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ORIGINAL RESEARCH

The effect of working length, as measured by one of three distinct apex locators, on the apical extrusion of debris after instrumentation with a rotational Ni–Ti instrumentation system

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Abstract

Objective: The objective of this study was to compare and analyze the impact of working length (WL) calculated by three different electronic apex locators (EALs) on the apical extrusion of debris that occurred after the instrumentation using a rotational NiTi instrumentation system.

Method: In this study, forty human maxillary or mandibular premolar teeth that had been removed were used. Each tooth had a single root and canal. After preparing standardized access cavities, the samples were then divided into four groups according to the method that was used to determine the WL. Group I (n = 10) consisted of the actual working length (AL), Group II (n = 10) consisted of the Root ZX mini, Group III (n = 10) consisted of the CanalProTM, and Group IV (n = 10) consisted of the PropexPixiTM. During the process of instrumentation, each specimen was kept in its own test apparatus so that the apical extrusion of debris could be evaluated. The ProTaper Next was used to do the instrumentation on each and every specimen up until the size X3. The debris that was expelled from the apex of the tube was collected and its weight was determined by deducting the starting weight of the tube from the weight of the tube after it had been used to dry the debris. The weight score for the apically extruded debris was determined and tabulated before being put through statistical analysis with a one-way analysis of variance and a post hoc Tukey test.

The findings showed that Groups II and III produced outcomes that were comparable to one another and produced much less apical extrusion of debris in comparison to Groups I and IV.

The WL that was evaluated using EAL (Root ZX mini and CanalPro) revealed a lower apical extrusion of debris when compared to the WL that was determined using AL.

Apex locators, CanalProTM, PropexPixiTM, Protaper next, and Root ZX small are some of the keywords to look for.

Introduction

The comprehensive removal of debris from the root canals and the establishment of a three-dimensional seal on the root canal system are two of the most important preconditions for effective root canal therapy. The chemomechanical preparation and intracanal medicine both contribute to the final result of full disinfection. Dentine chips and pulp tissue, both of which

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are known to harbor germs, may, on the other hand, be extruded into the periapical tissues during the process of root canal therapy. Postoperative problems such as discomfort or flareups may arise as a consequence of this periapical extrusion of debris, which, in turn, leads to delayed periapical healing. [Case in point:] [Case in point:] [Case in point:] [Case in point:] [[1], [2]

In an ideal situation, the preparation of the root canal and the filling should not extend past the root of the tooth, nor should it leave uninstrumented regions within the root canal.

[3] Because it frequently corresponds with the root canal's diameter at its narrowest point, the apical constriction (AC), also known as the minor apical diameter or simply the minor diameter, is the end reference point or termination of the working length (WL). [4] The cementodentinal junction, which symbolizes the transition between pulpal and periodontal tissues, has also been considered as the termination point for WL. This is due to the fact that the junction separates the two types of tissues. [5]

The use of radiography, knowledge of anatomy, anatomical averages, tactile feeling, and the presence of moisture on paper points are the traditional procedures that are utilized for the purpose of determining the length of the root canal. All of these procedures suffer from a variety of drawbacks, including increased exposure to radiation, extensive time commitments, and inaccurate readings in the event that the canals are small and the apex is young and open.

As a result of this, the development of the electrical approach may be attributed to the pursuit of a method that is both more accurate and more reliably able to anticipate WL.

The most current iteration of the Root ZX, which was developed by J. Morita in Kyoto, Japan, is known as the Root ZX small. This electronic apex locator (EAL) makes use of various frequencies and may be categorized as a fourth-generation device (Kobayashi, Suda, 1994). It comes in at little over 4 inches by 2 and a third inches. With a progressive display and a high contrast, the liquid crystal display panel keeps an outstanding level of readability throughout its operation. The vivid, colorful, three-dimensional (3D) panel that is featured on the CanalProTM (Coltene, Whaledent, Germany) is indicative of the device's precision in terms of measuring. It is easy to use and features an ergonomic design, which makes it comfortable to hold. The accuracy of the CanalPro apex locator's measurements, along with its user friendliness and sophisticated interface, are all guaranteed (colored 3D panel). The EAL known as PropexPixiTM was developed by DensplyMaillefer in the United States. In addition to computing the root mean square values of the electric signals, the fifth generation of EAL makes use of numerous frequencies.

