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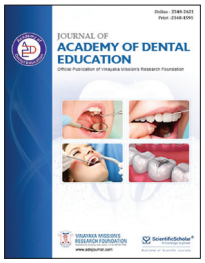

Review Article

Apical reference point - A clinical perspective

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ABSTRACT

The clinicians face various challenges in trying to find the optimum working length during root canal treatment. Unless proper biomechanical preparation up to the apical limit is done, reinfection of the canal occurs. Apical reference point must be measured with at most care as to avoid any damage to the surrounding periodontal tissues during the treatment.

Keywords: Apical limit, Apical constriction, Apical foramen, Cementodentinal junction, Optimum working length

INTRODUCTION

The primary goal of an endodontist is to provide disinfection and prevent the recurrence of infection. The success of pulpectomy depends on determining the precise measurement of the canal and sanitizing up to its apical limit. A proper pulp space treatment is established where instrumentation is performed to remove the pulp and other necrotic debris and the canal is filled with an appropriate material till its apical limit to prevent the invasion of any bacterial toxins. If the canal is not properly disinfected up to its apical point, the remaining bacteria may thrive within the canal causing root canal treatment failure. Maintaining the proper canal length till the end of the treatment has positive outcomes.

VARIOUS LANDMARKS

The root end is a complex anatomical structure with distinct landmarks. These landmarks aid in finding the appropriate working limit. Apical 3 mm of root canal is considered as the significant zone.[1,2] According to Kuttler, the apical end consists of

(1) Anatomical apex, (2) apical foramen, (3) apical constriction, and (4) cementodentinal junction.

Anatomic and radiographic apex

Anatomic apex is the most apical anatomical structure. It is a point where the neurovascular bundle enters the root apex. The tip or end of root that is identified morphologically and radiographically is called as anatomic and radiographic apex, respectively.[3]

Apical foramen

According to Kuttler, apical foramen is defined as the circumference or rounded edge, like one of a funnel or crater, like that differentiates the termination of the cemental canal from

the exterior surface of the root.[4] Kuttler reported that up to 80% of the teeth had deviated apical foramen while Levy and Watt reported a deviation of 66.4%. The mean distance between major foramen and the anatomic root apex was found to be 0.59 mm.[5] Location of the apical foramen (at center) in permanent teeth was 48.95% and 42.08% of the upper and lower teeth, respectively.[6] The shape of the external contours of the apical foramina was described as asymmetric, hourglass, semilunar, or serrated.[7] Most common shape was round in both maxillary and mandibular teeth.[8]

Apical constriction

Narrowest part of the root canal is the minor apical foramen. The apical constriction lies 1.5 mm coronal to major foramen.[9] According to the European Society of Endodontology (2006), quality guidelines recommend that the canal length determination must be close to apical constriction. The distance between major and minor constriction and root apex and minor constriction was found to be 0.4–1.2 mm and 0.5–1.01 mm, respectively.[10] The shape of the apical constriction has four possible configurations – single, tapered, multi-constricted, and parallel.[4] The labiolingual dimension of the minor diameter was larger when compared mesiodistally by 0.5 mm.[10] Most commonly found shape of the minor diameter was oval.[11]

Cementodentinal canal junction (CDC)

The CDC junction and minor constriction are not one and the same.[8] At this junction, root dentin and cementum meet in the canal. It is a passage point between the endodontium and periodontium. It is a histological landmark and cannot be located clinically. If this is considered as the apical limit, invasion of bacterial toxins can be prevented.[12] Kuttler when analyzing the CDC junction demonstrated that the extent of cementum into pulp space in people between 18 and 25 years of age was ×508 μm and ×343 μm and in people over 55 years of age was ×802 μm and ×619 μm on the right and left quadrants, respectively.[4] Values vary between 200 μm and 800 μm. The CDC was coronal to the apical foramen by at least 0.3 mm while maximum distance reported between the CDC and root apex was 2.5 mm.

CLINICAL CONSIDERATIONS

The measurement, instrumentation, and filling of the root canal are made precisely to avoid encroachment of the periodontal space.[5] Kuttler recommended that all endodontic procedures should be terminated 0.5 mm from the apical foramen, because it is considered as nearest to the apical constriction.[13]

WORKING LENGTH DETERMINATION

Definition of working length is the distance between a coronal reference point and the point at where canal preparation and obturation should terminate.[14] Methods by which canal length can be determined are tactile sensation, assessment of pre-operative radiographs, and electronic apex locators (EALs). Measuring the canal length through tactile sensation is a skilled procedure and may lead to errors. Radiography remains the best choice for canal length determination. Pre-operative radiographs have certain limitations such as it provides only a 2D image, repeated exposure to the patient as well as the clinician, time consuming, and sometimes it may be difficult to interpret.[15]

