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Tampon Vital Pulp Therapy in the Management of Excessive Haemorrhage in Inflamed Pulps: A Hypothesis

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Current principles in vital pulp therapy (VPT) modalities emphasise the importance of haemostasis and normal clotting in the achievement of successful treatment outcomes. However, the aforementioned notion could be challenged by the new and recent emerging evidence; suggesting that prolonged or excessive bleeding/haemorrhage (PB) in cases of intensly inflamed pulps, conventionally infamous as irreversible pulpitis (IP), may not impede the healing potential of the remaining dental pulp tissue following VPTs using endodontic biomaterials. "Tampon VPT (tVPT)" may be considered a treatment approach for the management of stated IP cases; characterised by severe pulpal inflammation and delayed clotting process. The presented hypothesis evaluates clinical studies, experimental research and molecular impacts on clotting within the inflamed dental pulp, so as to explore the efficacy as well as the safety of tVPT as a viable treatment option. Latest clinical investigations have reported positive outcomes with tVPT; even in the presence of IP with PB. It has been shown that inflamed dental pulp tissues exhibit molecular impacts on the clotting cascade, which may contribute to the delayed clotting process. Nonetheless, the healing capacity of the dental pulp is not negatively affected by hyperaemia. Additionally, enhanced blood flow in the inflamed pulpal tissues may be associated with improved healing and boosted hard tissue formation. Moreover, tVPT could possibly promote pulpal healing and/or regeneration through continuing the presentation of essential nutrients, *e.g.* oxygen, and growth factors to the injured tissue. Furthermore, increased blood flow may facilitate the recruitment of immune and reparative cells; promoting tissue repair and encouraging the formation of dentinal bridge(s) after VPTs. Consequently, the state-of-the-art research and their findings could support the hypothesis that tVPT may effectively manage IP cases with PB and contribute to favourable outcomes.

Keywords: Blood Flow; Dental Pulp; Irreversible Pulpitis; Tampon Pulpotomy; Vital Pulp Therapy

Introduction

Vital pulp therapy (VPT) has revolutionized the field of endodontics by providing ultraconservative treatment options for the management of carious pulp exposures as well as the preservation of dental pulp health [1, 2]. Vital pulp therapy modalities primarily aim to promote healing and prevent the need for more invasive procedures; *e.g.* pulpectomy, complex root canal therapy (RCT) or tooth extraction. Different VPT techniques involve the removal of the affected dental pulp tissue and the application of endodontic biocompatible materials in order to facilitate pulpal healing and/or regeneration [3]. By preserving the natural tooth structure and maintaining the vitality of the dental pulp, VPT can contribute to long-term oral health and patient satisfaction [4-6].

Traditionally, normal haemostasis has been considered crucial for successful VPT outcomes, with the belief that prolonged bleeding (PB) during the procedure may compromise the healing potential of the remaining dental pulp [7]. However, emerging evidence challenges the mentioned notion and suggests that stem cells within inflamed pulps remain functional [8].

Irreversible pulpitis (IP) is a condition resulting from various irritants, *e.g.* dental decay, which leads to the inflammation of the dental pulp [9]. In cases of IP with uncontrollable PB during

treatment, tampon VPT (*i.e.* tampon pulpotomy; tVPT) has recently emerged as a potential treatment approach [6, 10, 11]. Seemingly, tampon pulpotomy can manage IP cases characterised by pulpal inflammation and delayed clotting process. However, it is essential to re-assess the significance of haemostasis in VPT outcomes and explore the effectiveness of tVPT in the promotion of pulp healing and regeneration.

The current paper critically evaluates clinical studies, experimental research and molecular impacts on clotting within the inflamed dental pulp tissue to provide scientific evidence; guiding clinical decision-making and enhancing the quality of dental care for patients suffering from IP with PB.

Hypothesis

The presented hypothesis proposes that the results of VPTs following the tampon approach, in combination with appropriate infection control and optimal elimination of aetiological factors, can effectively manage cases of IP with prolonged bleeding and promote treatment outcomes. By critically evaluating the recent and present-day literature on tampon therapy and incorporating a novel understanding of the pathogenesis and mechanism of action, the current paper aims to provide a more comprehensive and in-depth analysis of tVPT and its effects. In addition, the hypothesis is grounded on the belief that tVPT can effectively endorse dental pulpal healing and regeneration, even in cases with persistent haemorrhage *via* addressing the underlying inflammatory processes.

Evaluation of the Hypothesis and Discussion

The evaluation of the hypothesis primarily aims to determine the potential efficacy of tVPT in cases of IP with PB. By critically examining clinical studies, experimental research, and the molecular impacts on clotting within the dental pulp, new insights can be gained on the effectiveness and safety of tVPT as a viable treatment option.

