Review Article

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Methods to Determine Root Canal Curvatures and its Managements

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ABSTRACT

Background: Endodontic treatment consists of different steps including access cavity preparation, instrumentation, irrigation and obturation of root canal system, which can all influenced by root canal curvature. It is necessary to know the severity of root canal curvature to select the correct instrument and instrumentation technique. Severe canal curvatures of different degrees within the roots can lead to a variety of errors such as ledge formation, separation of instruments, perforation, canal blockage or teardrop transportation at the apex. The anatomical variations of complex root canal morphology may lead to endodontic treatment failure, so it is essential to have thorough knowledge of external and internal morphologies of the teeth. This paper reviews different methods used to determine root canal curvature, its significance and how to manage it with various instruments and instrumentation technique.

Keywords: Curvature, root canal, endodontics.

INTRODUCTION

Endodontic therapy involves treating vital and necrotic dental pulp so that patients can retain their natural tooth in function and esthetics.[1] Endodontic treatment consists of different stages including access cavity preparation, instrumentation, irrigation and obturation of root canal system which can all influenced by root canal curvature, even the teeth with straight roots can harbour severely curved canals, although successful therapy depends on all these factors, one of the most important steps in any root canal treatment is canal preparation. This is essential because preparation determines the efficacy of all subsequent procedure, but canal preparation is adversely influenced by highly variable root canal anatomy which can not be accurately visualized by radiographs.[2-3]

Most root canals are curved, whereas endodontic instruments are manufactured from straight metal blanks due to which uneven force distributes in certain contact areas[4-5] and tendency of instrument to straighten itself inside root canal[6] resulting in over preparation of apical area towards outer curve or convexity of the canal, whereas more coronal area are transported towards concavity or furcation in multirooted teeth.

CLASSIFICATION OF ROOT CANAL CURVATURE

1. According to anatomic location-

(a) Apical third curvature

(b) Middle third curvature

(c) Coronal third curvature

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2. Schneider's classification –

(a) Straight (if angle <5)

(b) Moderately curve(if the angle is 10-20)

(c) Severely curve (if the angle is > 20)[7]

3.Dobo-Nagy classification –

(a) I shape (straight)

(b) j-shape (apical curve)

(c) c- shape (entirely curve)

(d) s- shape (multi-curve)[8]

4. Radius based curvature -

(a) Severely curved (r >4mm)

(b) Moderately curved (r 4mm-8mm)

(c) Mild curvature (r 8mm)

5. Shape-based curvature –

(a) Apical gradual curve

(b) Sickle shape curve

(c) Bayonet curve

(d) Dilacerated curve

METHODS TO DETERMINE ROOT CANAL CURVATURE

Root canal curvature should be determined preoperatively to avoid procedural errors and subsequent treatment failure.

Periapical radiograph- Periapical radiographs are most commonly used during root canal therapy worldwide because of convenience and low cost but it is difficult to assess root canal curvature on it because it forms 2- D image of a 3 D object , so that curvatures that are present buccolingually may not be visible. Most of the canals do have some curvature on different planes and thus it is difficult to assess then solely on the basis of radiographs.[9]

Cone Beam Computed Tomography – CBCT is a new advancement in the field of radiology and is used for detailed 3D imaging of oral and maxillofacial structure. CBCT helps in assessing the true size ,extent , nature and position of the lesions as compared to conventional radiography.[10] Periapical pathology can be detected sooner as compared to other radiological approaches as the lesion that are present in the cancellous bone can only be detected using CBCT.

The radius of root curvature can be determined through CBCT measured by circumcenter using Planimp software (CDT Informatics,Cuiaba, MT, Brazil,3D imaging system)based on the 3 mathematical points. CBCT provides a better view of root canal morphology as compared to radiograph.

The radiation dose of the CBCT is much less than the medical scanner or conventional radiograph.

Schneider's method

Using this method, a mid-point is marked on the file at the level of the canal orifice. A straight line is drawn parallel to the image, and that point is labelled as point A.

