Review Article

Root Apex and its Management Strategies

Deeksha Kulkarni[1], Anuraag Gurtu[1], Ashish Aggarwal[2], Sivani Sangam[1], Saummya Singh[1], Mamnoon Ghafir[1]

[1]*Department of Conservative Dentistry and Endodontics, Institute of Dental Sciences, Bareilly, Uttar Pradesh, India*
[2]*Department of Oral Medicine & Radiology, Institute of Dental Sciences, Bareilly, Uttar Pradesh, India*

ABSTRACT

The anatomy of the root apex is an area of interest to the endodontist. Achieving an optimum working length and a proper apical seal is essential for successful root canal treatment. The variations in the anatomy of the root apex and its treatment are technical challenges for the endodontists. Practitioners can execute better with amplified illumination and magnification. Both the quality and biocompatibility of apical seals have been improved with advancements in the root canal filling materials. Along with these advances, the art and science of endodontic surgery has improved the chances of saving a tooth which was earlier considered for extraction. This article highlights the importance of root apex and various methods for its management to achieve a successful endodontic treatment.

Key words: Root apex, root canal treatment, apical foramen

INTRODUCTION

The anatomy of the root apex is an area of interest to the endodontist. Achieving an optimum working length and a proper apical seal is essential for successful root canal treatment (RCT). To achieve this objective, enlargement of the apical area has been advocated for better removal of the infected dentin, along with the increased flushing action of irrigants in the apical region, and significantly reducing the bacterial load in the root canals.[1]

The root canal anatomy consists of three anatomic and histologic landmarks in the apical region of a root: The apical constriction (AC), the cementodentinal junction (CDJ), and the apical foramen (AF), respectively. These apical landmarks are considered as the limits for the extension of root canal instrumentation and filling.[2]

The variations in the anatomy of the root apex and its treatment are technical challenges for the endodontists. These variations include accessory canals, lateral canals, ramifications immature foramina, fracture to the apical third, resorption, and curved canals which may be present in a greater frequency in the apical third than that of the coronal and the middle third of the root.[3]

The outcomes of conventional endodontic treatment are reported to be successful in 79–96% after a primary endodontic treatment. The objectives of treatment being the same: Prevention or elimination of apical periodontitis, peri-radicular surgery, if indicated, must be considered as an extension of the non-surgical treatment. The apical third of the root is morphologically the most complex region; theoretically challenging; radiographically most unclear and obscure area; and prognostically the most important part.[4]

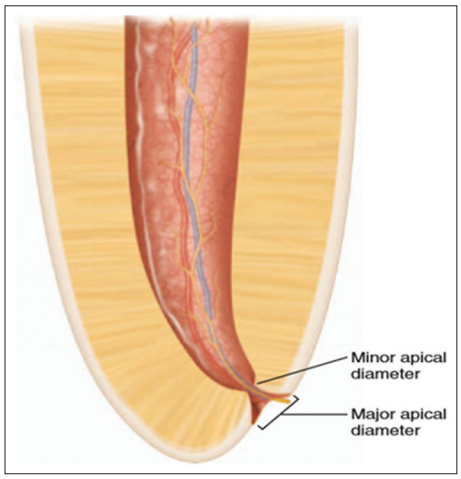
APICAL FORAMEN ANOTOMY

The root canal anatomy consists of three anatomic and histologic landmarks in the apical region of a root: The AC, the CDJ, and the AF, respectively. The AC is the part of the root canal with the smallest diameter and is most often considered as the reference point for the apical termination of cleaning, shaping, and obturation. The successful treatment of inflammation in the root canal is difficult because the blood vessels of the pulp are narrow at the AC. The healing process may be compromised and the post-treatment discomfort is more when the AC area is violated by filing and obturating materials.[5]

The cementum meets dentin at the CDJ and it is the position where pulp tissue ends and periodontal tissue begins. The location of the CDJ varies considerably in the root canals. The canal broadens as it approaches the major apical diameter (AF) from the minor apical diameter (AC) and hence it attains a funnel shape or is considered to have the shape of a morning glory flower.[6]

Variability and unpredictability are the two characteristic features of the apical region. The enormous variations in the shape and diameter of the root canals makes the overall cleaning and shaping procedures intricate. The success of the treatment depends on the anatomy of the root canal system, the proportions of the canal walls, and the final size of enlarged instruments.[6]

Corresponding Author:
Dr. Deeksha Kulkarni, Department of Conservative Dentistry and Endodontics, Institute of Dental Sciences, Bareilly, Uttar Pradesh, India.
E-mail: deeksha9993@gmail.com



LATERAL CANALS AND ACCESSORY CANALS

The glossary of American Association of Endodontists defines lateral and accessory canals as follows:

Lateral canal

It is defined as a canal located at approximately right angles to the main root canal.

