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Minimally Invasive Biological Treatment in Endodontics: A New Appraisal

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Abstract

Aim-The aim of minimally invasive biological treatment in endodontics is to effectively manage pulpal and Peri apical pathologies while preserving tooth structure, promoting healing, and enhancing patient comfort. Minimally invasive biological treatment in endodontics represents a contemporary approach expected at preserving tooth structure, promoting healing, and enhancing patient comfort. This treatment philosophy emphasizes conservative interventions that minimize trauma to the tooth and surrounding tissues while harnessing the body's natural healing mechanisms. Key principles include selective removal of diseased tissue, biocompatible disinfection, gentle instrumentation, and the use of biomimetic materials for obturation. By adhering to these principles, clinicians can achieve successful outcomes while preserving tooth vitality and promoting long-term dental health. This abstract explores the principles, techniques, and clinical considerations associated with minimally invasive biological treatment in endodontic, highlighting its benefits for both patients and practitioners.

Keywords - Minimally Invasive, Biological Treatment, Tooth Preservation, Selective Dentin Removal, Root Canal Disinfection, Minimal Trauma.

INTRODUCTION

In recent decades, the field of endodontics has witnessed a paradigm shift towards minimally invasive approaches, driven by advancements in technology, materials, and techniques. This evolution has transformed the way root canal therapy is conceptualized and performed, emphasizing the preservation of natural tooth structure and the promotion of biological healing processes. Minimally invasive endodontics represents the culmination of these advancements, offering patients and practitioners alike a more conservative yet highly effective approach to managing pulpal and peri-apical pathologies [20].

At the heart of minimally invasive endodontic lies the principle of tissue preservation. Unlike traditional approaches that often necessitate extensive tooth structure removal, minimally invasive techniques aim to conserve as much healthy tissue as possible while addressing the underlying pathology. This not only enhances the long-term prognosis of the tooth but also minimizes patient discomfort and accelerates the healing process. By embracing a philosophy of preservation, practitioners can achieve predictable outcomes while promoting patient-centered care [1,12].

This guide is designed to provide a comprehensive overview of minimally invasive endodontics, covering key principles, techniques, and

clinical considerations. From initial diagnosis and treatment planning to instrumentation and obturation, each aspect of the endodontic procedure will be examined through the lens of minimally invasive dentistry. Furthermore, case studies and practical tips will be included to illustrate the application of these principles in real-world clinical scenarios. Whether you are a seasoned endodontist or a dental professional seeking to enhance your skills, this guide will serve as a valuable resource for incorporating minimally invasive techniques into your practice and delivering optimal care to your patients.

In the majority of cases of mature teeth diagnosed with irreversible pulpitis or apical periodontitis, root canal treatment is the therapy of choice to save the tooth. Inherent in this procedure is loss of dental hard tissue and subsequent weakening of the treated tooth (Kishen 2006, Al-Omiri *et al.,* 2010), making them more prone to fracture (Reeh *et al.,* 1989, Al-Omiri *et al.,* 2010) [3].

Irreversible pulp inflammation and apical periodontitis indicate a dental infectious disease related to the presence of microorganisms in and/or outside the root canal system (Haapasalo *et al.,* 2011) [7].

To resolve apical periodontitis and more advanced pulpal disease, the conventional treatment is removal of the complete pulp (root canal treatment) with the aim to reduce the number of bacteria in the root canal treatment which cause infection. However, cross sectional research in the Netherlands has shown that around forty per cent of root filled teeth are associated with an apical radiolucency when examined using two-dimensional dental radiographs (Peters *et al.,* 2011), indicating failure of the procedure, as only a small proportion of apical radiolucencies remain visible as fibrotic healing scars (Nair *et al.,* 1999, Love & Firth 2009) [12].

This trend is seen worldwide (Wu *et al.,* 2009). Furthermore, endodontically treated teeth without visible radiographic signs of apical periodontitis can still be infected (Molander *et al.,* 1998, Ricucci *et al.,* 2014).

Therefore, the actual failure rate of standard root canal treatments performed in general practice is significantly higher than expected. Furthermore, these treatments are lengthy and costly and are often subject to retreatment (Figdor 2002) [15].

