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MINIMALLY INVASIVE ENDODONTICS

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ABSTRACT

The idea of minimally invasive endodontics (MIE) is to preserve as much of the tooth's coronal, cervical, and radicular anatomy as possible while doing endodontic treatments. MIE can be used in several stages of endodontic treatment, including surgical endodontics and access opening, root canal cleaning, and shaping. The aim of new-age endodontics is minimal intervention; this review article explores the range of methods that can be implemented at each stage of the process.

KEYWORDS: Minimally Invasive Endodontics, Endodontics, Minimally Invasive Dentistry

Over the past 30 years, there has been a great deal of progress in the discipline of cariology. The majority of these developments are founded on scientific understanding of minimally invasive methods of treatment and prevention. Minimal intervention dentistry is the term for this "rational" approach to treatment (Sheiham, 2002). Dentistry was dominated by the surgical model in the past. However, the development of adhesion and etching brought in the era of minimally invasive preparations (Wolff *et al.*, 2007).

NEED FOR MINIMALLY INVASIVE ENDODONTICS

The prognosis of the tooth following restoration is mostly determined by the structural integrity of the remaining tooth (Tang *et al.*, 2010). Numerous investigations have demonstrated that endodontically treated teeth's dentin characteristics are identical to those of healthy dentin (Sedgley and Messer, 1992). Therefore, greater fracture susceptibility brought on by structural loss is the main cause of endodontically treated teeth failing. Because of this, the idea of minimal intervention has great importance in the field of endodontics.

PRINCIPLES OF MINIMALLY INVASIVE ENDODONTICS

Peri Cervical Dentin (PCD)

According to Clark and Khademi's 2008 definition, pericervical dentin is a region that is approximately 4 mm from coronal to crestal bone and 4 mm from crestal to apical bone. It serves as the tooth's neck and sends masticatory pressures to the bone and root. As a result, the dentin that surrounds the alveolar crest is frequently referred to as the "Irreplaceable Critical Most Zone" because, in contrast to the coronal third of the clinical crown, which can be surgically removed and replaced, the dentin that surrounds the alveolar crest is sacred and cannot be replaced. This important landmark in the anterior teeth is called the peri-cingulum dentine. Since PCD preservation enhances survival rates proportionately with preservation, the term "directed dentine conservation" was developed to refer to this process (Clark *et al.*, 2013).

3D Ferrule (Clark *et al.*, 2013)

The axial wall of the crown or bridge abutment covers the dentin in all three dimensions, which is referred to as the three-dimensional ferrule. It is an assessment of the dentin that is accessible to support the crown. The term "3D" describes the following ferrule components:

1) Vertical element: approximately 1.5 to 2.5 mm
2) Dentin thickness (Girth): 1-2 mm is the absolute minimum thickness.
3) Total occlusal convergence/Net Taper: This refers to the total draw of two opposing axial walls to receive a fixed crown. For traditional stainless-steel crowns, this can be 10° in 3 mm or 20° in 4 mm of vertical ferrule; however, for the more recent porcelain crowns, this must be 50° or more taper due to their deep chamfer marginal zones.

Soffit/Banking (Clark *et al.*, 2013)

Architects refer to the underside of a roof, where the wall and roof meet, as a soffit. The chamber of a molar tooth, which is enclosed by a floor with tiny openings spaced along its edges, four walls, and a roof, can be thought of in the same way. The soffit, a tiny piece of roof encircling the pulp chamber's coronal section, provides an excellent illustration of the construction of a

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banked tooth. The adjacent PCD is being harmed significantly more by the attempts to remove the soffit. This method of storing dental structure helps teeth remain in place throughout time and avoid breaking.

Since maintaining dentin is the primary goal of MIE, the technologies for doing so are broken down into the following stages:

Phase 1-Planning: in order to view the clinical scenarios. Important information for less invasive root canal procedures can be found in CBCT scans. The following details, which are not clinically presented by other radiographic methods, can be obtained from a thorough evaluation of the pre-operatory volume: identifying the point of entry, evaluating anatomical details (the pulp chamber's size and position, the number of roots and their configuration, curvatures, canal splitting, horizontal root bulk, and canal dimension at the peri-cervical region).

Phase 2-Treatment: These include dentin preservation technologies such as magnification tools, image-guided endodontic access (including static and dynamic guided access preparation), etc.

PROCEDURES USED IN MINIMALLY INVASIVE ENDODONTICS (MIE)

MIE can be used in all stages of endodontics, including surgical endodontics, biomechanical root canal preparation, and access opening. We will talk about all of these in more detail while keeping the MIE concept in mind.

