to tactile sensation and radiographic method. Bernardes commented that apex locators are able to produce good precession at 1 mm distance from the apical foramen. However, it is also reported that accuracy of apex locator is highly dependent on the establishment of electrical circuit and electrical conduction properties of canal. Some researches proved that electrical conductivity of solution also may affect the accuracy of apex locators. Moreover, apex locators cannot be used in a patient with pacemakers. Chakravarthy Pishipati et al. have observed that the apex locators are more efficient in working length determination than radiographs and thereby reduces the possibilities of overestimation. However, Mohan and Anand had concluded that apex locators are not superior in determination of working length. Moreover, Khursheed has indicated that highly electroconductive irrigating solution may affect the efficacy of apex locators.

Incorporation of isometric voxel in MDCT and CBCT allows the clinicians to see tooth is all possible direction without any dimensional changes and with higher sensitivity and specificity than conventional or digital radiography. There are fewer possibilities of iatrogenic errors in images, image distortion overestimation of length, and thereby less discomfort to patient and dentist, like in digital radiography. The sensitivity and specificity among MDCT and CBCT are reported to be similar. Connert et al. have recommended that CBCT if 0.2 mm voxel size can be used to determine the working length accurately. As MDCT does not necessitate endodontic access cavity preparation, so chances of pushing infected debris into apical region are minimal. Moreover, as this technique can be used in mentally or physically challenged individuals and patients with cardiac pacemaker, clinical time can be reduced, thereby increasing patient convenience. It is also useful to determine calcified canal, narrow canal, curved canal, and immature apex, thereby treatment planning for root canal system becomes much easy. Only disadvantages of working length measurement with MDCT are high radiation dose and cost-effectiveness as compared to conventional and digital intraoral radiography.

For the past few decades, there are controversies among researchers among the efficacy and usefulness of the advanced cross-sectional imaging modalities over conventional of digital intraoral radiographic modalities. Lucena et al. observed that electronic apex locators are more efficient than CBCT, in determining the major foramen than the minor apical constriction under the experimental setup but CBCT is good to find minor apical foramen. Kqiku and Städtler in their study concluded that results in a radiographic and electronic method of working length determination equally give good and comparable results. Alothmani recommended paralleling cone technique for working length determination and advocated use of combination technique of radiographic and tactile sensation techniques to reduce patient radiation exposure and clinical time.
till date limited CBCT scan machines can be used for working length determination and future studies are needed to evaluate whether preexisting CBCT scans could replace initial periapical radiographs and working length periapical radiographs. Janner et al. observed that CBCT scan of teeth to be endodontically treated can be useful to determine the endodontic working length in combination with clinical measurements such as the EAL. Among CBCT and MDCT as three-dimensional (3D) imaging, we choose MDCT because benefit of MDCT are it is painless, noninvasive, accurate, fast and simple procedure, allows to see image of bone and soft tissue at the same time, provides very detailed images of various types of tissue, reveals internal injuries quickly, and is cost-effective imaging tool for a wide range of clinical problem. Furthermore, availability of MDCT is more than CBCT. Only disadvantage of MDCT is slice thickness is more than CBCT. MDCT is an advanced imaging modality that provides multiple cross-sectional images along the 3D planes. 3D images are with minimal image distortion and thereby enabling endodontists’ accurate analysis of the morphology of the root canal system with minimal patient discomfort. In our study, we found no significant difference in between MDCT, conventional radiography, and manual tactile sensation in the accuracy of working length determination.

CONCLUSION

In the present study, comparison of working that length measurement with MDCT scan and other two convention methods does not show a significant difference in measurement. Keeping other potential advantages in consideration, we conclude that the use of MDCT imaging technique is useful in root canal treatment for measuring working length before doing instrumentation in clinical practice of dentistry.

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Conflicts of interest
There are no conflicts of interest.

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