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Factors Influencing Ledge Formation and Its Management in Endodontics

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Abstract

Endodontic treatment can be predictable, successful, and relatively easy to perform if every individual step is performed appropriately. Hasty mechanical and chemical manipulation of the root canal system can lead to procedural error. Procedural accidents during endodontic treatment occurs either due to inadequate attention to the details. Removal of canal wall structure on the outside curve in the apical half of the canal due to the tendency of files to restore themselves to their original linear shape during canal preparation may lead to ledge formation and possible perforation.

Keywords: *Ledge, Procedural error, Endodontic Mishap, Prevention and management*

Introduction

Among the complications that occur during endodontic procedure ledge is the most common endodontic mishap. Endodontic mishaps are error that occurs due to lack of enough attention to the details or sometimes it happens unintentionally by the clinician. [1,2] Even the most experienced clinician may commit procedural error like ledge, the successful endodontic treatment is based on thorough knowledge regarding internal and external anatomy of teeth.[3,4] Insufficiently designed access cavities lead to an improper guiding of the instruments by the walls of the cavity with a loss of control of the instruments during root canal preparation leading to ledge.[5] The other factors that could result in ledge formation are inaccurate working length, instrument material used for cleaning and shaping, irrigation, instrument design and instrumentation technique. This review addresses the causative, prevention and management of ledge formation in endodontics.

Preoperative assessment

Clinicians should know the tooth morphology, crown root angulation of teeth, any variation in the morphology and any calcification within the canal should be accessed before the start of access cavity. An Assessment is done by visual examination, radiological evaluation with preoperative x-ray, following SLOB technique wherever needed and also using dyes when difficult to assess with regular x-ray. These methods will help you to evaluate the architecture, internal and external anatomy, number of canals, any branching of canals, lateral canals, curvature of canal and the relationship of canal orifice to the pulp chamber and externals surface of teeth. Root curvature could be of different degree it can be straight (lesser than 5°), moderately curved (10-20°), severely curved (greater than 20°). It was shown that degree, position and severity of canal curvature are some of the factors that is important.[4] Studies have shown that root curvature more than 20 degree produces more ledges [5], whereas root canals with less than 10 degree curvature produces less ledges.[6] Use of inflexible larger instrument in curved canal results in ledges. Cleaning and shaping of canals which are narrow or calcified produce more ledges hence the evaluation of the internal anatomy of teeth before the commencement of endodontic therapy is needed.

Access related

The main purpose of an access opening is to create an unimpeded passageway to the pulpal space and apical foramen of the tooth. This preliminary step of preparation of the access cavity, the opening in the dental crown permits localization, cleaning, shaping, disinfection, and three- dimensional obturation of the root canal system. The success of the endodontic treatment depends on precise, proper execution of access cavity[7].Failure of the adequate extension of access cavity will prevent the access to the apical part of the root canal resulting in ledge. [5,8,9]

An access cavity that has been prepared improperly in terms of position, depth, or extent will hamper the achievement of optimal results. There should be unobstructed access to the canal orifices and direct access to the apical foramen. After locating the canal orifices endodontic files are introduced into the canal to determine whether the instruments are either "under stress" or free of interfering tooth structure. If there is any binding seen than the coronal outline form is extended to free up the shaft of the file. The operator would not be able to control over the direction of the tip of the instrument and it would gouges into the wall of the canal resulting in ledge if there is binding. Significant crown root angulations are common in maxillary lateral and mandibular premolar. Severely tipped or a crowded teeth requires modification in the access preparation. There should be proper aligning of the round bur vertically with the long axis of the tooth, failing which results in ledge and perforation. Incorrect assessment of root canal direction results in ledge. Conventional radiograph can tell us mesiodistal curvature but not buccolingual[10], hence it would result in wrong estimation of root canal direction.

Working length related

Accurate method of working length determination should be done either with radiographic or non-radiographic method. Many times ledges are formed when the operator works the files short of the full canal length and the canal becomes blocked at that point, which is short of the working length or it might begin to deviate from the canal path resulting in transportation. Improper working length is one of the main causative in ledge formation.[5,11] We should maintain the working length during entire procedure of cleaning and shaping failing to do this would result in ledge.

Instrument Material used for Cleaning and shaping

Between stainless steel and Nickel titanium instruments studies have shown that using a bigger non curved stainless steel instrument in a curved canal resulted in more ledges.[7,12] When comparing between hand instruments, Stainless steel and Nickel titanium in a study done by Pettiette et al showed more straightening in stainless steel hand instrument when compared to Nickel titanium hand instrument in curved canal.[13] Namazikhah et al, compared between hand and rotary files to show the higher incidence of ledges with hand when compared to rotary.[14] Xu et al studied the cleaning and shaping with hand instrument in curved canal produces more ledges when compared to protaper rotary system.[15]Nickel titanium instrument can retain the shape of the curved canal and does not straighten like stainless steel.

Irrigation

Inadequate irrigation and lubrication during instrumentation result in blockage of canal [18] due to accumulation of dentin mud in the canal. If there is ledge filing is performed with lots of irrigant with short vertical strokes always keeping the file tip apical to the ledge. Sodium hypochlorite is the commonest irrigant used it dissolves the organic portion of dentine and has antibacterial property, but it might affect the flexural strength of dentine and potentially influence the adhesive capacity of dentine. Chelating agent is helpful but should be used with caution because excessive use of chelating agent results in perforation because it would soften the dentin. It is recommended to use chelating agent carefully in narrow, curved or ledged canal, but liquid EDTA is used as a final rinse to remove smear layer. Surfactants are compounds of lower surface tension they are used in conjunction with commonly used irrigants such as EDTA, Chlorhexidine and Sodium hypochlorite. They act as wetting agent, emulsifier, detergent and lubricant to assist cleaning and shaping procedure.