Less invasive alternative strategies could be used to treat pulpitis and increase the success of endodontic procedures beyond the improvement of the 'tools and gadgets' used during conventional root canal treatment. As new insights in pulp biology have been gained, recent clinical research on vital pulp therapy now provides options for developing new biologically driven treatment protocols (Aguilar & Linsuwanont 2011, Simon *et al.,* 2013, Tomson *et al.,* 2017) [14].

Such treatment modalities have two major advantages: first, pulp tissue is preserved, thus maintaining it's physiological and defensive functions; secondly, less hard tooth tissue is removed, which results in less weakening of the tooth. Combining knowledge of pulp biology with insight into why conventional therapies often fail stimulates a shift in thinking about endodontic treatment. Avoiding full pulpectomies (complete removal of the pulp to the apical constriction), where possible, could be the first step in improving treatment outcomes. A biological immune response from even a partially retained pulp could improve the treatment outcome by preventing infection of the apical area (Aguilar & Linsuwanont 2011), and research has shown that results of vital pulp treatments are comparable to conventional root canal treatment (Asgary *et al.,* 2015) [13,16].

Dentine as a Bioactive Substance

Biomineralization- Dentin has the ability to mineralize in response to stimuli such as injury or infection. This process involves the deposition of new hydroxyapatite crystals within the dentinal tubules and intertubular dentin matrix, which strengthens the tooth structure and helps seal off exposed dentin surfaces.

Dentinogenesis- Dentin contains odontoblast cells within the pulp tissue, which are responsible for the formation of new dentin in response to injury or irritation. When dentin is exposed due to caries or trauma, odontoblasts become activated and lay down new dentin matrix, a process known as tertiary or reparative dentinogenesis.

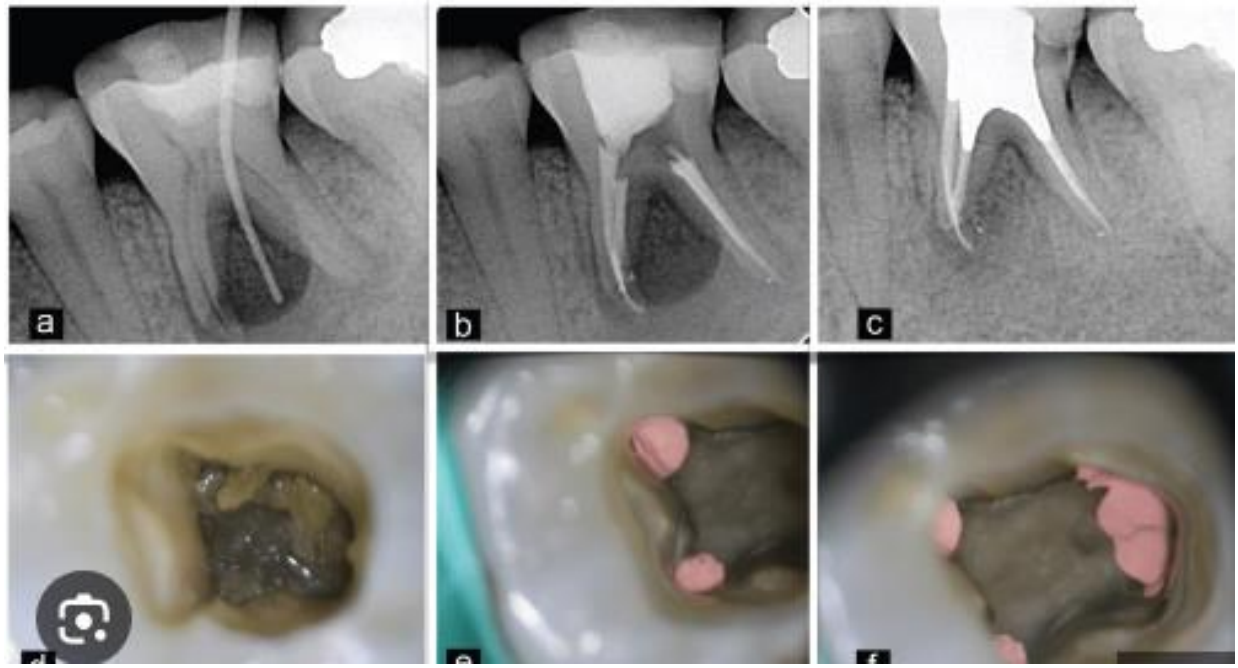
Dentin-pulp complex- is a dynamic interface between the dentin and the dental pulp. Dentin contains numerous dentinal tubules that house cellular extensions of odontoblasts and nerve fibers, facilitating communication and nutrient exchange between the pulp and the surrounding tissues.