Accessory canal

It is defined as the canal that branches off from the main root canal, usually in the apical region of the root.[7]

In vital teeth, after the endodontic therapy, the lateral and accessory canals become obliterated by the deposition of cementum as the time progresses, but in teeth with completely inflamed or necrotic pulp, granulation tissue is formed in accessory canals preceding the endodontic therapy. Later, this inflammatory tissue gets resorbed and is replaced with uninflammed connective tissue.[8]

Lateral and accessory canals are difficult to clean adequately. Thorough and effective irrigation techniques should be carried out. A tooth with multiple accessory canals in the apical third may harbor microorganisms and debris which may continue to irritate the periapex and cause pain in spite of proper filling of the principal canal. Periapical surgery is indicated in such cases.[8]

AGE CHANGES AT APEX

The distance present between structures at the root apex and the changes that may occur over time are important to be considered while working in this area. Aging effects and environmental conditions are the two major factors which are responsible for the histological changes that lead to the changes in the morphology.[9]

Cementum is deposited at the apex during the entire life of tooth vitality, which is accountable for the change in the location of the foramen. Hence, our main aim clinically is to locate this deviated foramen and estimate the precise length up to which obturation should be done. Apex locator, to a very large extent, helps in this process but the thickening of the apical cementum makes it difficult to get precise estimation of the working length in the first attempt and thus also increases the time required in the age group that is above 25 years.[10]

RADIOGRAPHIC ASSESSMENT OF APICAL THIRD

Good radiographs serve as the "eye" of the dentist during diagnosis, treatment, and recall. Accurate periapical radiograph is necessary for proper diagnosis and to know about the presence, extent, and severity of periapical pathology, if any. The paralleling technique is mostly used for radiography.[11]

The lateral canals, accessory canals, and other anatomic aberrations cannot be easily identified. The clinician should have sound knowledge about these anatomic variations. Clinically also, we should examine carefully for extra canals by probing the potential area using a sharp pointer or an endodontic explorer. Radiographically, we can assess and sometimes identify the anatomic variations.

1. When the radiograph shows that the root canal shadow suddenly stops in the radicular region, it can safely be assumed that it has bifurcated or trifurcated into finer diameter tributaries at that point. To confirm this dichotomy, a second radiograph may be exposed from a mesial angulation of 10–30°. This diagnostic clue as pointed out by Slowey, called the "Fast Break," is usually seen in maxillary first premolars.
2. Clinician should suspect an extra root canal whenever the outline of the root is unclear, or has an unusual contour, or strays in any way from the expected radiographic appearance.
3. It is imperative that radiographs should be taken, from minimum two angulations before attempting endodontic treatment. Angled views of teeth can better reveal the anatomic variances. Mesial angulation technique is used for identifying two canals wherein the lingual root always appears mesially on the film (same lingual opposite buccal rule).[12]
4. The radiograph also gives several clues to anatomic aberration: Lateral radiolucency indicates the presence of lateral or accessory canals, an abrupt ending of a large canal signifies a bifurcation, a knob-like image indicates an apex that curves toward or away from the X-ay beam (Bull's eye), multiple vertical lines indicate thin root which may be hourglass shaped in cross-section, hence susceptible to strip or lateral perforations.
5. A second canal may be suspected if an extra dark line is evident in the coronal third of the root, running parallel to the test file in the radiograph. This is particularly helpful in detecting the fourth canal in the mesiobuccal root of the maxillary first molars and the distal roots of the mandibular first molars.
6. Knowledge of normal root curvatures may be quite helpful in interpretation of the radiographs. For example, palatal roots of permanent maxillary molars often have sharp apical curvatures toward the buccal side.[12]

PREPARATION OF APICAL THIRD

The paramount objective of root canal therapy is to minimize the number of microorganisms and pathologic debris in root canals for the prevention or treatment of apical periodontitis.[13]

Length determination

The first step in the apical preparation is the location of the foramen in the root apex. Although a radiographic assessment with a measured endodontic instrument in the canal is an accepted procedure for the determination of the tooth length, measurements using electronic instruments are becoming increasingly popular.

