EDITORIAL

PROTOCOL FOR THE DEVELOPMENT OF A NEW COMPREHENSIVE CLASSIFICATION FOR IATROGENIC TOOTH PERFORATIONS

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Running title: CLASSIFICATION FOR IATROGENIC TOOTH PERFORATIONS

Funding: This report received no funding**.**

Conflict of interest: The authors deny any conflicts of interest related to this report study.

Acknowledgement: The first (VN) and second (SP) authors equally contributed for this editorial.

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INTRODUCTION

In endodontics, perforation of a tooth has been defined as "the mechanical or pathologic communication between the root canal system and the external surface of the tooth" (AAE Glossary of Endodontic Terms, 2020). Pathological perforations may occur due to tooth resorption or caries (Saed et al., 2016) whilst perforations that occur due to mishaps during operative procedures, such as root canal treatment or post-space preparation, are referred to as iatrogenic perforations (Fuss & Trope, 1996; Tsesis & Fuss, 2006; Estrela et al. 2017).

The occurrence of all forms of perforations has been documented to range from 3% to 10% (Eleftheriadis & Lambrianidis, 2005; Seltzer et al. 1967; Seltzer et al., 1970; Tsesis et al. 2010); with 73% reported to involve maxillary teeth and 27% mandibular teeth. In maxillary anterior teeth, iatrogenic perforations occur predominantly on the labial aspect of the tooth, primarily due to access preparation misalignment in relation to root inclination. In posterior teeth, perforation of pulp chamber floors may occur during access cavity preparation when locating canal orifices (Kvinnsland et al., 1989), or along the root following excessive tooth tissue removal during inappropriate canal instrumentation. Reports in the literature have identified that one of the significant contributing factors influencing the outcome of the root canal retreatment was the existence of a perforation (Farzaneh et al., 2004).

If located sub-gingivally, there is an intense inflammatory reaction at the site of a perforation due to microbial contamination and/or the injury created by the instruments that had created the mishap. This chronic inflammation can result in gradual breakdown of the periodontium if not managed appropriately. Ultimately, the inflammatory cascade is likely to result in the development of a periodontal pocket, fistula and bone resorption

(Clauder & Shin, 2006; Saed et al., 2016; Tsesis & Fuss, 2006) as well as a range of symptoms.

If a perforation is not recognised and an infection is established, the prognosis of the repair will be uncertain, and the possible complications can lead to tooth loss (Tsesis & Fuss, 2006). In theory, a supragingival tooth perforation may not necessarily progress towards irreversible inflammation or treatment failure, as long as the site does not become infected and it is managed appropriately (Fuss & Trope, 1996). Even if a perforation is repaired, the inappropriate selection and/or manipulation of the repair material and a lack of effective microbial control may compound the problem so that healing is less likely to occur (Fuss & Trope, 1996). The presence of perforative or resorptive defects of root, and canal obliteration plays a crucial role in predicting treatment failure in teeth diagnosed with pulpal disease. Perforations at coronal-level may further increase the risk of microbial leakage and poor structural integrity leading to tooth loss or fracture. Literature evidence reveals an increase in tooth structure loss by three-fold with the presence of pre- or intra-operative perforations (Ng et al. 2011; Sjogren et al. 1990). In summary, iatrogenic tooth perforations are serious complications of endodontic treatment and if not recognised, diagnosed and managed, they will inevitably lead to destruction of the periodontium and/or persistence of apical periodontitis. Factors such as the timing of diagnosis, presence/absence and degree of microbial contamination, proximity of the perforation to the crestal bone and epithelial attachment, as well as the clinician's approach to management, are all crucial to prognosis (Estrela et al., 2018).

A systematic review by Siew et al., (2015) concluded that non-surgical repair of perforations led to an overall favourable outcome of approximately 73%. Orthodontic forced eruption is a non-surgical alterative approach when the crestal perforation can be elevated above the attached gingiva, provided the tooth has adequate root length (Tsesis & Fuss, 2006). Various preoperative considerations may contribute to the likelihood of healing following perforation repair. Teeth in the maxillary arch, absence of a radiolucency at the perforation site, and use of a hydraulic calcium silicate cement are considered as positive contributory factors for tooth survival after perforation repair (Siew et al., 2015). Various materials have been employed in the repair of perforation

defects. Along with the aspect of providing efficient seal, the ideal root perforation material should also offer biocompatibility, be non-toxic, and should promote regenerative potential of periradicular tissues. Materials like MTA, Biodentine, Endosequence, and Bioaggregate are recently studied for its effectiveness as root repair material. Despite several perforation repair materials, MTA is known to offer excellent biocompatibility and reduced microleakege against Fusobacterium nucleatum at the furcal region (Main et al., 2004, Gorni et al., 2016, Kakani et al., 2015). Given the relatively favourable clinical outcome, non-surgical repair is considered the preferred management for root perforations. However, there are many factors that may affect the outcome and all these need to be considered.