Even if the preparation does not reach the apical terminus, it has been reported that all of the preparation and instrumentation techniques are associated with the extrusion of infected debris into the periradicular tissue during chemomechanical preparation. This has been the case even when the preparation does not reach the apical terminus.

[6],[7] VandeVisse and Brilliant [8] were the first researchers to quantify the quantity of debris that was extruded apically when hand files were being used in the instrumentation process.

Laboratory research has shown that the use of motor-driven rotary instruments produces less dentine debris extrusion than hand-file techniques do. This was discovered despite the fact that all preparation methods and instruments are associated with some kind of debris extruding through the apical foramen.

[9],[10]

There is no study that has been done that compares the impact of WL utilizing different apex locators on the amount of debris that is extruded from the apex. Therefore, the purpose of this study was to conduct a comparative analysis of the effect that the root length (WL) measured by one of three distinct apex locators (Root ZX mini, CanalPro, and Propex Pixi) had on the

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apical extrusion of debris that occurred after the instrumentation using a rotary Ni–Ti instrumentation system (ProTaper Next [PTN]).

Methodology

The process of selecting the sample and preparing the sample

For the aim of this study, forty human maxillary or mandibular premolar teeth that had recently been taken for orthodontic purposes were chosen. Each of these teeth had a single root, mature apices, comparable lengths, and straight root canals (curvature of 0–10 degrees). These specimens were kept in 1% thymol until they were required for use. The sample size was determined based on the results of an earlier pilot research, which included 10 samples in each group and was carried out with the program Open Epi, version 3, in Atlanta, Georgia, United States. The sample that had been utilized in the pilot trial was thrown away.

Standard oval-shaped access cavities were produced by utilizing a high-speed air rotor hand piece and Endo access bur under water chilling. This was done in order to obtain a reproducible stable reference point. The cuspal tips of each tooth were flattened. The pulp chamber was flared and redefined using an Endo Z bur, and then the opening of the root canal was found. A 10-k file was utilized in order to examine the apical patency of each and every tooth. In a crown-down fashion, the coronal part of the canal was flared using successive Gates Glidden burs #4, #3, and #2. This procedure was done in order.

The aggregation of the samples

The method that was utilized for the calculation of WL required the samples to be arbitrarily split up into four groups, with each group including ten separate samples.

The actual length of time spent working in each group (n = 10) (AL)

Group II (n = 10) – Root ZX tiny Apex locator (J. Morita, Kyoto, Japan)

Group III (number of participants: ten): the CanalPro Apex locator (Coltene, Whaledent, Germany)

Group IV (n = 10) – Propex Pixi Apex finder (DensplyMaillefer, USA).

Group I: To get the AL, a size 15 K-type stainless steel file was introduced into the canal under 2.5 magnification loops until the tip of the file became barely visible at the root apex. This was done in order to obtain the AL. The file was then retracted until its tip was tangential to the apical foramen, after which the silicon stopper was adjusted. After removing the file from the canal, a digital caliper was used to determine the gap in length that existed between the end of the file and the stopper. The AL was calculated by taking this WL and subtracting 0.5 mm; the final result was rounded to the closest tenth of a millimeter.

An in vitro alginate model was created to determine the WL in Groups II, III, and IV to replicate the periodontium. This was done so that the WL could be calculated. The periodontium was imitated by embedding samples of these groups up to the cementoenamel junction in a container filled with newly mixed alginate. This served as the model for the periodontium. In order to finish the circuit, a labial clip was inserted into the alginate and brought into touch with it. Within thirty minutes, all of the measurements were taken while ensuring that the alginate model remained adequately damp. All of the WL measurements for Groups II, III, and IV were carried out in accordance with the instructions provided by the manufacturer. It was determined that the measurements obtained using various apex locators were reliable provided the reading maintained its consistency for at least five seconds, the measurements were carried out three times, and the mean values were computed and recorded for each sample and for each EAL.