Another second point is marked where the flare starts to deviate that is labelled point B. A third point is marked at the apical foramen and is termed point C and the angle formed by the intersection of these lines is measured [Figure 1]. If the angle is less than 5°, the canal is straight;if the angle is 5-20, the canal is moderately curved; and if the angle is greater than 20°, the canal is classified as a severely curved canal.[11]

Lutein method

Lutein *et al*. modified Schneider's method by using twolines drawn by the identification of four geometric points.

Point A is first marked at the center of the canal orifices and then point B is marked 2 mm below the orifices in the long axis of the canal. A first primary line is drawn joining point A and point B and then point C is marked 1 mm coronal to the apical foramen. Point D is marked at the apical foramen then a second primary line is drawn joining these two lines [Figure 2]. The angle formed by intersection of the two lines is measured as in the Schneider method.

Cunningham's and Senia's method

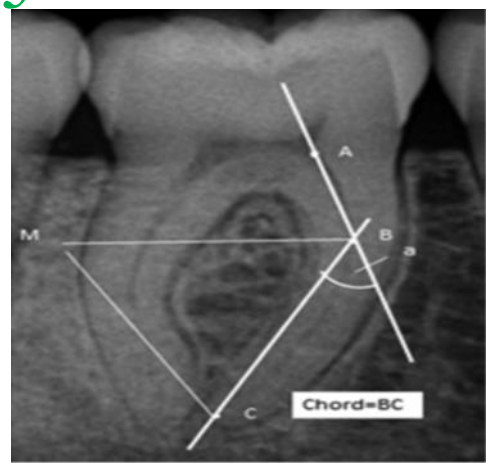

Fig 1: Diagrammatic representation of Schneider's method.

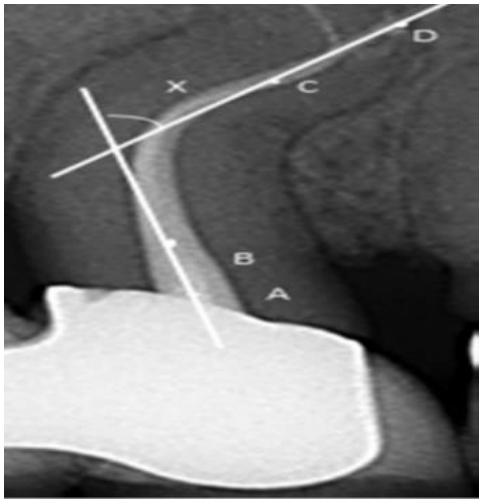

Fig 2: Diagrammatic representation of Lutein method.

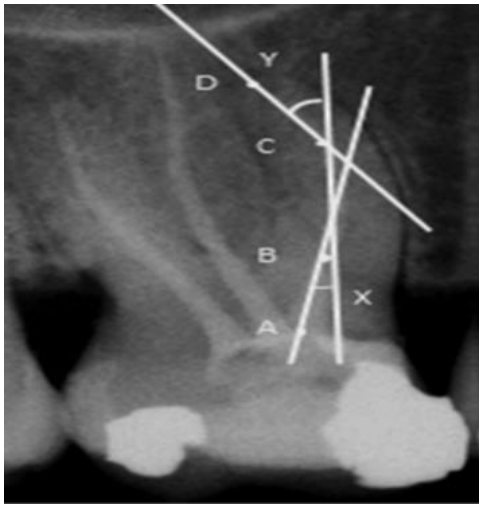

Fig 3: Diagrammatic representation of Cunningham's and Senia's method.

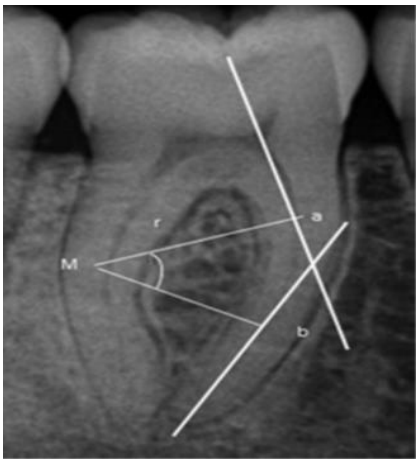

Fig 4: Diagrammatic representation of Weine's method.