EALs have become the most important tool in measuring the working length. The mechanism of EAL is by positioning a conductive clip on the patient's lip and connecting the endo file to the other clip. A circuit is created between the two clips with multifrequency alternating current. The circuit is formed by the patient's tissue and pulpal space contents. There are various generations of apex locators. All EALs on market are 4th or 5th generation. The use of alternating current has allowed the design of an electronic system, including the tooth, supporting tissues, and the liquids that may possibly be present in the canal.[2]

OPTIMUM WORKING LENGTH

Different authors suggest various terminating points. Conducting procedures up to the apical foramen may sometimes go beyond the point and may cause over instrumentation or overfilling of the pulpal space. Although the authors have different opinions on CDC being the termination point, the CDC junction is a controversial point of talk as it is only histologically identified and not morphologically. Hence, a point that lies between these two landmarks is to be considered as the optimum working length, that is, the apical constriction. Apical constriction is the narrowest part of the canal, it can be easily identified morphologically and many authors have advocated that having the working length up to apical constriction has shown many successful outcomes.

BIOMECHANICAL PREPARATION

Cleaning and shaping remains to be the most important step in the root canal procedure. The infected pulp and other necrotic contents are removed from the canal. The cleaning of the canal is performed using hand files or rotary instruments. The instruments must be confined to the canal and it should not cause trauma to the periradicular tissues. The apical portion of the endodontic area, 3–4 mm must be enlarged that facilitates the irrigant flow up to biologically

crucial apical third. About 90% of healing occurred when the instrumentation was allowed up to minor constriction.[10] Dunlap *et al*. advocated that the cementodentinal junction has the most well-suited position to terminate the preparation of the canal and obturation.[9]

Scandinavian concept[12]

According to the Scandinavian concept, the canal preparation should be left short and it should be stopped 1-2mm short of radiographic apex. An apical box should be formed with an apical diameter of 0.35–0.80 mm. This type of preparation allows deep penetration of the irrigation needle which permits delivery of irrigating solution to the apical third. In case of an infected tooth, an intra-appointment medicament like calcium hydroxide (↑pH, disinfects the last few mm where instrumentation and irrigation were not possible) is placed in the canal for 1–4 weeks. There is formation of apical plug which creates an apical barrier. This approach is more biological than the North American concept.

The North American concept[12]

According to this concept, the shaping of the canal is done till the radiographic apex. A histological analysis of the apical area shows that if the filling reaches this point, there may be filling beyond this point in the root canal and this slight extension of the filling material is considered. The extension of the filing material causes periapical irritation and lack of biocompatibility. Although biocompatibility of the materials has not been clearly proven, they are not responsible for the failure.

Over instrumentation means extension of the instrument into the periapical area, beyond the root canal system. This should be avoided to prevent post-operative discomfort and complications. Over instrumentation also promotes over filling which may cause mechanical and chemical irritation to the periapical tissues. Under instrumentation refers to biomechanical preparation to a level shorter than aimed. This may lead to improper removal of the debris and the infected tissues at the apical end of the canal. Under instrumentation leads to canal length loss and leading to dentin mud clogging at the apical end which, in turn, causes reinfection and prevents healing.[10]

After cleaning and shaping the canal, there may be remaining dentinal chips and debris. To remove these residues, irrigating the canal is very important. Needles that are used for irrigation should be placed 1–3 mm short of the endodontic working length.[16] Irrigating the canal is not only to remove the remaining particles but also to eradicate the intraradicular microorganisms. Irrigating instruments and ultrasonic handpieces must be handled with care to avoid iatrogenic damage of the canal.[16,17]

The medicament must be restricted within the canal and caution should be taken not to extrude it beyond the apex into the periradicular tissues, as it may cause inflammation, swelling, and tooth loss.[18]

OBTURATION

According to Schilder's concept the apex, as seen on the film is only a reliable reference point for the clinician, and the filling must reach this landmark.[12] A detailed histologic analysis of the apical area shows that if the filling reaches this point, there will always be some filling material beyond this point.[2] However, this overfilling must be considered as a part of overall concept, where the shaping must be tapered, and the apical foramen kept as small as is practical (ideally 0.20–0.25 mm).[2,19,20] The termination point of the root canal procedures should lie in the anatomic area between apical constriction and apical foramen.[14,21]

CONCLUSION

A root canal treatment is a procedure done on a tooth with a necrotic or infected pulp. It consists of canal length determination, canal preparation, irrigation, medicament placement, and three-dimensional filling. A paramount importance must be given in determining the working length as all procedures will end at that point. As advocated by many authors, various landmarks were suggested as the apical reference point, but the apical constriction was the one landmark that convinced many authors.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

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Conflicts of interest

There are no conflicts of interest.

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