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Preparation of the instrumentation for the test

The experimental model developed by Myers and Montgomery [11] was utilized in order to record the apical extrusion of debris. After separating the Eppendorf tubes, the original weight was determined with an analytical balance to within 5–10 grams of precision. The mean value was determined by repeatedly weighing each tube in order to get an accurate reading. It was necessary to put specimens through the stopper all the way to the cementoenamel junction. In addition, a 27G- needle was inserted into the stopper so that the air pressure both inside and outside of the tubes would be equalized. After the stoppers were secured to the vials, the tubes were inserted into their appropriate locations. After that, the specimens were put into the equipment that was being used for the test.

Samples that have undergone biomechanical preparations

When preparing the samples with a torque-controlled endodontic motor at 300 revolutions per minute and 2 Newton-centimeters of torque, a PTN system was employed to make mild inward and outward motions. Every instrument was played at a WL that had been established in beforehand. During the instrumentation process, the PTN was utilized in accordance with the instructions provided by the manufacturer from X1 (17/0.04) to X2 (25/0.06), which was then followed by an apical expansion at X3 (30/0.07). As an irrigation solution, a total amount of three milliliters (mL) of distilled water was utilized.

Tin foil was used to cover the glass vial that was being used throughout the instrumentation process so that the root apex would not be visible to the observer.

Accumulation of waste products

Following the completion of the instrumentation, the stopper, needle, and tooth were removed from the Eppendorf tube. Debris that had stuck to the root surface was recovered by washing the root with one milliliter of distilled water while it was still in the tube. In order to remove the distilled water from the tubes, they were kept in an incubator at 68 degrees Celsius for five days.

Each of the tubes was given three separate weigh-ins, and the average of those results was then determined. The amount of debris that was extruded was determined by taking the initial weight of the tube and subtracting it from the weight of the tube after it had been filled with dry debris. The weight score for the apically extruded debris was computed, then tabulated, and finally subjected to statistical analysis with SPSS version 20. (IBM SPSS Statistics for Windows, IBM Corp, Armonk, NY, USA) A one-way analysis of variance (ANOVA) was used to quantify the changes that occurred across the various groups, and post hoc comparisons were made using the method of least significant difference.

Results

Extrusion of debris was found to be at its lowest in Group II (Root ZX small), whereas it was at its highest in Group I (actual length). Comparisons between Groups II and III revealed no significant differences and came in much lower than those between Groups I and IV. Comparisons between Groups I and IV revealed no significant differences. [Table 1].

Groups	Apical extrusion of debris (mean)
Actual length determination (Group I)	0.00152
Root ***ZX*** mini (Group II)	0.00092
CanalPro (Group III)	0.00120
Propex Pixi (Group IV)	0.00160

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Discussion

The EALs are one of the primary factors used to establish the WL. Numerous research have been conducted to examine the accuracy of WL determination by utilizing EALs. The results of these studies have indicated that EALs have a high level of accuracy and also lower the likelihood of overinstrumentation. [12]

However, to this day, no research has been conducted to analyze the impact of these apex locators—Root ZX small (J. Morita), CanalPro (Coltene), and Propex Pixi (Dentsply)—on the apical extrusion of debris. Several studies have been conducted to examine the accuracy of various apex locators. For the purpose of this research, the uniformity of the chosen specimens was ensured by the use of forty premolars with a single root. The teeth that had a similar canal size at the WL and canal curvature were used because this reduces the number of variables and ensures that the amount of apically extruded debris was caused by the instrumentation techniques and not the tooth morphology. The teeth that had a similar canal size at the WL were used because this reduces the number of variables. The AL was obtained with the use of a size 15 K-type stainless steel file that was introduced into the canal until the tip of the file became barely visible at the level of the main apical foramen while using a magnification of loops of 2.5. After then, the file was retracted until its tip was tangential to the apical foramen, as was done in past investigations that were published in the scientific literature. [13],[14] The equipment that Mayer and Montgomery (1991) developed was utilized in this investigation so that the apical extrusion of debris could be measured. Because each tooth specimen was held in a preweighed Eppendorf tube, which was then fixed inside the glass vial through a rubber stopper, the apical extrusion is not limited by this apparatus. This is because there is no physical back pressure provided by periapical tissues, which is why there is no limitation on the apical extrusion. [11] During the instrumentation process, the operator's view of the root apex was hidden by a foil that was placed over the vial. In several research that have been published, the Mayer and Montgomery model has been utilized to analyze the apical extrusion of debris because it can quantify the total quantity of debris that is extruded. [15],[16]