The prolonged bleeding observed in the inflamed dental pulp can be attributed to the complex interplay of inflammatory response mechanisms and the coagulation process within the pulpal tissue. Inflammatory mediators released during inflammation have intricate effects on the coagulation system, which can lead to alterations in the activation of the coagulation process. Although inflammation generally promotes faster coagulation [12], specific inflammatory response(s) within the dental pulp in cases of IP can result in a delay in the clotting process. Probably, the release of inflammatory mediators and their effects on the coagulation system, combined with disruptions in platelet function and altered microvascular dynamics, could contribute to the mentioned delay in clot formation. Moreover, the inflammatory response within the dental pulp induces hyperaemia and increased blood flow, which, in turn, can further contribute to PB [13].

It is essential to differentiate between the time required for haemostasis and the healing capacity of the dental pulp in the context of VPT. No significant difference was observed in the level of different cytokines except IL-6 in the blood samples obtained from the exposure site of primary molars with carious exposures whether haemostasis could be achieved within five min or not [14]. The presence of PB should not be interpreted as a negative prognostic indicator for pulp healing [15], but as a possible indication of a robust blood supply necessary for pulp vitality, repair and regeneration. Eliminating the source of infection and aetiological factors for pulpitis, *e.g.* in cases of caries-induced pulpitis, allows the inflamed pulp tissue to have the potential to heal. However, the precise pathophysiological mechanisms underlying the clotting delay in inflamed dental pulp require further investigations to develop more targeted and effective strategies for managing the clotting process during VPT.

Clinical studies have shown promising outcomes in cases where tampon pulpotomy was performed despite PB. Researchers have reported successful management of IP in three cases of primary molars using tampon pulpotomy, with favourable results observed over a mean follow-up period of 34 months [10]. Another clinical study has evaluated the treatment outcomes of VPT as an alternative to tooth extraction in permanent molars with hyperplastic/irreversible pulpitis; demonstrating the efficacy of tampon pulpotomy in preserving the pulp and avoiding extraction [6]. A recent case study has reported the successful outcomes after the application of tampon pulpotomy in a vital molar tooth with irreversible pulpitis after a previous miniature pulpotomy failure [11]. These findings suggest that tVPT can be considered an effective treatment approach even in cases with IP/PB in primary or permanent teeth.

Experimental research has provided further evidence supporting the proposed hypothesis. Limjeerajarus *et al.* [16] investigated the effects of the prolonged release of iloprost, a prostacyclin analogue, on dental pulp healing in a rat model of mechanical pulp exposure. They observed increased tooth blood flow and enhanced tertiary dentine formation in the iloprost-treated group; indicating that prolonged release of certain molecules, *e.g.* iloprost, could stimulate higher blood flow and promote hard tissue formation in the dental pulp. The association between blood flow enhancement and hard tissue formation in the dental pulp is significant. Other studies have highlighted the role of biomaterials in enhancing blood flow and promoting healing in the dental pulp. Zhang *et al.* [17] investigated the effect of a biomaterial-based delivery system on angiogenesis and dental pulp healing. Their results showed

increased tooth blood flow and enhanced expression of vascular endothelial growth factor, a key factor in angiogenesis and tissue regeneration, in the biomaterial-treated group.

The rationale behind the observed association between the enhanced blood flow and the improved healing capacity of the dental pulp is multifactorial. Increased blood flow supplies vital nutrients, *e.g.* oxygen, and growth factors to the injured pulpal tissue; creating an appropriate environment conducive to healing and regeneration. Additionally, enhanced blood flow can facilitate the recruitment of immune and reparative cells to the site of injury; promoting tissue repair and/or regeneration.

While the relationship between blood flow enhancement and hard tissue formation in the dental pulp is logical and supported by several studies, further research is necessary to fully elucidate the underlying mechanisms and optimise treatment protocols. Future studies should investigate the specific factors involved in promoting blood flow and stimulating hard tissue formation as well as explore the long-term outcomes of tVPT in larger patient cohorts.

Conclusions

In conclusion, the evaluation of the presented hypothesis seems to support the potential effectiveness and safety of tVPT as a treatment modality for the treatment of IP with PB. The obtained findings from clinical studies and experimental research have provided evidence that the results of VPT following the tampon approach may be comparable to cases where the physiological clotting process occurs without significant delay. The association between enhanced blood flow and improved hard tissue formation in the dental pulp emphasises the importance of applying tVPT to control PB and facilitate pulpal healing.

Additionally, the evaluation of the hypothesis may well contribute to the understanding of the effectiveness and safety of tVPT as a treatment modality for managing IP. The outcomes gained from the comprehensive analysis of clinical studies and experimental investigations have provided valuable insights that can guide clinical decision-making and optimise treatment protocols. Nevertheless, further research is warranted to fully uncover the underlying mechanisms and refine the use of tVPT in the management of IP with PB.

Conflict of Interest: 'None declared'.

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