Design feature of Instruments

Tip design: Use of instruments with sharp cutting

tips produces more ledges when compared to modified tip design. Tip design with biconical shape produces less of ledges when compared to conical and pyramidal shaped. Zmener and Marrero in their Scanning electron microscope study compared between Tri-files, Flex-R files, Flexo files, and K files in curved root canal 0% ledges were seen with Tri-files & Flex-R, whereas 10% ledges were seen in Flexofile and 30% ledges in K-file.[16] Flex R files are made by removing sharp cutting edges from the tip of instrument called as modified tip design to reduce the ledge formation. When pyramidal tip design was compared with conical and biconical tip design ledges were more commonly seen with pyramidal tip which has sharp transition and a forward cutting ridge on the face when compared to conical tip which has sharp transitional angle and a smooth face and biconical tip which has reduced transitional angles and dual- guiding faces.[17] Modified- tip files tend to maintain the original canal curvature better like flex R files,Control safe file, Anti ledging tip files and Safety hedstrom files rounded tip design of these files does not cut into the wall but will slip alongside it. Rotary files can have either cutting or noncutting tip. Protaper rotary files have convex triangular cross-section but they have finishing files which are non-cutting blunt tip and shaping files which are partially active thereby reducing ledge and perforation. Protaper, Profile, Hero 642, GT files and RaCe have non cutting tip whereas Quantec, flex master and K3 have cutting tip. Using C-file which has stronger buckling resistance compared with K-files provides easier access to the apical portion of canal and allows easier location of the canal orifices and thereby reducing the incidence of ledges. The pyramid-shaped tip facilitates insertion during negotiation of the canal and the square cross-section provides better resistance to distortion.

Rake angle

Rake angle is the angle formed by the leading edge and the radius of file. If the angle formed by the leading edge and the surface to be cut is obtuse than it is positive rake angle and if it is acute than it is negative rake angle. If Rake angle is slightly positive, results in an effective cutting action but if it is too positive, the blade becomes engaged into the surface excessively and binds without forming chips. A negative angle will scrape the dentin rather than cutting it. Protaper, Hero 642, RaCe, K3 and flex master exhibit positive rake angle resulting in optimum cutting efficiency. Light speed and Greater taper show neutral rake angle and profile has negative rake angle.

Instrumentation technique that reduces and corrects ledge

Balanced force technique which was introduced by Roane and Passive step back technique are considered to reduce the incidence of ledging.[18] Studies have shown that apical patency reduces formation of ledges; it is a technique in which the apical portion of the canal is maintained free of debris by recapitulation with a small file through the apical foramen. Stadler et al clinically studied 520 samples to show the treatment done by supervised dental student had more ledge effect with reaming technique in comparison with filing technique. Root canal curvature with more than 35 degrees has main effect on incidence of ledges.[22] Pre-curving the instrument and following sequential use of instrument [5,8], reduces the incidence of ledges.[1] It should be noted that in tightly curved canals where it is extremely difficult to advance from a No. 10 file to a No. 15 file, there are "half-step" files that are commercially available as FlexoFile Golden Mediums studies have shown that subsequent filing with these modified files will open the canal some more and render it more suitable for negotiation with the next available standard size.

Anticurvature filling- Bypassing of ledge is removal of ledge by instrumentation and obturation at new working length. It is done in two steps, in first step the entire canal pathway coronal to the ledge must be relatively straightened to allow correct file operation. This is done by filing against the wall opposite the apical curvature with instrument used in sequential order without skipping the size in retraction-rotation motions. Second step in bypassing a ledge is by following anticurvature filling technique. The resistance of the endodontic instruments to deformation, referred to as elastic memory by forcing a straight instrument into a curved path it tends to uncurve, and as a result the tip of the instrument cuts more into the wall opposite the curve by following this steps we could bypass the ledge. Anticurvature filing was compared with the stepback technique in a study Anticurvature technique reduces ledge and perforation than step back technique.[21]

Passive step back provides a gradual enlargement of root canal in apical coronal direction. This technique uses hand files and GG drill or peeso reamer to provide sufficient coronal flaring before apical root canal preparation, resulting in easier access to irrigation and removal of debris. They provide straight line access to the apical foramen and reducing procedural error like ledge formation.[19,20]

Balanced force technique is used in curved canals using more flexible Flex R file. It is made of triangular shaped flute design with biconical tip and increased flute depth. Flex R file is turned 1/4 turn with apical pressure in clockwise direction and then again, with apical pressure, 3/4 turn counter clockwise direction is used.

Anti-Zipping Preparation System for Curved Root Canals

This technique was introduced by Benjamin Brisefio Marroquin. Ideally, the curved root canal has two sides concave side and convex side, towards the inner side is concave and towards outer side is convex. The original canal axis should not be transported either in a concave or convex direction it should follow the canal path during root canal preparation. This is done in four phase, first the straight portion of the canal is prepared with Peeso reamers depending on the anatomic consideration of each canal. In second phase we need to prepare the concave portion or inner side of the canal. In third phase we need to prepare the convex portion of the canal axis of canal moves to the original position. Finally in fourth phase we have to remove the irregularities that are left at the interface of manual and mechanical preparation.[23]

Conclusion

Ledge formation is one of the procedural error that occurs frequently. It is important to understand the cause of ledge formation and thereby prevention or management plays a key role in the endodontic success. Outcome of the treatment depends on how well the canal has been disinfected and the ledge formation is managed before obturation. This review might help the clinician to understand the prevention, consequence of ledge and its management. Operators are recommended to have lot of perseverance and patience while managing ledge.

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