With increasing knowledge regarding the biological healing processes in response to infected carious dentine and pulp, a new understanding of vital pulpal therapy has emerged (Simon *et al.,* 2011). Dentine is a vital, cellular tissue, containing the cellular processes of the odontoblasts that lay in the pulp. Therefore, dentine and pulp must be considered together as a pulpo-dentinal complex (Pashley 1996).

Recent research shows that the pulp is more resilient to significant microbial attacks than previously thought (Farges *et al.,* 2013, Bjorndal *et al.,* 2014, Cooper *et al.,* 2014). Pulpal defence mechanisms to reduce the diffusion of microbes and microbial products towards the pulp include sclerosis of dentinal tubules and the formation of tertiary dentine (Bjorndal 2008) [12].

Apart from sclerosis and the replacement of dead odontoblasts, a host of growth factors, including TGF-b, ADM and IGF-1/-2, are released from the pulp-dentinal complex when dentine is demineralized during the progression of a carious lesion (Finkelman *et al.*, 1990, Cassidy *et al.*, 1997, Cooper *et al.*, 2010, 2011). These growth factors can have a positive effect on pulpal responses by enhancing the processes involved in pulp repair and regeneration (Smith *et al.*, 2012, 2016) [17, 19].

Ongoing research shows the impact of different growth factors encapsulated in dentine (Tomson *et al.*, 2017). The fact that the regenerative potential of the pulpo-dentinal complex is evident in teeth with symptoms indicative of irreversible pulpitis suggests that the current classification of pulpitis may need to be revised (Ricucci *et al.*, 2014).



Minimally Invasive Endodontics

Minimally invasive endodontics (MIE) represents a contemporary approach to root canal treatment that prioritizes the preservation of natural tooth structure, minimization of treatment invasiveness, and promotion of biological healing processes. This approach stands in contrast to traditional endodontic methods, which often involved more extensive removal of tooth structure and could lead to compromised long-term outcomes. MIE techniques aim to achieve successful treatment outcomes while minimizing trauma to the tooth and surrounding tissues, thereby enhancing patient comfort and preserving tooth vitality [4].

Key Principles and Techniques of Minimally Invasive Endodontic Include:

Precise Diagnosis- Accurate diagnosis using advanced imaging technologies such as cone-beam computed tomography (CBCT) and digital radiography helps determine the extent and nature of the dental problem, enabling targeted treatment planning [5].

Conservative Access Cavity Preparation- Minimally invasive access cavity preparation involves removing only the necessary amount of tooth structure to gain access to the pulp chamber while preserving as much healthy tooth structure as possible.

Selective Dentin Removal- Instead of wholesale removal of dentin, selective removal of diseased or infected dentin is performed, preserving sound dentin and minimizing trauma to the tooth.

Gentle Instrumentation- The use of flexible nickel-titanium (NiTi) instruments and advanced instrumentation techniques, such as rotary or reciprocating motion, helps minimize stress on the root canal walls and reduce the risk of procedural errors or instrument-related complications.

Biocompatible Irrigation Solutions- Irrigation of the root canal system with biocompatible solutions, such as sodium hypochlorite and chlorhexidine, effectively disinfects the canal while minimizing damage to periapical tissues.

Minimally Invasive Opturations- Sealing the root canal space with biocompatible materials, such as gutta-percha and bioceramics, ensures a hermetic seal and promotes healing while minimizing disruption to surrounding tissues.

Traditionally, it was thought that there is a poor relationship between clinical signs and symptoms and the histological state of the pulp in mature teeth (Seltzer & Bender 1963, Garfunkel *et al.*, 1973, Dummer *et al.*, 1980), however, recently this was questioned, and a histological study showed that there is a good correlation between clinical symptoms of pulpitis and the corresponding histological state of a diseased pulp (Ricucci *et al.*, 2014) [11].