Determination of the working length is an essential step in obtaining the hermetic seal as wrong estimation could either lead to an enlarged foramen resulting in

i) Periapical irritation,
ii) Possible weeping of the canal, and
iii) Loss of control during obturation, or lead to preparation short of foramen with the resultant ledge formation and accumulation of dentin debris.[13]

Instruments and instrumentation

Time spent on the proper preparation of the apical portion greatly simplifies the subsequent canal preparation. Two general principles to be adhered to, while preparing the apical third, are – the maintenance of the spatial integrity of the foramen and smooth shaping of the original course of the canal.

Careful selection of instruments and special manipulative techniques are essential requirements for a successful preparation of apical zone.[14]

Flexible files are preferred over stiffer varieties since they may change the course of the canal, form a ledge or transport the foramen by ripping. D-type files (produced from rhombus blanks) are more flexible than regular K-type files (produced from square blanks) in size no: 30 and above. The new K-type file (triangular cross sections) is more flexible than H-file.[15]

Methods of preparation

Preparation design has an influence on the final seal. Step back or flaring type of preparation of the apex is found to be advantageous over the conventional method. Flared preparation provides a cleaner environment, better receptacle for the obturating material, and a stronger apical dentin matrix. Chances of apical ripping and shifting the foramen are less with step-back technique.[15]

Irrigation

A strict rule to follow is to irrigate the canal copiously between each instrumentation. It facilitates the removal of dentin shavings and maintains the cutting efficiency of the instruments by relieving clogging. Once the dentin mud settles at the apical level, it becomes difficult to be dislodged. Since 1955, Grossman (1982) has advocated the alternate use of 5% NaOCl with 3% hydrogen peroxide. The effervescence obtained on using hydrogen peroxide, would bring the shavings to surface.[16]

Sonic and ultrasonic irrigation

In recent years, new innovations have been developed and brought to market in an attempt to more effectively reduce the microbial load in the root canal space. One such item is the Endo Activator (EA). The EA is a handheld portable device that agitates solutions sonically and can be fitted with three types of disposable polymer tips of different sizes at different speeds; 2000–10,000 cycles/min. The manufacturer recommendations are to activate irrigation solution used for 30 s as a final rinse.

There are two types of ultrasonic irrigation systems. The first one being simultaneous use of ultrasonic irrigation and instrumentation. The second being passive ultrasonic irrigation that works without any simultaneous instrumentation.[15]

Obturation

Sealing is done to eliminate all the portals of entry from the root canal into the adjacent periodontal tissues through which exudates, bacteria or their toxins might pass, and to make the environment favorable for healing.

ENDODONTIC SURGERY

Orthograde RCT has always been the first line of treatment in the management of apical periodontitis and has reported a success rate of up to 85%. Surgical endodontic treatment must be considered only when the non-surgical approach is not possible or when the non-surgical treatment has failed. An endodontic surgery may involve root-end resection, apical curettage, and root-end filling.[17]

With the use of microscope and microinstruments, endodontic surgery has evolved into endodontic microsurgery over the past few decades. The microscope provides magnification and illumination allowing the optimal visualization of surgical field. Microinstruments provide conservative preparation of the root end and precise root-end fillings. It is no longer considered admissible to perform endodontic surgery without the use of magnification.[16]

Indications and contraindications to endodontic surgery

Endodontic Surgery has to be considered in any of the following situations:

1. Persistence of periradicular disease in an endodontically treated tooth where orthograde retreatment has failed or cannot be performed;
2. A biopsy is needed;
3. When perforation, internal or external root resorption, or root fracture are doubted and need direct visualization;
4. Root amputation or hemisection.[1]7

Absolute contraindications endodontic surgery are as follows:

1. Recent myocardial infarction or cerebrovascular accident, intravenous bisphosphonate use, immunosuppression, bleeding disorders, a history of radiotherapy to the oral cavity, psychological health issues, and any debilitating illness.
2. Local anatomical factors:
   a. Poor access to the apical area;
   b. Short sulcus depth and prominent frenal/muscle attachments;

c. Proximity to surrounding structures: Maxillary sinus, mental nerve, or inferior alveolar nerve;
d. Severe periodontal disease or extensive loss of coronal tooth tissue.

3. Experience of the operator: Skill, training, and expertise of the surgeon have a huge impact on the success rates.

ROOT-END FILLING MATERIALS

The obturation and restoration of the tooth should seal the root canals both apically and coronally to prevent leakage and percolation of oral fluids and recontamination of disinfected canals, are the obligatory requirements of the RCT. To save the tooth, apicoectomy with retrograde obturation is a familiar procedure in endodontics, when all the efforts for the successful orthograde endodontic therapy have failed.