Attempts have been made to classify iatrogenic perforations (Fuss & Trope, 1996) based on three main prognostic factors: location (apical-coronal or crestal), size (small or large), and time of occurrence (recent or old), of the perforation. Although this classification is helpful, it does not fully take into account other important factors, which may affect the outcome; for example, the cause of the perforation, periodontal status before the perforation and subsequently, radiographic evidence of pathosis at the perforation site, and presence or absence of infection are not considered in this classification (Fuss & Trope 1996). Specifying the dimension, or time frame of occurrence of the perforation is more likely to guide clinical decision-making and help to inform the prognosis.

The aim of this editorial is to set out the rationale and methodology to be followed in the development of a new classification system for iatrogenic tooth perforations. It is anticipated that a new, structured, clinically meaningful, and comprehensive classification will serve as a valuable tool for all stakeholders, including clinicians, educators, and researchers.

Key highlights of the proposed classification for iatrogenic perforations

The proposed, comprehensive classification will integrate multiple relevant clinical and radiographic parameters to improve the management, including diagnosis, treatment planning, communication and documentation of cases with iatrogenic perforations.

The potential advantages of the proposed classification are:

- Treatment Planning: guide the choice of repair material (e.g., hydraulic calcium silicate cements for furcation/complex perforations), operative approaches (non-surgical vs. surgical), and estimation of the prognosis;
- Documentation: easier to integrate into patient records, facilitating consistent record-keeping and effective referral communications;
- Training and Education: enhance clarity in case discussions and learning activities for students and practitioners at all levels of training and education;
- Research consistency: enable standardisation in reporting, thereby improving the ability to compare clinical studies, case series and experimental studies regarding iatrogenic perforations.

METHODS

Phase 1: The project leaders (VN, PD) will establish a steering committee made up of a group of experts who will oversee the development of the new classification.

Phase 2: The steering committee will develop the initial draft classification for iatrogenic tooth perforations and lead the consensus building process.

Phase 3: The steering committee will establish a panel of experts to solicit their opinions on the clarity, relevance and utility of the draft classification using an online Delphi methodology using a dichotomous scale ('yes' or 'no') and a 9-point Likert scale. Each criterion in the new classification will be accepted if it attains a score of 7–9 from a minimum of 70% of the participants and a score of 1–3 from fewer than 30% of members. Each criterion will be eliminated from the classification if it obtains a score of 1–3 from more than 70% of the participants and a score of 7–9 from fewer than 30% of participants. The panel will consist of academic or clinical endodontic specialists, endodontic postgraduate students and general dental practitioners. The experts will be chosen from across the world in order to provide a global perspective. The anonymous comments provided by the members will be incorporated into each subsequent round of the Delphi exercise, with the criteria and text of each category being modified from the feedback received. Additionally, members will be able to propose new categories for the classification.

Phase 4: Five endodontists with a minimum of five years of clinical or academic experience will independently pilot the classification system for consistency and reproducibility when evaluating anonymized clinical, radiographic, and cone beam computed tomography (CBCT) images of perforated teeth sourced from various universities or dental clinics. No patient will be subjected to additional imaging procedures for the purpose of this project; the retrospective nature of this project means it is impossible to obtain informed consent from these individuals. The images will be used by each assessor to classify perforations in accordance with the proposed classification. Kappa statistics and other statistical tests will be employed to evaluate the inter-rater reliability of the five assessors.

Phase 5: The steering committee will modify and finalize the classification system for iatrogenic tooth perforations in accordance with the feedback received from the Delphi process and the reliability testing by the seven to ten independent endodontists. The final classification will be published in appropriate journals and presented at scientific meetings/congresses.

Future initiatives

To promote widespread, uniform and practical application of the new classification in every day clinical and educational activities, the authors also intend to consider the following strategies:

- Integrating the new classification with standard therapeutic protocols;
- Providing additional supportive aids, such as clinical photographs and illustrative images and literature to enhance the reproducibility of the classification;
- Developing a rapid decision-making reference algorithm for chairside use.

These measures not only aim to promote the seamless incorporation of the new classification into routine clinical practice but they will also improve diagnostic accuracy and consistency, streamline clinical-decision making, and provide fundamental support for endodontic research and education.

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