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Root Curve Detection: Introducing a New Method to Facilitate Endodontic Operations

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Abstract

Root canal treatment is one of the most routine dental operations that require expertise in tooth anatomy, including an accurate assessment of root canal curvature (e.g., degree of curvature, radius, level, length, height, and coefficient). Since the identification occurs in the early stages of the treatment, a misdiagnosis could prevent the removal of all of the pulp tissue and microorganisms from the root canal which can lead to post-procedural infections. It is customary to utilize clinical and radiographic examinations to increase the accuracy of the root canal curvature measurement. Recently, digital instruments such as the Apex locator assist the dental practitioner in this process by providing a more practical solution for the necessary assessments before endodontics procedures. Unfortunately, the above-mentioned methods of root canal curvature identification have some critical disadvantages that would result in a high level of uncertainty and information gaps that are necessary for a successful procedure.

These disadvantages could include things such as the exorbitant price of Apex locators, and the unavailability of necessary documents to assist dentists in case of legal matters if supporting evidence on the success of endodontic treatment is requested by the patient. We have designed an innovative dental instrument to improve the accuracy of endodontic treatment. The Root Curve Detector (RCD) is placed inside the damaged teeth and with the help of the x-ray imaging, can detect the buccal/ lingual root curvature. RCD is an affordable device that equips the dentist with a high-precision diagnostic tool regarding root canal curvature. It would also allow gathering and recording evidence on the endodontic treatment process.

Keywords: *apex locator, endodontic, radiographic, root-canal morphology, canal curvature.*

Introduction

In most cases, root canal treatment fails when it does not meet acceptable standards **[**1-4**]**. Committing procedural errors (usually about unidentified root canals) are some of the most usual reasons that can cause the failure of a root canal treatment. Also, the occurrence of such errors would not allow an acceptable amount of control and would be an obstacle to the prevention of intracanal endodontic infection **[**4**]**. Moreover, to identify and assess the DL (Disto-Lingual) of a root, one of the most usual preoperative methods applied is radiographic examination. The problem with the aforementioned method, however, lies in the fact that the conventional images taken in radiographic examination produce a 'shadowgraph' which is a two-dimensional image resulting from the compression of complex three-dimensional anatomies. Naturally, the identification of supernumerary roots in such images would be rather difficult. Consequently, mesial and/or distal parallax view would be used to get additional information that otherwise could not be gathered from the radiographic image **[**5**]**.

Furthermore, it is worth mentioning that to obtain all the necessary information to identify all relevant anatomy, the abovementioned problem with shadowgraphs would not be necessarily remedied through taking multiple intraoral images. Other than the limitations imposed by the two-dimensionality of the images, there are well-known shortcomings to the information provided through periapical radiographs including geometric distortion and anatomical noise **[**6**]**. As an example, the greatest angle of curvature between roots belongs to the Disto-Lingual canals, making it more difficult to identify and assess their curvature. It goes without saying that since the anatomical features of every root are unique, the preparation of canals in different roots would also be accordingly varied.

It is a widely known fact that a large number of roots do not have a round shape which may require more reliable diagnostic tools **[**7**]**. To perform endodontic therapy, Fava & Dummer have introduced

different types of radiographic projections. Through changing the angle of the x-ray beam additional information can be gathered, that helps with the diagnosis and treatment, which are usually not available with standard radiographic images. These changes in the angle of the x-ray beams can facilitate the process of determining the curvature and number of roots and their respective canals. Thereby enabling the practitioner to determine the superimposed roots and differentiate between the anatomical landmarks and apical pathology **[**8**]**.

A recent powerful tool used in the assessment of root-canal morphology is micro-computed tomography (MCT). Using this technology would allow the gathering of a more advanced amount of knowledge of the effects of canal preparation on the overall anatomy of the tooth and root in a three-dimensional format. Such a detailed description and analysis cannot be used in a clinical setting yet **[**9-11**]**. Considering the limitations of current technologies, what can certainly help with performing root canals and endodontic treatments, is thoroughly recording the patient's complaints, medical history, previous treatment review, and treatment plan. Keeping 3 such records would allow other practitioners to continue with the treatment in case it becomes necessary. It is needless to say that the importance of these records also lies in their medico-legal reasons. According to the EU laws, in keeping such records, some factors should be more closely monitored such as tracking the prescribed medications, method of rubber dam isolation, preparation technique, curvature, length, and the size of the canals and their reference points, significant features (such as fractures, cracks, or iatrogenic defects), the material used in root filling and type of dressing, volume and concentration of irrigation, the process of the temporary restoration, sealer and the applied technique, complications, type and number of radiographs, and the detailed analysis of the radiographs taken **[**12**]**. Furthermore, based on the medical biller and coder resource MB-Guide it is also important in the United States of America for the medical practitioners in all fields of activity to keep records and documentation regarding the patient's history and operations conducted as part of the billing. Before starting a root canal treatment, the canal's morphology has to be assessed using at least one reliable shadowgraph. The radiographic images mainly determine the apical extent of the instrument used and the type of root filling, both of which play a substantial role in the success or failure of the treatment. When radiographic images prove insufficient, electronic apex locators can be used to assist. Using these locators would also lessen the number of radiographic images necessary to determine the treatment process. Furthermore, they would help determine where the apical foramen has been distanced from the radiographic apex and the specifics of root canal perforation. When determining endodontic working length, a variety of these methods has to be used to arrive at a satisfactory conclusion. CDJ (Cementodentinal Junction) is a viable and anatomical point of preparing the root canal that cannot be diagnosed through radiography. The position of the CDJ can be determined with an accuracy of approximately 90% using electronic apex locators, however, there are still some limitations to how much they can achieve. Nonetheless, a combination of having sufficient knowledge of the apical anatomy, using electronic apex locators, and having reliable radiographic images can help practitioners with having a successful operation **[**13**]**.