IDEAL REQUIREMENTS OF A ROOT-END FILLING MATERIAL ARE

It should-

1. Adhere and adapt to the walls of the root canals
2. Prevent effusion of microorganisms and their products into the periradicular tissues
3. Be biocompatible
4. Be non-resorbable
5. Be unaltered by moisture
6. Be easy to manipulate and place
7. Have good radiopacity
8. Possess anti-caries activity
9. Be non-toxix and dimensionally stable
10. Not cause paresthesia
11. Not cause any pigmentation
12. Not corrode or be electrochemically active
13. Have bactericidal or bacteriostatic effect
14. Stimulate cementogenesis
15. Be well tolerated by periradicular tissues with no inflammatory reactions.[18]

There are many root-end filling materials but none fulfills all the properties for an ideal retrograde filling.

Amalgam has been the first material of choice for a root-end filling for many years. Other metals such as gold foil, titanium screws, and gallium alloy and cements such as glass ionomers, super EBA, IRM (zinc oxide-eugenol cements), carboxylate cements, zinc phosphate cements, calcium phosphate cement, Diaket, mineral trioxide aggregate, composite resins, and gutta-percha are also widely used.[18]

CONCLUSION

The apical part of the root includes several landmarks including the AC, AF, and CDJ. Attaining an optimum working length is a pre-requisite for favorable RCT outcome.[1]

The main aim of the clinician should be to preserve as much tooth structure as possible without any compromise in disinfection and eradication of bacteria from the root canals. To achieve this goal, endodontists have developed new techniques, materials, and instruments. Practitioners can execute better with amplified illumination and magnification. Both the quality and biocompatibility of apical seals have been improved with advancements in the root canal filling materials. Along with these advances, the art and science of endodontic surgery has improved the chances of saving a tooth which was earlier considered for extraction.[19]

REFERENCES

1. Kambale S, Patil S, Hoshing U. Apical preparation size in endodontics: A review. Int J Curr Res 2018;10:70208-11.
2. Alothmani O, Chandler N, Friedlander L. The anatomy of the root apex: A review and clinical considerations in endodontics. Saudi Endod J 2013;3:1-9.
3. Arora S, Tewari S. The morphology of the apical foramen in posterior teeth in a North Indian population. Int Endod J 2009;42:9309.
4. Nair PN. On the causes of persistent apical periodontitis: A review. Int Endod J 2006;39:249-81.
5. Chaudhari A, Asthana A, Parmar A. Significant of apical third: A review. Sch J App Med Sci 2014;2:1613-7.
6. Hargreaves K, Berman L. Cohen's Pathways of the Pulp. 10th ed. St. Louis, Missouri: Elsevier; 2010. p. 137-40.
7. Deus Q, Horizonte B. Frequency, location, and direction of the lateral, secondary, and accessory canals. J Endod 2000;11:361-7.
8. Pineda F, Kuttler Y. Mesiodistal and buccolingual roentgenographic investigation of 7,275 root canals. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;33:101-10.
9. Sachdev S, Munde A. Correlation between age related histologic changes at the root apex and measurement of working length. J Endod 2008;14:585-90.
10. Burke FM, Samarawickrama D. Progressive changes in the pulpo-dentinal complex and their clinical consequences. Gerodontology 2000;12:57-66.
11. Slowey R, Carlos S. Radiographic aids in the detection of extra root canals. J Endod 2011;37:762-71.
12. Ove A, Peters PD. Current challenges and concepts in the preparation of root canal systems: A review. J Endod 2004;30:559-67.
13. Baugh D, Wallace J. The role of apical instrumentation in root canal treatment: A review of the literature. J Endod 2005;33:333-9.
14. Tan B, Messer H. The quality of apical canal preparation using hand and rotary instruments with specific criteria for enlargement based on initial apical file size. J Endod 2002;28:658-64.
15. Alsalleeh F, Almeida J. Efficacy of the EndoActivator system used throughout the endodontic cleaning and shaping procedure to disinfect the infected root canals. Int Endod J 2017;29:7-10.
16. James L, Gutmann M. Surgical endodontics: Past, present, and future. Endod Top 2014;30:29-43.
17. Torabinejad M, Corr R, Handysides R, Shabahang S. Outcomes of nonsurgical retreatment and endodontic surgery: A systematic

review. J Endod 2009;35:930-7.
18. Vasudev SK, Goel BR, Tyagi S. Root end filling materials-a review. Endod J 2003;15:12-8.
19. Lee SJ, Wu MK, Wesselink PR. The efficacy of ultrasonic irrigation to remove artificially placed dentine debris from different-sized simulated plastic root canals. Int Endod J 2004;37:607-12.