Minimally Invasive Access Cavity Preparation

The main objective of endodontics is to reach the root canal system, clean and shape it, and enable complete and effective filling of the root canal space, leaving the tooth as strong as possible for its intended use (Reeh *et al.*, 1989). An operator's perspective may be obscured by an access that is too narrow, while an excessively large preparation may result in the needless removal of important tooth structure. But, compared to earlier periods when these were unavailable, we can now conduct minimally invasive preparations with much more ease and comfort because lighting and magnification have improved so much. Preserving the pericervical dentin (PCD) is essential during minimally invasive access cavity preparation since it is essential to the tooth's long-term survival and function. In order to maintain maximum resistance to structural flexure and eventual failure, the minimal invasion philosophy discourages the use of round burs and Gates-Glidden burs, as these instruments cause gouging of endodontic access and the coronal third of the root canal, particularly around the PCD (Reeh *et al.*, 1989). The designs of the minimally invasive access cavities shown below can be used:

Conservative endodontic access cavity (CEAC)

It has been suggested that this cavity design reduce the amount of extraneous tooth structure that is removed. The teeth are accessed at the central fossa in a cavity treated with conservative endodontic access, and the outline is only expanded when necessary to identify the canal orifices. This aids in the maintenance of the pulp chamber's floor as well as the pericervical dentin. With its location 4 mm above and 4 mm below the crestal bone, the pericervical dentin is crucial in distributing the functional forces placed on the teeth. Therefore, maintaining the pericervical dentin is essential to preserving the radicular dentin's biomechanical response (Clark and Khademi, 2010; Clark *et al.*, 2013).

Ninja Endodontic Access Cavity

An oblique projection is made towards the central fossa of the root orifices in an occlusal plane in order to obtain an access "ninja" form. Finding the root canal orifices is made easier even from varying visual angulations since the endodontic access is parallel to the enamel cut at an angle of 90° or greater to the occlusal plane (Plotino *et al.*, 2017).

Truss Access Cavity

Another name for it is the orifice-directed design. To get to the canals, two distinct cavities are made in this. Two distinct cavities are created for mandibular molars: one for the mesial canals and the other for the distal canals. When it comes to maxillary molars, one cavity is used to approach the mesiobuccal and distobuccal canals, while a different cavity is created to approach the palatal canal. These conservative cavities are made with the intention of preserving the dentin, leaving a dentin truss between the two created cavities (Neelakantan *et al.*, 2017).

Opportunistic Endodontic Cavity or Caries Driven Endodontic Cavity (CDEC)

In order to enter the root canal system from the pre-existing cavity without extending it with a preset shape, it is "a strategic interproximal or buccal access aiming to remove all the carious tissue and the entire old fillings, taking advantage of the loss of tooth structure." (Plotino, 2020)

Incisal Access

In this conservative preparation, cavities are made on the incisal borders rather than in the cingulum areas to decrease cuspal deformation and cuspal bending on flexure while retaining the dentin bulk and restorative needs. An appropriate incisal access can prevent blind tunneling and inverse funneling, which are side effects of typical endo access.

Calla-Lilly Preparation

It is predicated on the ICE principle: C-Compression based on I-Infinity edge E-Enamel driven, with 30% of dentin and 70% of enamel engaged. It is predicated on the ICE principle: C-Compression based, I-Infinity edge, E-Enamel driven (engage 70% enamel and 30% dentin) (Clark and Khademi, 2010).

Dynamic Access Cavity Design

The conventional predesigned shapes governed by the most prevalent anatomical variances in root canal architecture are not the same as the dynamic access cavity design. Prioritizing the removal of carious and damaged tissues always takes precedence over the negotiation of the pulp space in dynamic access.

IMAGE GUIDED ENDODONTIC ACCESS PREPARATIONS

CT Dynamic Access/ X Entry Access

Charles M. Buchanan popularized it. The field of implantology has long employed this method. In order to prepare access by 3D assessment of bur position and jaw position using overhead cameras and software such as 3-three dimensional camera system (X-NAV System), NAVIJET, the technique makes use of CBCT volume plan (Jain *et al.*, 2020).

CT/ CBCT Guided Static 3D Templates

This generates virtual images of burs and guide sleeves using 3D surface scanners and CBCT images. 3D printers are used to develop and print a virtual template. Templates are fastened to models and prepared using burs that are specifically made for this purpose. To improve visibility and preserve tooth structure, small-sized tip and long-shank burs like the round-end low speed Munce discovery burs, Clark's EG3 micro-access bur, CK burs (SS white), and Batt's bur type (non-cutting serrated spiral carbide bur) can be employed. Manage Files K-files and H-files from MC H files are Micro-Debriders and Micro-Openers K-files **(**Connert *et al.*, 2018).