This approach is different as it focuses on multiple root curvatures, that is S-shaped canals, and the angle is measured separately at the coronal and apical ends. Point A is first drawn at the centre of the orifices and then Point B is marked where the deviation or curve of the canal starts and a line is drawn joining these two lines. Point C is then marked where the canal again changes its direction or the deviation starts and points C is joined with point B. Point D is finally marked at the apical area and joined with point C. The angle formed by the intersection of lines through points A and B and then points B and C is named angle X while the angle formed by the intersection of lines through points B and C and points C and D is named angle Y.[12]

Weine's method

Weine described another method for the determination of root canal curvature similar to Schneider's method [Figure 4] but showed the differences in the angles according to the curvature of the canal. In this method, a straight line is drawn from the canal orifices to the point of curvature and a second line is drawn from the apex for the apical curvature and the angle is measured at the point of intersection between the two lines.[13]

Role of NiTi (Nickel Titanium) instrument in curved canal:-

Using stainless steel files causes high lateral forces in the curved canal due to their high stiffness that increases with increasing instrument size. The unique property of superelasticity may allow NiTi

files to be placed in curved canals with less transportation and decreases the incidence of canal aberrations.[14]

NiTi alloy can exist in two different temperature-dependent crystal structures named austenite (high-temperature) and martensite phase (low-temperature phase), with typical characteristics which are superelasticity(SE) and shape memory effect (SME) .These properties occur as a result of the austenite-to martensite transition (martensitic transformation), which can be induced by stress or temperature.[15]

R-phase may appear prior to the transformation to martensite. Thermomechanical treatment of NiTi alloy allows a change in the phase composition leading to the appearance of martensite or R-phase under clinical conditions. M-Wire and R-phase instruments maintain an austenitic state, CM Wire, as well as the Gold and Blue heat-treated instruments, is composed of substantial amounts of martensite.

The austenitic instruments possess superelastic properties and reveal high torque values at fracture. Thus, these files are appropriate to shape straight or slightly curved root canals. Additionally, the use of austenitic alloy in pathfinding instruments may compensate for the decreased torque resistance caused by the smaller diameter of these files. Due to an increased amount of the martensite phase, martensitic instruments are more flexible with enhanced resistance to cyclic fatigue and reveal a greater angle of rotation but lower torque at fracture.

Cyclic fatigue is known to occur more likely in complex curvatures and root canal anatomies. Thus, martensitic instruments should be preferred in cases of severely curved root canals or those with a double curvature. Moreover, martensitic instruments are prebendal, which can be useful when trying to bypass ledges.[16] NiTi rotary instruments if used properly, can achieve a final root canal preparation that conforms to general shape and direction of the original canal.

Different Instrumentation Technique

Schilder described the concept of flow and design objectives accordingly to which the canal should be tapering with apical foramen essentially as narrow as possible without altering its original position.[17]

Ideal canal preparation may not always be possible due to certain factors including complex root canal morphology anatomical variations, microbiological variations and iatrogenic mishaps.

MANAGEMENT OF ROOT CURVATURES

Managing apical curvature-

Apical third of root canal is mostly curved and it attempts made to straighten it may lead to treatment failure because of direct perforation, the formation of ledges and creation of teardrop foramen.

The preparation should be started using a smaller diameter K file such as 8 or 10. These files can also be precurved in the direction of apical curvature.[18] There are two types of precurving.One is placing an extremely sharp curve near the tip of instrument. This is used when the preoperative radiograph discloses a sharp apical dilacerations or when an obstruction is encountered. The other precurve is gradual for entire length of the flutes.

Incremental instrumentation/instruments with intermediate sizes- in curved canals even small increment of 0.05mm between instruments is great, so a new instrument may not achieve the same position that previously achieved by smaller size, to overcome this 0.5mm segment can be clipped from 10 file to make it 11 or 1mm clipped to make it 12 so on. Several companies have manufactured file systems that incorporate aspects of this technique. Currently available sizes are no. 12,17,22,27,32,37.

Chelating agent such as EDTA must be used used, along with copious irrigation of canals with NaOCl (sodium hypochlorite) and after withdrawn of file from the canal, it must be cleaned and recurved before reintroducing it.