The relevance of weighing the apically extruded debris lies in the fact that a greater incidence of postoperative discomfort may be predicted if a substantial volume of debris is extruded during the root canal instrumentation process. Additionally, it is well known in the literature that extruded bacteria and debris might produce an inflammatory reaction when it was pressed apically during root canal preparation. This was done in order to remove it. None of the WL determination methods completely avoided the apical extrusion of debris, as shown by the findings of the current study. The method that showed the least amount of debris extrusion was Group II (Root ZX mini), followed by Group III (CanalPro), Group IV (Propex Pixi), and Group I (Actual length) [Table 1]. As a result, the hypothesis of no effect was not supported. In comparison to the findings of the apex locator groups, the AL determination revealed a greater quantity of extruded debris. This might be due to the fact that AL was manually computed by seeing the tip of the file at the root apex using loop, and then calculating it by deducting 0.5 mm from the total length of the file. This may have resulted in a reduction in the accuracy with which the WL was calculated or even the precision with which the AC was located. As a result, the likelihood of an overestimation of the WL increased, which in turn led to an increase in the amount of debris that was extruded from the apex. In a study that was conducted by Arora and Tewari on the morphology of the apical foramen in posterior teeth in a North Indian population, it was discovered that the distance (in mm) and % age deviation of minor apical foramina from the apex for the mandibular first premolar range from 0.112 to 2.18 mm, with an average of 0.79 mm. This information was gleaned from the findings of the study This indicates that the distance between the anatomic

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apex and the AC is not always the same, and falling less than 0.5 mm short of the anatomic apex may result in an overestimation of the WL. [17]

When compared to AL (Group I), CanalPro (Group III), and Propex Pixi, Root ZX small had the lowest amount of debris extrusion (Group IV). It's possible that this is because of the fundamental mechanism on which the Root ZX mini operates. It is a form of apex finder that is reliant on the frequency being measured and operates on the frequency or comparative impedance concept. The Root ZX small delivers an extremely precise indication of the position of the file, which is unaffected by the presence or absence of blood, other discharges, electrolytes, saline, tap water, or hydrogen peroxide. In contrast, the results of the research conducted by Rana demonstrated that the accuracy of the Propex Pixi and the Root ZX small were not significantly different from one another. [18] The findings of our research are in agreement with the findings of Naveed and Pradeep and Ravichandra et al., who demonstrated that the precision of the Root ZX micro was higher than that of the Propex Pixi. [19],[20]

When compared to AL and Propex Pixi (Group IV), CanalPro (Group III) exhibited a lower level of apically extruded debris (Group II). This could be due to the mechanism of CanalPro that measures two frequencies that are alternated and not mixed. Because of this, the need for signal filtering is eliminated, as is the noise caused by nonideal filters. As a result, the measurement is much more immune to various kinds of electromagnetic noises. Dual frequencies are transmitted away from the device and then brought back to it when they have completed their journey via the electric circuit. The findings of our research are consistent with those obtained by Taneja et al., who discovered that the CanalPro Apex locator had a higher degree of precision when compared to the Propex Pixi device. [21] It's possible that CanalPro achieved more accurate findings than AL did due to AL's arbitrary approach to calculating the AC.

Propex Pixi (Group IV) demonstrated much less apical extrusion of debris compared to AL (Group I). This is due to the fact that Propex Pixi recognizes the small apical foramen based on an investigation of the electrical characteristics of the various tissues found inside the root canal system. In contrast, the AC in the AL was determined by taking the anatomic apex and subtracting 0.5 mm from that value.

Following all of the manufacturer's instructions is the best way to reduce the amount of apical extrusion of debris that results from WL determination using any method, whether actual or EALs. However, studies have shown that WL determination using either method causes some amount of apical extrusion of debris. For the purpose of justifying the impact of WL determination by a variety of apex locators on the apical ejection of debris, more in vitro and in vivo investigations are necessary.

Conclusion

EALs were shown to be more exact in identifying WL in compared to AL, which led to a reduction in the quantity of debris that was extruded from the apex of the tooth. This conclusion was reached within the confines of the research. In compared to the other apex locators that were employed for the study, the amount of apically extruded debris was at its lowest when WL was calculated using the Root ZX micro.

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