Cleaning and Shaping of the Root Canal Space

This is a crucial phase in the endodontics process that can be made minimally invasive by utilizing a variety of methods and tools.

Taper of Endodontic Files

The days of large-scale, forceful canal-flaring are long gone. Furthermore, there is less evidence to support the idea that larger canal shapes result in a better seal and fewer endodontic failures. Conservative designs leave the tooth significantly stronger. Larger apical diameters and improved instrumentation in the apical region weaken the root by causing a loss of apical dentin and a reduction in control over the obturation part of the procedure. Therefore, continued tapering and smaller apical preparations are favored. This type of preparation creates a tight apical seal, encourages the formation of resistance, and protects the root dentin to provide enough shape for effective disinfection (Buchanan, 2000).

Self-Adjusting File (SAF) System

Because of its least intrusive design, the Self-adjusting file system, or SAF, has becoming more and more common. When the curved canal is shaped, the SAF design results in minimal stress concentrations in the apical root dentin, increasing the likelihood of maintaining the integrity of the root dentin with a decreased risk of dentinal defects and apical root cracking (Weine *et al.*, 1975).

Photon Induced Photo-Acoustic Streaming (PIPS)

The laser point had to reach the apical third of the root in the conventionally employed laser applications, which required a typical preparation for at least up to size 30. However, the PIPS tip can also be inserted into the root canal's coronal reservoir. As a result, this method permits the root canal to be prepared with little invasiveness (Pathak *et al.*, 2016).

Photodynamic Therapy in Endodontics (PDT)

When treating periapical lesions, PDT is a useful addition to routine antibacterial intracanal cleaning and shaping. When this method is applied well, it is possible to disinfect the canals without unintentionally instrumenting them or removing too much dentin (Plotino *et al.*, 2019).

MINIMALLY INVASIVE PREPARATION IN PRIMARY TEETH

Kedo-S File System for Primary Teeth

For the purpose of cleaning and shaping primary teeth, Reeganz Dental Care Pvt. Ltd. in India created the Kedo-S pediatric rotary apparatus. They are made specifically for the biomechanical preparation of primary teeth with ribbon-shaped morphology and shorter, thinner, curved roots. Primary teeth can effectively benefit from their use without having the thin root canal wall overly instrumented (Panchal *et al.*, 2019).

Obturation in Minimally Invasive Preparation

A filling substance that mimics the internal anatomy of the root canal space, clings to interfacial dentin, and forms an impermeable, irreversible seal at all exit portals is necessary for biominimalism in canal space preparation. And the hydraulic cementation processes can help achieve this. "Hydraulic cements" are materials intended for endodontic application, such as bio ceramics or Bioactive Endodontic Cements (BECs). Because the natural moisture in the canal and tubules is very hydrophilic, hydraulic endodontic techniques are recommended in minimally invasive procedures (Gandolfi *et al.*, 2009).

1. These sealants produce a tight, impenetrable seal because they do not shrink but rather slightly expand and become insoluble in tissue fluids.
2. A coating of bio ceramic nanoparticles is applied to the surface, which has been demonstrated to enhance filling seal and perhaps close the space between the sealer and the core.
3. These new filler materials do not require high temperatures or strong and deep condensation forces.

Surgical Endodontics

Apicectomy was traditionally used for teeth with periapical abnormalities. Since this is a rather invasive operation, less invasive alternatives like microsurgery and Apexum have become more and more popular in recent years.

Microsurgery in Endodontics

Endodontic microsurgery is a minimally invasive procedure that promotes quicker wound healing and reduced swelling and pain following surgery. Compared to the conventional apical surgery procedure, it gives a much greater success rate. The best way to accomplish a minimally intrusive procedure is to utilize the surgical microscope to magnify and employ light (Floratos and Kim, 2017).

Apexum (A Non-Surgical Approach)

With this technique, periapical tissues can be removed without the need of sutures, periosteal elevators, or scalpels (Metzger and Abramovitz, 2008). It is based on a minimally invasive device (Apexum Ablator; Apexum Ltd, Or Yehuda, Israel) that removes the chronically inflammatory periapical tissues through a root canal access (Raisingani, 2011).

CONCLUSION

As a result, a wide range of solutions are available to preserve tooth structure and essential tissue thanks to developments in endodontics. Surgical endodontics, biomechanical canal preparation, access opening, and other methods can all be used to provide a less invasive endodontic approach.

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