Method

To increase preparation effectiveness and prevent procedural errors, the traditional endodontic cavity (TEC) emphasizes straight lines into root canals **[**14-16**]**. Over the past decade, several new nickel-titanium instruments, as well as rotary endodontic handpieces have been developed for manual root canal preparation and designed to simplify the difficult and time-consuming process of cleaning, shaping, and enlarging the root canal system as well as improving the final quality of a root canal preparation **[**17**]**. The root canal treatment outcome plays a major role in substantiating clinical decisions, especially when RCT is compared to extraction of natural teeth or replacement with prosthetics **[**18**]**. Performing root canals properly (preparation, filling, sealing) is a critical element to achieving high success rates, even with infected canals **[**19-22**]**. By predicting root curvature radius and minimizing anatomical challenges and limitations of endodontic instruments, it is possible to plan a more precise root canal instrumentation.

A root curve detector (RCD) is a piece of a dental instrument designed to solve the problem of detecting the root canal length and determining its curvature direction for endodontics. As radiographic images do not guarantee the correct diagnosis of root canal curvature, especially in cases where the curvature is buccal or lingual, we need a more practical solution. If the curvature in the root of the tooth is not determined, the root canal operation also fails. Furthermore, if the direction of this curvature is misdiagnosed, endo-surgery cannot be successful either and the dental canal would be dilated in the wrong direction, which can no longer be corrected. On the other hand, digital devices such as high-priced apex locators have a margin of error and are faulty, also the results displayed on their monitors are not recordable and documentable. Considering all that has been mentioned, we decided to design the RCD instrument, which is both cost-effective and can be used together with the radiographic method. RCD is a calibrated product that has a shape similar to endo files or spreaders. It has cross-sectional grooves that are created at equal intervals of 0.1 mm in the range of 6 mm at the beginning of its tip. This instrument can be placed inside the damaged tooth canal. Thereafter the curvature of the root canal is determined by taking X-Ray images of the instrument while it is inserted inside the aforementioned canal which helps the dentist diagnose the curvature of the root. By placing the scaled RCD inside the dental canal and performing radiography, the distal and mesial curvatures can be easily determined, even though these types of curvatures can already be assessed using different methods. The Buccal and lingual curvatures, however, are harder to diagnose using the conventional methods. These two types of curvatures can also be detected through the changes in degrees on our proposed instrument which is then depicted on the radiographic images taken while the instrument is in place (Figure 1). The consistency of the scaling size on the tool and its distances would notify the dentist about the absence of the curve and the reach of the root canal. However, in the case of the buccal curve, the distance between the scalings on the RCD will be increased (Figure 2) whereas the lingual curve would necessitate a decrease between the scalings on the RCD (Figure 2). This device would determine a forward or backward curvature that has not been seen before due to the verticality of the X-ray image

on the tooth surface. It would also allow documenting and confirming the accuracy and exactitude of the dentist's work, which is a vital procedure in regulations and policies of the Islamic Republic of Iran Medical Council. It can be confidently said that RCD provides a cost-effective method that facilitates determining severe root curvatures before performing a root canal treatment.

