ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)
IJDSIR : Dental Publication Service
Available Online at:www.ijdsir.com
Volume – 7, Issue – 4, August – 2024, Page No. : 203 - 209

Newer approach to modern endodontic access cavity: A review

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Citation of this Article: Dr Rashmi Misra, Dr Nikita Toprani, Dr Mansi vandekar, Dr Shreya Gupta, Dr Gayatri Pendse, Dr Shradha Tapadiya, “Newer approach to modern endodontic access cavity: A review”, IJDSIR- August – 2024, Volume –7, Issue - 4, P. No. 203 – 209.

Type of Publication: Review Article

Conflicts of Interest: Nil

Abstract

The foundational concepts of access cavity preparation established by G.V. Black, Guttman, Weine, and Grossman, have endured over time. Success of endodontic treatment depends on access cavity design. In traditional cavity design, an extension for prevention is performed to ensure straight-line access to the foramen or the primary curvature of the canal. This process leads to the weakening of the tooth structure and increasing the risk of fracture. David Clark and John A. Khademi introduced a new approach to modern endodontic therapy. The recent concept in access cavity design is preserving as much as natural tooth structure and being more conservative. This change is made possible because of new armamentarium, such as cone beam computed tomography (CBCT), operating microscope (OM), and ultrasonic instruments. Newer access cavities design comprises of ninja access, contracted access and truss access. These approaches maintain the survival of endodontically-treated teeth by preserving the dentin and increasing resistance against tooth fracture. Ninja endodontic access cavity offers better resistance to fracture compared to conventional access cavity preparations. The main objective of the "truss" access cavity design is to preserve dentin by leaving some amount of dentin between two prepared cavities. In Incisal access, cavities are made on incisal edges rather than in cingulum areas to minimize cuspal deformation and bending, thereby preserving dentin bulk. When comparing traditional access cavities with the Calla Lily enamel preparation, it was found that traditional methods, lead to an unfavourable C factor and poor engagement of enamel rods while Calla Lily preparation enhances occlusal surface involvement, providing better fracture resistance. This review highlight on newer approach to modern endodontic access cavity design.

Keywords: Access Cavity, Fracture Resistance, Ninja Access, Pericervical Dentin, Soffit, Truss Access

Introduction

Endodontic treatment comprises of access preparation, cleaning and shaping and obturation of root canal. Endodontic access plays a vital role in instrumentation and irrigant administration during the endodontic procedure. Since proper cleaning and shaping are crucial for the success of a root canal procedure, the entire process is affected if there is a poor endodontic access cavity. Negotiation, debridement, cleaning, and ultimately obturation of the root canals, becomes challenging when there is insufficient endodontic access cavity. A well-constructed endodontic access cavity also aids in preventing iatrogenic errors like as file separation, ledge formation, and perforation that may occur during root canal therapy.[1]The foundational concepts of access cavity preparation established by G.V. Black, Guttman, Weine, and Grossman, have endured over time. Nonetheless, conventional endodontic access cavity designs have largely focused on achieving straight-line access and a suitable "convenience form" to ensure predictable endodontic treatment. These principles, however, cater more to the needs of the operator than to the longevity of the tooth. Traditional access techniques and instrumentation often result in weakened teeth due to extensive outline forms, shapes, and unintentional gouging., David Clark and John A. Khademi introduced a new approach to modern endodontic therapy for long term success in endodontically treated tooth. Modern access cavity preparation now relies on scientifically driven evidence and prioritizes the preservation of tooth structure.[2]

The recent concept in access cavity design is preserving as much as natural tooth structure and being more conservative.[1] This change is made possible because of new armamentarium, such as cone beam computed tomography (CBCT), operating microscope (OM), and ultrasonic instruments. Minimally invasive access cavities comprise of ninja access, contracted access and truss access. These approaches maintain the survival of endodontically-treated teeth by preserving the dentin and increasing resistance against tooth fracture. A conservative access cavity design poses challenges including impaired vision of pulp chamber and canal, reduced effectiveness and efficiency in canal instrumentation and disinfection, and loss of orientation.[3]