In cases with irreversible pulpitis, the morphological changes indicating inflammation or necrosis were principally occurring in the coronal pulp whilst the radicular pulp was viable. This suggests that the radicular pulp could potentially be retained when a pulpotomy procedure is performed, thus preventing the need for a pulpectomy. This less invasive treatment approach has the following advantages:

- Preservation of immunological functions and retaining structural integrity of the tooth.
- Simplifying treatment procedures and avoiding treatment complications associated with difficult root canal anatomy.
- Suggested procedures cause little pain (Simon *et al.*, 2013).
- Reducing cost and inconvenience for patients and society.

Using vital pulp therapy, proper case selection and treatment protocols are essential if it is to be successful (Taha *et al.*, 2017). Teeth exhibiting symptoms suggestive of irreversible pulpitis have little chance to revert to normal if no other intervention takes place than removal of irritants. In these cases, the section of the pulp that is inflamed must be removed so that the remaining un-inflamed tissue can recover and heal (Ricucci *et al.*, 2014). This has proven to be successful, and teeth diagnosed with irreversible pulpitis have been successfully treated with a pulpotomy (Taha *et al.*, 2017, Qudeimat *et al.*, 2017) [14].

Pulpitis – Symptom Assessment and Pulpal Diagnosis – A New Philosophy

The writers suggest a new analytic scheme of pulpitis and related management decisions for how pulpal disease should be achieved. In light of the evidence described in the above-mentioned current studies, it develops clear that it is time for outdated intellectual and conventional root canal treatment procedures to be revisited. Caries progression in itself does not dictate treatment modalities, but observed clinical symptoms are important in predicting pulpal conditions and therefore indicate the choice of treatment. Probably, many pulps diagnosed with irreversible pulpitis have the potential to heal after implementing the appropriate minimally invasive treatments.

This means that lingering pain after a stimulus, normally recognized as indicative for irreversible pulpitis, may not necessarily correspond to an irreversible state of inflammation of the entire pulp. Often, only pulp tissue located in the pulp chamber is irreversibly inflamed if symptoms of prolonged lingering pain after cold/hot stimulus are present. Therefore, symptoms of pulpitis and pulpal diagnosis need to be considered carefully and followed by appropriate intervention. Indirect pulp treatment (IPT) or coronal pulpotomy could be excellent less-invasive alternative treatments that allow uninflamed pulp tissue to remain in place to regenerate and heal (Asgary *et al.*, 2014, Taha *et al.*, 2017) [13].

A recent positive development in pulpal diagnosis was the summary of a new organization based on scientific indications (Hashem *et al.*, 2015). Hashem and co-workers classified pulpitis as:

Mild Reversible Pulpitis: Patients' descriptions of sensitivity to hot, cold and sweat lasting up to 15– 20 s and settling spontaneously.

Severe Reversible Pulpitis: Increased pain for more than several minutes and needing oral analgesics.

Irreversible Pulpitis: Persistent dull throbbing pain, sharp spontaneous pain and tenderness to percussion or pain exacerbated by lying down. We propose to change the criteria for the clinical diagnosis of reversible pulpitis and suggest the following expansion of the diagnostic classification of pulpal inflammation, relating the diagnosis to minimally invasive treatments, whereby the extensively inflamed tissue is removed, leaving uninflamed vital tissue in place. This means that there is always vital pulp tissue that has the potential to heal if it is managed correctly.

CONCLUSION

Vital pulp treatment has been shown to be extremely fruitful if the interference has been performed with the accompanying clinical symptoms as a recommendation. There is good correlation between clinical symptoms of pulpitis and the corresponding histological state of an inflamed pulp. This information, composed with the pre-treatment and mid-operative scientific findings, can be used to possibly save and retain pulp and tooth tissue with supplementary benefits. Growths in our understanding of pulp biology and the response of the pulp to the release of dentine-bound bioactive growth factors have made it clear that the pulp has substantial regenerative capabilities and that inflammation is a normal part of the healing response of the pulp.

Vital pulp tissue that has been managed properly is quite resilient, and a diseased pulp can heal if most of the inflamed/necrotic tissue is removed. Management approaches, new discussion and examination in the part of vital pulp management will be encouraged with development in treatment consequences for patients in the future.

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