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WORKING WIDTH: UNDIVULGED CONCEPT IN ENDODONTICS

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ABSTRACT

The elementary goal of the dentist is 3-dimensional cleansing of the root canal system. Pertaining to canal preparation, cleaning and shaping to the definite working width and length is most important. Working width is the horizontal dimension of a root canal. The aim of this article is to review the importance of working width, factors affecting working width and recent advancements for determining the working width.

INTRODUCTION

Comprehensive understanding of anatomy of the tooth is important for success of endodontic treatment. The main objective of the endodontic treatment is to achieve a microorganism free environment and hermetic seal.[1,2] So to achieve these objectives, the clinician must determine 3 clinical parameters: Working length of the canal, working width of the canal and taper of the preparation.[3] Working width refers to the canal diameter coronal to the apical constriction.[4] For proper apical sealing it requires complete debridement of apical area without removing unnecessary root dentin. Incorrect working width (WW) will cause either excess dentin removal or incomplete cleaning of the apical area.[1]

The main aim of this paper is to perform an updated literature review of working width in endodontics based on available upto date scientific literature. Four electronic databases PubMed, Scopus, Science direct and Web of science were used to perform a literature search from last three decades using the keywords: Working width, factors affecting working width, Apical seal, dynamic navigation system, Cone beam computed tomography, SAF file. Following the literature search, 44 articles were identified and included in the review.

The current breakthrough in the imaging systems like cone beam computed tomography, microcomputed tomography, dynamic navigation system helps in better understanding of the working width along the length of the root canal.

Significance of apical third

Determining the definite working width in apical third is most challenging because of its internal anatomy. Apical sealing of root canal is more important, and it is difficult to seal as apical Foramen may exit on mesial, distal, buccal or lingual surface of the root. It may also lie 2-3 mm away from the anatomic apex.[5,6] In the infected canal apical 3 mm is most critical as Micro-organisms located at this region have better accessibility to periapical tissue and contain apical and lateral ramifications of the main canal that form a communication between the pulp & periodontium.[7,8,9,10]

Ramifications can be observed anywhere along the length of the root, but they occur more commonly in the apical portion and in posterior teeth.[9,11]

A review article by Domenico et al,(2010) described that in 73.5% of the cases, ramifications are found in the apical third of the root, in 11% in the middle third, and in 15% in the coronal third.[12] Hence Root canal system need to be enlarge sufficiently to remove debris and proper irrigation to apical third of the canal.

According to Wein's modification, if periapical bone resorption is evident radiographically, the working length is reduced to 1.5 mm short of apex. If apical root resorption is seen, the working length is reduced 2 mm short of radiographic apex.[5,13] In such cases, working width should be determined to its definite modified working length.

Working width

Dr. Yi-Tai Jou et al (2004) from university of Pennsylvania defines that, working width is the diameter of the canal that corresponded to the tip size of the final instrument which reaches up to the working length.[1] It

is also called as "Forgotten Dimension" by Carl Hawrish, an endodontist from Canada.[1,4,14,15,16,17]

Kumar M (2016) described the minimum initial working width as initial apical file size, which binds at working length.[3] The maximum final working width which corresponds to the master apical file size.

Wu et al (2000), described that the diameters of apical canals vary greatly in all tooth groups hence no established size is desirable for the apical enlargement.[18] Grossman, Ingle, Bakland, and Weine recommended enlarging the apical root canal to three sizes beyond the first file that binds at the established working length.[3,11,14,15,19,20]

Walton and Torabinejad introduced the concept of apical clearing, which involves the sequential use of files 2 to 4 sizes larger than the master apical file in reaming motion throughout the working length.[11]

Michael K et al (2020) in his study evaluated that, to determine accurate apical size, sufficient cervical preflaring is helpful.[21] However, disproportionate enlargement of the cervical region and the removal of pericervical dentin result in diminished root strength and reduced resistance to vertical root fracture.[7]

Even though there are many studies on the scales and average sizes of root canals, there have been only a few clinical attempts to determine the working width. Horizontal dimension of the root canal is more difficult to investigate than vertical dimension, as it is difficult to section all the levels of the teeth and make the section plane exactly perpendicular to canal curvature.[3]

Factors affecting the determination of initial working width at apical third of the canal

Canal taper, Canal length, Canal shape, Canal curvature, Canal wall irregularities, Canal contents.[1,3,4,22]

Canal taper

Biradar et al (2022) reviewed, Disparity between the gauging instrument and canal tapering may lead to engagement of the instrument into the canal wall leading to erroneous sensation of apical binding and causes the determination of initial working width difficult.[1,23]

As stated by Loai Alsof (2019), Instruments with progressive taper can shape canals more quickly than instruments with constant taper.[22]

Canal length

Compared to the canals with short working length (<25mm), canals with working length (>25mm) shows high frictional resistance which will affect the tactile sense of the clinician in determining the initial working width.[1,23] Mei Tang (2018) in his study concluded that canal curvature is a confounding factor to canal length which in turn affects the working width.[24]

Canal shape

The working width of the root canal and its cross-sectional shape can vary immensely from the orifice to the apex. The shapes are classified as round, oval, elliptical or ribbon shaped.[16,25] The number and shape of canals in each level will vary accordingly.[9] Round canals offer better determination of initial working width compared to other canals. Wu et al (2000) in his study described most of the canals are oval in cross-section.[18] Steve Senia (2008) described root canals with oval shape have two diameters, a minor and a major diameter. The quality of cleaning and shaping is mostly dependent on instrumenting to the major diameter.[15]