Preservation of Tooth structure

Since the quantity of residual tooth structure determines the fracture resistance of teeth, endodontic access should be viewed as the key to both endodontic and restorative success as well as the long-term retention of endodontically treated teeth. To prevent fracture, following should be considered:

- Peri Cervical Dentin
- 3D Ferrule
- Soffit/Banking

Peri Cervical Dentin

Dentin surrounding the alveolar crest is referred to as "irreplaceable critical most zone". Peri cervical dentin is 4mm above the crestal and 4mm below the crestal bone. Lost tooth structure in coronal aspect can be restored by composite and ceramics. Peri cervical dentin located at level of alveolar crest is irreversible. The long-term retention of the tooth and resistance to fracture depend on the thickness of PCD.

Peri cervical dentin attributed to three main factors:

Ferrule

The ferrule is a band that keeps the tooth from wearing out or splitting by encircling the remaining tooth structure. It's been suggested that maintaining at least 2 mm of dentin is essential to avoid fracture lines. To counteract the tooth's biomechanical reactions to masticatory stresses, preservation of ferrule is crucial.[2]

Fracture resistance

Preservation of PCD withstand both excessive shear and compressive forces during mastication. Inadequate thickness of PCD results in crown root separation and horizontal fracture of teeth[2]

Dentinal tubule orifice proximity

At cervical region, the length of dentinal tubules and the thickness of enamel and dentin is less which after endodontic therapy, tooth wear results in thinning of enamel and cementum at cervical region which allow microorganisms and microbial toxins to enter the root canal space through open dentinal tubules. The ability of these toxins to enter the canal space is reduced if the PCD is preserved.[2]

3D ferrule

The ferrule, as its name implies, is a band of metal that encircles the entire dental structure around the cervical area. "A circular region of axial dentin that extends from a tooth's preparation edge to its cervical section is known as a ferrule.[11] Three components of 3D ferrule consists of the vertical component, dentin girth, and occlusal convergence.[4]

- Vertical component: 1.5 to 2.5mm
- Dentin thickness (Girth):1-2mm

Total occlusal convergence/net taper: Total draw of two opposing axial walls to accept a fixed crown is 10° in 3 mm and 20° in 4 mm. Traditional stainless-steel crowns can have a taper of 10° or greater because of their deep chamfer marginal zones, but the more recent porcelain crowns require a taper of 50° or more.[4]

Soffit/Banking

Clark and Khademi suggest minimizing the width of the access cavity preparation without extending into the pulp horn area, forming a "soffit."[2] This architectural term describes a 360° stepped access in dentistry, which preserves dentin and improves the biomechanical properties of treated teeth. This lip or cornice can vary from 0.5 mm to 3.0 mm, depending on the need for additional strength and the tooth's anatomy.[4]

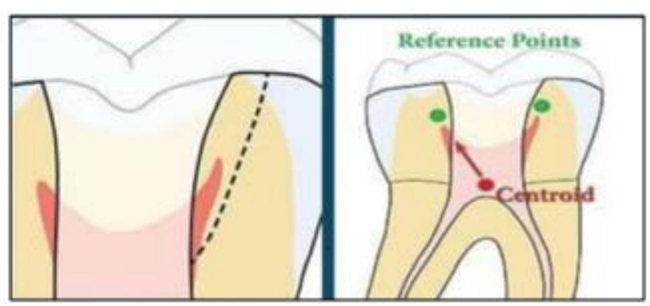

Figure 1: Area between the lines should be maintained, referred to as soffit

Conventional endodontic access cavity

The traditional endodontic access cavity design has an outline form that defines the extent of the cavity occlusally. The convenience form of the cavity is created to facilitate straight-line access, necessitating the removal of sufficient tooth structure. In traditional cavity design, an extension for prevention is performed to ensure straight-line access to the foramen or the primary curvature of the canal. This in turn results in the loss of vital dentin, leads to loss of tooth structural integrity. Therefore, conserving radicular or coronal dentin and maintaining the root geometry are crucial to preserving the mechanical strength of endodontically treated teeth.[1]Traditional endodontic access cavity designs persisted for a long time, mainly due to the lack of advanced imaging and diagnostic tools.