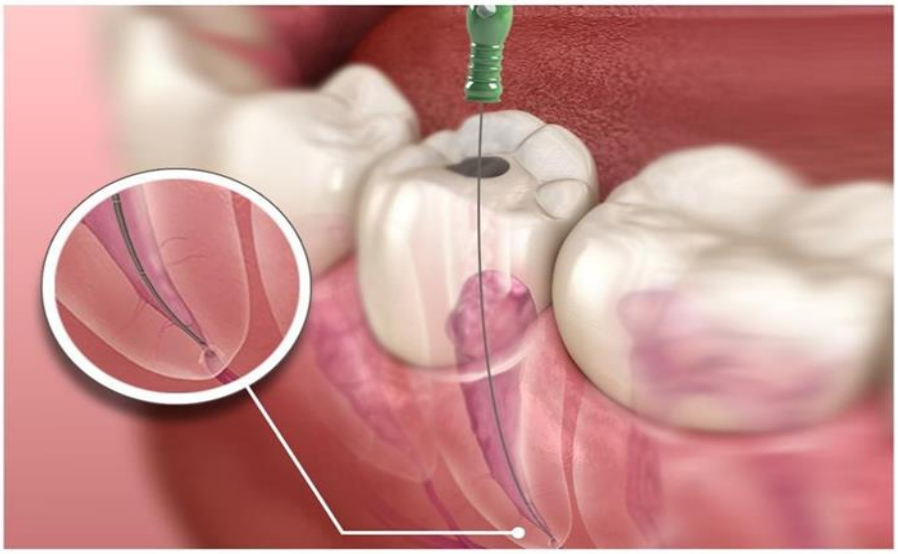

Figure 1-The RCD instrument inserted in root canal

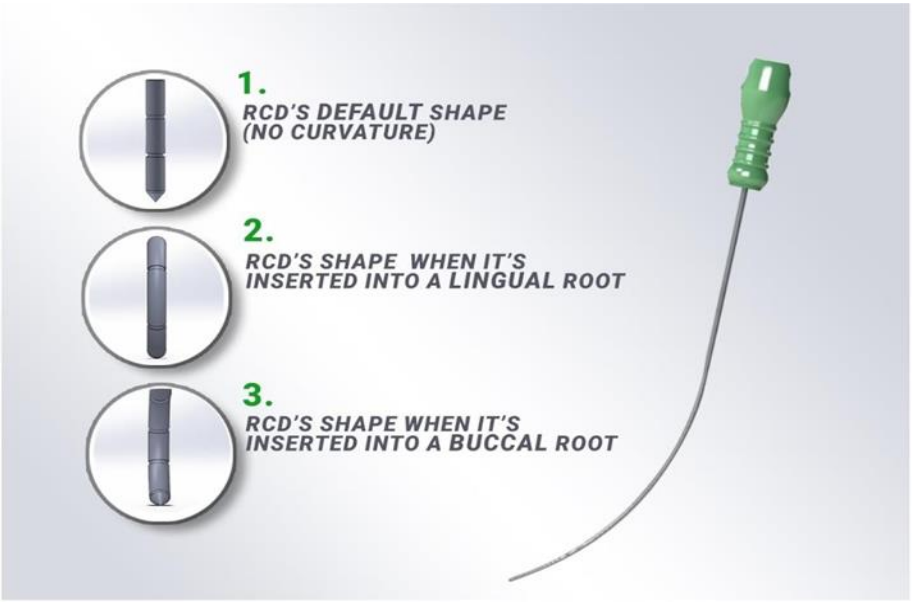

Figure 2- A complication of all of the RCD device's forms

Results

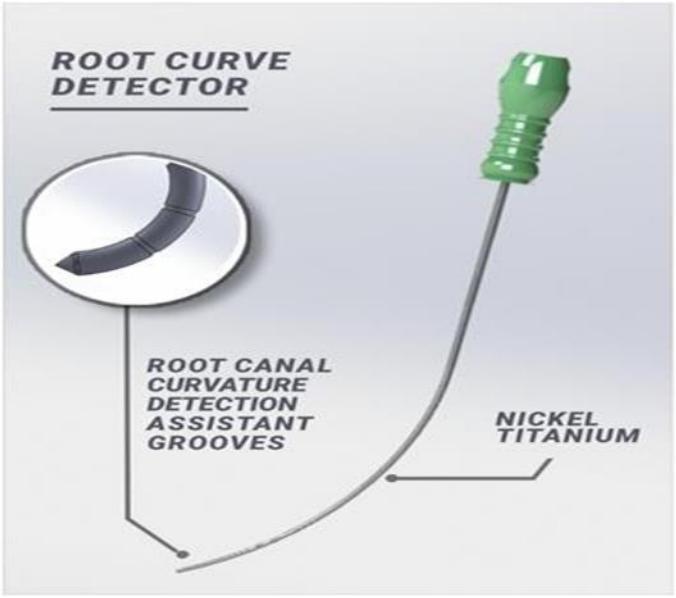

Figure 3-Root curve detection instrument

This study provides an overview of dental instruments that measure the length of the root canal and diagnose its curvature. Increased distance between the scaling of the RCD describes the lingual root while the decreased distance between the scaling of the RCD represents the buccal curve of a tooth canal. Detailed instruction on how to use our innovative tool, RCD was also revealed. We have provided further information on the ways to improve and accurizing current practices through the development of national guidelines. We hope to promote dental-based curve detection activities worldwide, especially in Iran.

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