Canal curvature

Curvature in the canals causes deviation of gauging instrument and increases the frictional resistance. Root curvatures can be described by Schneider into straight (5 degree or less), moderate (10-20 degree), severe (25-70degree).[26,27,28]

Each type of curvature influences the clinician's tactile perception in distinct ways.[24,29,30] Roane et al. (1985) demonstrated that coronal flaring can reduce the curvature magnitude, enabling accurate measurement of the working width.[31] Additionally, James B et al. (1985) highlighted that the principle of balanced forces facilitates the enlargement of canals with severe curvatures, while maintaining the integrity of the canal diameter.[31]

Canal wall irregularities

Internal and external resorption will produce concavities on the canal surface. Attached pulp stones, reparative dentin and denticles will create convexities on the canal surface. Both these have an influencing role in determination of true working width.[23,29] In a study of 80 mesial canals of lower first and second molars, Kumar M et al. (2016) found that irregularities in the canal walls create false pressure against the file, which interferes with the clinician's tactile sensation, making it difficult to determine the precise contact and tightness at the apex.[3]

Canal contents

The contents of the canal may be fibrous or calcific in nature. Both will affect the tactile sense of the clinician and increases the frictional resistance of an instrument.[29]

Special considerations

Teeth with immature or incomplete apical formation pose a challenge in determining both working length and width due to the presence of large open apices and thin dentinal walls which are very much susceptible to fractures during or after root canal treatment. Hence while performing chemo mechanical preparation of the tooth, preserving the remaining dentin thickness along the diameter of the canal is important. Frequently they are associated with periapical lesions and inflammatory

apical root resorption further makes the course of the treatment lengthy.[32,33,34]

Minimizing the influence of affecting factors

Proper awareness of the affecting factors in determination of initial working width is the major step that helps to increase the accuracy.[23]

Before determining the initial working width, it is advisable to enlarge the canal orifice and perform early coronal enlargement. This enhances irrigation efficiency and helps maintain the clinician's tactile sensation.

Contemporary innovations

Cone beam computed tomography is the gold standard investigation that defines the root canal length and its width.[4,7,14,23] In accordance with Biradar et al (2022) CBCT is the most favorable preoperative analysis for measuring working width compared to radiographs, Light speed rotary instrument technique and Micro CT.[1]

Micro CT imaging is a multiplanar radiographic imaging technique which provides a detailed root canal anatomy with its width along the length till the apex. But due to the disadvantage of radiation dose and increased exposure time, it is mostly used in invitro laboratory interpretations.[1,4,7,14,23]

New innovations like the S curve design of the TRUshape for cleaning and shaping has a property to deform according to the canal shape and dimension, thus it helps in preserving the dentin thickness and maintaining proper working width.[4,14] TRUShape provides conservation of dentin by limiting dentin removal and prevents canal transportation.[35]

Reden Nova introduced Self-adjusting file (SAF) systems which adapt to the canal shape and produce 3-dimensional cleaning of the apical part of the root canal.[4,14] A study done by Ana Arias et al (2017), proved SAF maintains better original ribbon-shaped anatomy of the root canal compared to other rotary systems.[1]

Zvi Metzger et al (2010), proposed that SAF file has better features compared to rotary Nickel titanium (NITI)files as NITI files results in uneven thickness of remaining dentin wall when manipulated in flat root canals. This uneven remaining dentin thickness makes the tooth more susceptible to vertical fractures. Whereas SAF file removes the uniform layer of dentin from the canal wall thus maintaining the proper working width.[36]

XP-endo finisher file recently introduced for the management of Un instrumented areas of the canal.[4,14] It is a continuous rotation file with high flexibility which can perform at variation of temperatures and takes the shape of the canal. These are more effective in removal of smear layer and debris in isthmus, fins, accessory and lateral canals in root canal system.[37]

Dynamic Navigation System (DNS) is based on computer-aided surgical navigation technology and analogous to global positioning systems or satellite navigation.[38] DNS is a promising technique with a high degree of predictability and a low risk of iatrogenic damage.[39]

Preparing access cavities with definite working width in calcified teeth is clinically challenging. Mistakes in this critical step are often destructive, especially in teeth with minimal dentin, such as mandibular incisors. An unsuccessful attempt for locating calcified canals may result in gouging, perforation, and excessive dentin loss.[40]

Dianat et al. examined the performance of a Dynamic Navigation System (DNS) to prepare access cavities in calcified human teeth and compare the results with the Free Hand (FH) technique. The results showed as compared to FH technique DNS showed less reduction in dentin thickness maintaining the working width.[38]

Ultrasound is a non-ionizing, non-invasive, real-time, chairside modality that generates cross-sectional images to assess both soft and hard tissues. It utilizes acoustic waves that are transmitted into the body, where they are scattered or reflected back to the transmitter upon encountering tissue interfaces. The Curie brothers first discovered the fundamental concept and application of ultrasound in 1880.[41,42,43]

A recent advancement in ultrasound technology is ultrasonic endodontics, which is used for preparing the root canal system in specific clinical situations where determining the proper working width and working length is challenging, such as in cases of anatomical defects, accessory canals, and calcified canals.[44]

Chaniotis et al. (2021) stated that ultrasonic tips are effective in removing calcifications from the pulp canal and pulp chambers with minimal dentin removal, thereby helping to preserve the horizontal dimension of the canal.[30]

CONCLUSION

To summarize, the concept of working width has been acknowledged and implemented by endodontic experts for decades. Currently, there is no standardized instrument, technique and guidelines to determine definite working width. Additional studies, clinical guidelines, histopathological investigations, technical advancements in imaging techniques and awareness in Navigation technologies are required for adequate determination and management of working width.

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