Newer advances in access designs

Conservative endodontic access cavity(cecs)

Clark and Khademi have recommended modifying the traditional access design from complete deroofing to a preparation that removes less tooth structure.[10] They suggest starting the constricted access at the central fossa and then extending the cavity towards the orifices. Importantly, the walls between the orifices are not straightened. Instead, the cavity outline follows the location of the orifices on the pulpal floor, extending from the centre to the peripheries with occlusally convergent walls. This method prevents the diversion of the occlusal cavity and results in incomplete deroofing of the pulp chamber at the pulp horn region, forming what is known as a "soffit."[2]

Advances in irrigation protocols have facilitated the debridement of tissue present in the soffit region. The soffit significantly improves the fracture resistance of the tooth by increasing the remaining dentin thickness.[2] Moreover, the use of Gates Glidden (GG) burs for coronal enlargement and burs for the removal of the pulp chamber roof has been claimed to be detrimental to the structural strength of the pulp chamber dentin (PCD) and soffit.[3] Studies have shown that mandibular molar fracture resistance are higher when prepared using conservative endodontic techniques compared to traditional endodontic cavity (TEC) preparation.[12] It was observed that class II cavities did not result in increased strength of the teeth treated with conservative endodontic cavity (CEC) preparation compared to TEC preparation.[5]

Figure 2

Ninja endodontic access cavity(necs)

The Ninja access cavity, also known as "PEAC" (point endodontic access cavity) and "UEC" (ultraconservative endodontic cavity), start from the central fossa and move towards the canal orifices following an oblique projection. This design aligns with the enamel cut at an angle of 90° or greater to the occlusal area, making the tracing of root canal orifices from various visual angles.[6]

In an vitro study by Gianluca Plotino, the fracture strength of restored teeth and roots was compared among conservative cavities, traditional cavities, and Ninja endodontic access cavities.

The study by Gianluca Plotino found that endodontically treated teeth with conservative endodontic cavities (CEC) and Ninja endodontic cavities (NEC) had a reduced chance of fracture. The fracture resistance of teeth treated with CEC and NEC was higher than that with traditional endodontic access cavities. Therefore, it can be concluded that the Ninja endodontic access cavity offers better resistance to fracture compared to conventional access cavity preparations.[5]

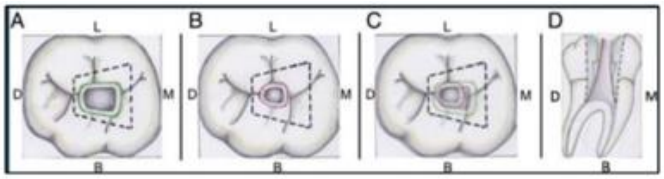

Figure 3

Dentin conservation and orifice-directed access cavity (truss access cavity)

The main objective of the "truss" access cavity design is preservation of dentin between two prepared cavities. Different cavities are made to approach the canals, accessing the pulp chamber through crown discontinuities, such as caries or a previously done restoration. This approach is lesion-dependent and minimizes the restorative necessity by taking advantage of the absent hard tissue structures for access. Two separate cavities are made to preserve the dentin in between.[8] The limiting factors of this design include the inclination of the tooth, complexity of the anatomy, and other patient-specific factors. For example, in mandibular molars, two different cavities are made to reach the mesial and distal canals. In maxillary molars, the mesiobuccal and distobuccal canals are reached through a single cavity, while a separate cavity is made for the palatal canal.[5]