Table 1: Many techniques of canal preparation have been described which are as follows:

Instrumentation technique	Method	Merits	Demerits
1.Balanced force technique	Placement phase(placement of file with the clockwise motion of maximum 180° with apical advancement). Cutting phase (counterclockwise rotation of 120° with apical pressure). Removal phase(clockwise rotation with the coronal movement of file.	-Better apical control of the file. -Less amount of extrusion of debris from the canal. -Good centring of the instrument in the canal.	High incidence of procedural errors such as instrument breakage and canal stripping. -require more working time.
2. Step back technique	Apical preparation is done with smaller files, and then the length of the file is reduced with an increase in file size.	Comparatively better than the standardized procedure.	Increased incidence of perforation and iatrogenic errors in severely curved canals.
3.Step down technique	The coronal portion of the canal is prepared before the apical part and then the apical area is ready with smaller files.	Less periapical extrusion of debris. -Less apical zip formation. -Fewer chances of ledge formation. -Straight access to the apical region.	Increased incidence of ledge formation.
4.Hybrid technique	Involves a combination of the crown down and step back technique. Phase I- coronal third instrumentation Phase II- apical third Phase III- middle third	-Ability to shape the canal predictably with hand instrumentation using stainless steel instruments. -Optimizes the advantages of the crown down and step back techniques.	-Middle third preparation has to be done carefully in order to prepare a continues tapered canal preparation.
5.Standardized technique	The file or reamer is inserted to the full working length, and the canal is cleaned.	-Easy to prepare straight canal.	-Ledge formation zipping and perforation in severely curved channel.
6.Anticurvature technique	Selective filling in the coronal portion of curved canals to prevent strip perforation into furcation, the walls on the opposite side from the curve are instrumented more than inner walls, resulting in decrease of overall degree of canal curvature.	-Less incidence of perforation in curved canals.	Require expertise.

The diameter of the glide path is then increased with NiTi hand files before the preparation of the canal with rotary NiTi file[19] to prevent instrument separation or ledge formation.

Managing middle curvature –

Mid canal curvatures are relatively difficult to handle, if not properly handle it may lead to iatrogenic errors.

-Preoperative evaluation and usage of the correct instrumental technique are highly recommended.

-Two steps should be followed for better management of mid –root curvature i.e. adequate access and good coronal third preparation, this will ensure the greater volume of irrigants to reach the mid-portion of the canal and allow instrumentation without any restriction and thus create an ideal platform for preparation. Once the coronal third portion of the canal is prepared, the mid-portion is prepared using pre-curved files.

The bend given on the file should be gentle because sharp acute bend may lead to file fracture. The precurve file helps in negotiating the canal and makes a glide path before rotary NiTi files are introduced for cleaning and shaping.[19,20].

Rotary systems in the management of curved canals

Following are the steps which has to be followed while doing rotary instrumentation: -

Straight-line access should be made.

The cross-sectional diameter of a canal needs to be confirmed with hand instruments before introducing a rotary shaping file; sufficient space must exist to accommodate and guide the noncutting or partially active tip of rotary instruments.

Root canal anatomy should be known. Scouter files, provide critical information regarding the curvature, curvature or dilacerations of a canal. Rotary instruments need to be used according to the guidelines provided by the manufacturer. To reduce the potential for breakage , rotary shaping files are best used starting with large diameter or taper and then proceeding to smaller size instruments , by using the instruments in the crown down fashion , the area of the file engaging the canal is minimized thereby reducing the torsional stress exerted on the instrument.

Lubricate and "light touch" to reduce the risk of breakage; rotary shaping instruments are always used in the presence of a lubricating irrigant. Rotary instruments should be used passively within the canal furthermore one may not rotate the file for more than 10 sec in the canal, and during this period of time, the instrument may not stop rotating.[21]

CONCLUSION

Root canal treatment can be very challenging for an endodontist due to complex anatomy and presence of severe root curvatures that cause hindrance during ideal preparation of canal. Negotiating these canals depends on the size and construction of the canal, degree of curvature, size and flexibility of the instrument along with the skills of the operator.

Therefore, preoperative assessment of horizontal and vertical variations of the canals should be done, and selection of proper instruments and instrumentation technique is essential to avoid procedural errors such as separation of the instrument, ledge formation, blockage, Zip or elbow formation. However, In curved canals use of rotary NiTi files(martensitic phase) after making a glide path with hand stainless steel files is recommended.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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