EDITORIAL

Minimally invasive endodontics: a new diagnostic system for assessing pulpitis and subsequent treatment needs

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Aim

To introduce a new way of thinking about the inflamed pulp. We want to highlight that there is reversibly inflamed tissue in pulps that are currently diagnosed as irreversibly inflamed. This implies that the currently employed terminology may not reflect the actual inflammatory status of pulps evaluated clinically. We therefore propose and introduce a new diagnostic system with new terminology to highlight the healing potential of the pulp. This also implies that current treatment strategies are evaluated and revised to maintain pulp vitality with associated benefits.

Introduction

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). 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).

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 system 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). 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). 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). Such treatment modalities have two major advantages: first, pulp tissue is preserved, thus maintaining its 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).

**Dentine as a bioactive substance**

With increasing knowledge regarding the biological healing processes in response to infected carious dentine and pulp, a new understanding of vital pulp 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, Bjørndal 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 (Bjørndal 2008). Apart from sclerosis and the replacement of dead odontoblasts, a host of growth factors, including TGF-β, ADM and IGF-1/-2, are released from the pulpo-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). 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). Probably cases traditionally deemed irreversible may in fact still be salvageable, thereby shifting the balance of what was irreversible towards reversible, when the correct treatment is applied (Ricucci et al. 2014, Taha et al. 2017).

**Minimally invasive endodontics – ‘Endolight’**

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 pulpsitis and the corresponding histological state of a diseased pulp (Ricucci et al. 2014). In cases with irreversible pulpsitis, 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 (‘Endolight’) has the following advantages:

1. preservation of immunological functions and retaining structural integrity of the tooth.
2. simplifying treatment procedures and avoiding treatment complications associated with difficult root canal anatomy.
3. suggested procedures cause little pain (Simon et al. 2013).
4. 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 uninflamed 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).

If with the proper intervention, extensively inflamed pulps can be maintained, this then begs the questions,
should the term ‘irreversible’ be used in our diagnostic criteria? Such a term condemns the pulp, resulting in pulpectomy or tooth extraction. Therefore, as long as there is some uninflamed pulp tissue and the complete pulp has not become necrotic, this uninflamed vital tissue can be managed and retained. Such an approach would carry the advantages outlined above.

**Pulpitis – symptom assessment and pulpal diagnosis – a new philosophy**

With the introduction of the ‘Endolight’ concept, the authors propose a new diagnostic system of pulpitis and associated treatment options for how pulpal disease should be managed. In light of the information reported in the above-mentioned recent studies, it becomes clear that it is time for traditional thinking 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 or ‘light’ 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).

A recent positive development in pulpal diagnosis was the introduction of a new classification based on clinical symptoms (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 (ir)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.

**Our proposal for new clinical pulp diagnosis terminology and associated treatment modalities**

**Initial pulpitis**

Heightened but not lengthened response to the cold test, not sensitive to percussion and no spontaneous pain.

Therapy: IPT (van der Sluis et al. 2013, Asgary et al. 2015)

**Mild pulpitis**

Heightened and lengthened reaction to cold, warmth and sweet stimuli that can last up to 20 s but then subsides, possibly percussion sensitive. According to the histological situation that fits these findings, it would be implied that there is limited local inflammation confined to the crown pulp.

Therapy: IPT (van der Sluis et al. 2013, Asgary et al. 2015)

**Moderate pulpitis**

Clear symptoms, strong, heightened and prolonged reaction to cold, which can last for minutes, possibly percussion sensitive and spontaneous dull pain that can be more or less suppressed with pain medication. According to the histological situation that fits these findings, it would be implied that there is extensive local inflammation confined to the crown pulp.

Therapy: Coronal pulpotomy – partly/completely

**Severe pulpitis**

Severe spontaneous pain and clear pain reaction to warmth and cold stimuli, often, sharp to dull throbbing pain, patients have trouble sleeping because of the pain (gets worse when lying down). Tooth is very sensitive to touch and percussion. According to the
histological situation that fits these findings, it would be implied that there is extensive local inflammation in the crown pulp that possibly extends into the root canals.

Therapy: Coronal pulpotomy – if there is no prolonged bleeding of pulp stumps in the orifices of the canals, these will be covered with MTA in mature teeth, followed by restoration (Alqaderi et al. 2014). If one or more of the pulp stumps keeps bleeding after rinsing with 2 mL 2% NaOCl, a superficial pulpotomy can be carried out, whereby more inflamed tissue is removed from the canal up to 3–4 mm from the radiographic apex. If bleeding ceases, then the root canal up to the vital pulp tissue is filled with gutta-percha and sealer at this working length. If bleeding persists, a full pulpectomy needs to be performed in order to remove all inflamed tissue from the canal (Matsuo et al. 1996).

Recapitulating: ‘EndoLight’, the minimal invasive endodontic approach, can benefit dental health care in several ways:

- maintaining the viability of the pulp as long as possible to induce a biological response to prevent apical periodontitis and improving the success rate of vital pulp treatment.
- saving tooth structure and consequently increasing tooth survival.
- saving time and cost for both the patient and/or society.
- reducing pain and discomfort for the patient with these less invasive treatments and keeping teeth functional for longer.

If endodontic treatment fails, the following alternatives can be considered: endodontic retreatment and apical surgery or extraction.

Conclusion

Vital pulp treatment has been shown to be highly successful if the intervention has been performed with the accompanying clinical symptoms as a guideline. There is good correlation between clinical symptoms and the corresponding histological state of an inflamed pulp. This information, together with the pre-treatment and mid-operative clinical findings, can be used to potentially save and retain pulp and tooth tissue with associated benefits. Developments 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. This gives the remaining tissue a chance to recover. The authors hope that with the proposition of a new system for diagnosing different stages of pulpitis, using associated symptoms and implementing new minimally invasive treatment strategies, new debate and research in the area of vital pulp treatment will be stimulated with improvement in treatment results for patients in the future.

Conflict of interest

The authors have stated explicitly that there are no conflict of interest in connection with this article.

References