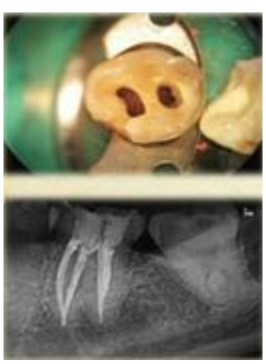

Figure 4

In an vitro study comparing the strength of teeth treated endodontically with Ninja endodontic cavities (NECs), traditional endodontic cavities (TECs), and conservative endodontic cavities (CECs). They found that both CECs and NECs exhibited higher fracture resistance than TECs in maxillary and mandibular molars and premolars. There was no significant difference in the mean fracture resistance between NECs and CECs. Traditional cavities preserve the canal's original anatomy better during shaping, especially at the apical portion. The rate of identifying MB2 was higher in traditional (60%) and conservative (53.3%) cavities compared to Ninja (31.6%) cavities. Although no major difference in fracture resistance was noted between TEC and CEC prepared teeth, fracture types were less severe with CEC preparation. Higher fracture resistance was observed in traditional cavity preparations. While conservation of dentin in conservative cavities increased fracture resistance, but conservative cavities lead to inadequate cleaning and shaping, missing canals and leading to poor treatment outcomes. Therefore, balancing both cavity types and using a design that minimizes failure is essential.[5]

Incisal access

In conservative endodontic preparation, cavities are made on incisal edges rather than in cingulum areas to minimize cuspal deformation and bending, thereby preserving dentin bulk and maintaining the tooth structural integrity. Traditional endodontic access often results in inverse funnelling and blind tunnelling, the latter caused by aggressive round bur use, leading to buccolingual gouging that isn't visible in radiographs.[9] Inverse funnelling occurs as the access cavity widens internally, leading to unnecessary loss of peri-cervical dentin with each bur entry. This conservative approach avoids such issues by using incisal access, preserving valuable peri-cervical dentin and reducing the need for extensive restorative work.[5]

Calla lily enamel preparation

In this access cavity preparation, the enamel is cut at a 45º angle to effectively engage enamel rods and achieve a favorable C factor. The resulting shape resembles a Calla Lily, encompassing almost the entire occlusal surface, which helps resist compressive forces. When comparing traditional access cavities with the Calla Lily enamel preparation, it was found that traditional methods, cutting at a 90º angle to the occlusal table, lead to an unfavourable C factor and poor engagement of enamel rods during the removal of old amalgam or composite. The 45º angle in the Calla Lily preparation enhances occlusal surface involvement, providing better resistance.

Figure 5

Calla Lily-shaped cavosurface should be used with highly bondable substrates like etchable enamel or porcelain and with bondable restorative materials like composite resin. When bonding is not possible for less bondable substrates or between the restorative material and substrate, a butt joint or a 70-90º cavosurface interface is recommended. For treatments requiring multiple visits and an unbonded temporary restoration, maintaining a 70-90º cavosurface angle until the final visit is advisable.

It is based on the principle of ICE:

I-Infinity based

C-Compression based

E-Enamel driven (engage 70% enamel and 30% dentin)[5]

Image guided endodontic access preparation

This approach leverages easily accessible images for clinicians to determine the specific location and size of the access cavity, avoiding a one-size-fits-all method. The goal is to preserve dentin and create the smallest possible access cavity.[7] Designing the access type based on the particular tooth is the ideal practice of this system. Image-guided endodontic access preparations primarily include two types: CT Dynamic access and CT/CBCT guided static 3D templates.

Dynamic access, commonly known as X entry access, was popularized by Charles M. Buchanan and traditionally used in implantology. This technique uses CBCT volume planning to prepare access by assessing the jaw and bur positions in 3D with overhead cameras and software.

Static 3D templates use CBCT images and 3D surface scanners to create virtual images of burs and guide sleeves. A virtual template is designed and printed using 3D printers, then attached to models to prepare access with specially designed burs.[5]

Conclusion

The newer access cavity designs are introduced in order to preserve the pericervical dentin and improving fracture resistance of teeth. The traditional access cavity design being more operator friendly had significant detrimental effect on fracture resistance. However, to overcome the challenge of complete biomechanical preparation the minimal access cavity preparations should focus on irrigation and irritant activation protocols for the success of root canal treatment. Balancing both traditional and conservative access cavity design leads to successful endodontic therapy.

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