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Intrusive Luxation Injuries in deciduous teeth: Literature Review and Treatment Complications Update

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INTRODUCTION

Dental trauma is a serious global health problem that affects both permanent and deciduous teeth, representing the most common orofacial injury (incidence of 11-30%) [Flores,2002]. In cases involving the primary dentition, the trauma, often asymptomatic, may go unnoticed by parents, representing the child's first interaction with a dentist.

Among various traumas to deciduous dentition, intrusive luxation, alongside avulsion, is the most common lesion in paediatric age [Spinas et al, 2006], defined as the apical displacement of the traumatised dental element deeper into the alveolus. It constitutes an injury to the tooth's supporting tissues (68.5%) [Mendoza-Mendoza et al 2015], surpassing injuries to the tooth's hard tissues (31.64%)[Mendoza-Mendoza et al, 2015], such as enamel fracture (30%)[Mendoza-Mendoza et al 2015] and root fracture (2%)[Murgia et al,2023; Spinas et al,2022], which are more frequent in permanent dentition due to the greater resilience of alveolar bone in deciduous dentition. Intrusive trauma predominantly affects the age group of 1 to 3 years, with the upper central incisor being the most frequently involved element (78%) [Costa et al,2016; Liu et al 2022]. In order to proceed with the therapeutic action, it is necessary to obtain a clear vision of the intrusive trauma; for this purpose, photogrammetry seems to be a good and accessible method [Zotti et al. 2022].

Intrusion has an incidence ranging from 4 to 33% of Traumatic Dental Injuries (TDIs)[Carvalho Pugliesi et al, 2020]. The male sex shows a slight prevalence over the female sex, but the difference does not reach statistically significant values. The majority of TDIs (69.2%) [Defabianis et al, 2022] occur at home, predominantly during childhood (2-3 years), resulting from accidental falls or collisions with furniture. Incidences outside the home are less frequent (18%) [Defabianis et al,2022].

Deciduous tooth intrusion demands special attention from clinicians due to the inherent risk associated with the trauma's direction. There is a potential for the deciduous apex to impact the developing permanent tooth germ. This risk is attributed to the bone's trabecular component's flexibility, making it more prone to dislocation than fracture. Additionally, physiological rizolysis typically begins around 4 years of age.

Intrusive trauma is classified by Andreasen[Andreasen et al,2007] into three grades:

- Grade I: intrusion <2mm with over 50% of the crown visible in the arch;
- Grade II: intrusion >2mm but <4mm, with less than 50% of the crown exposed (partial intrusion);
- Grade III: >4 mm or total intrusion;

Additionally, Oikarinen and Kassila [1987] classify intrusive trauma based on severity into three stages (mild, moderate, and severe), aligning with the grades proposed by Andreasen. Intrusive luxation is often linked to complications involving the deciduous tooth, including pulp necrosis (PN) (most common), pulp obliteration (PCO), and premature loss of the tooth (PTL). Additionally, it is associated with sequelae affecting the underlying permanent tooth (23%)[Bardellini et al, 2017], with enamel hypoplasia and hypomineralisation being the most frequently encountered. The latest IADT guidelines in 2020 [Day et al, 2020] emphasise, especially for very young patients with intrusive dislocation, the preservation of the traumatised tooth, advocating a watch-and-wait approach or waiting for spontaneous re-eruption. Extraction surgery is recommended only when radiographic evidence indicates direct impaction of the apex in the germ at the time of clinical assessment. This approach aims to reduce pressure on the germ and prevent or mitigate permanent outcomes. Patient monitoring is crucial until the exfoliation and eruption of the permanent tooth, with follow-ups scheduled at intervals of 1 week, 6-8 weeks, 6 months, and 1 year to detect any complications early [Day et al,2020].

The IADT guidelines [Day et al, 2020] provide valuable insights, establishing a consensus in literature on clinical practice and protocols for intrusive trauma. However, consensus becomes less clear when addressing complications in the deciduous tooth and potential sequelae on the permanent successor, especially in cases where spontaneous re-eruption fails, and extraction of the non-re-erupted tooth in infraocclusion is necessary.

The aim of this study is to conduct a literature review to assess the existence of protocols concerning:

- treatment of complications in the traumatised deciduous tooth;
- treatment of sequelae on the permanent successor of the traumatised deciduous tooth;
- management and maintenance of the space resulting from the early loss of the intruded tooth.

MATERIALS AND METHODS

The research was conducted from November 2022 to March 2023 by two independent reviewers (L.C. and T.M.), with a Cohen's Kappa coefficient of 0.70, indicating a significant level of agreement. The screening was performed using various databases such as PubMed, Medline, Scopus and Web of Science, using proper keywords: traumatic; intrusion; deciduous teeth; primary teeth, intrusive luxation; children.

Appropriate criteria for inclusion and exclusion were applied. Specifically, the included studies met the following criteria:

- published from 2000 to March 2023;
- focused on primary dental traumas;
- focused on complications and sequelae of intrusive luxation;
- examined risk factors and associations among factors;

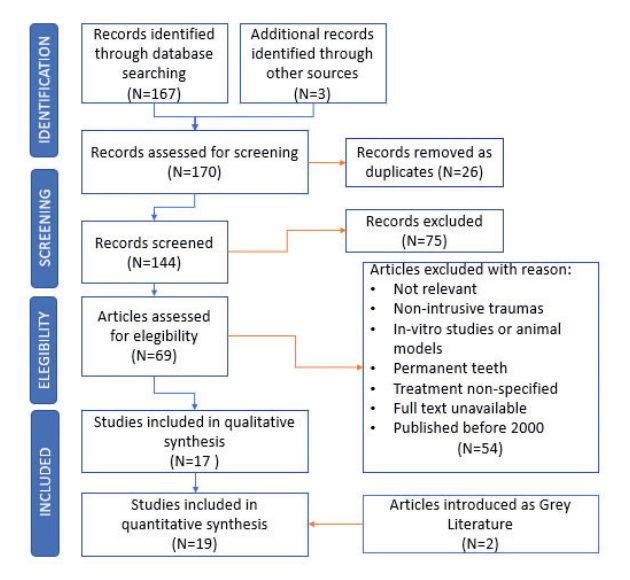

TABLE 1 Flowchart showing data extraction.

- presented a good level of evidence;
- full text was available for consultation;
- classified as a literature review;

Studies were excluded if they:

- were not relevant to the topic;
- focused on non-intrusive dental traumatic injuries (TDIs);
- exclusively addressed TDIs in permanent dentition;
- were in vitro studies or based on animal models;
- did not discuss treatment approaches;
- were published before the year 2000;
- if the full text was not available for consultation;

The data extraction procedures were performed using a scoping review flowchart, which is available for reference in Table 1. Additionally, two more studies [Spinas et al, 2006; Carvalho et al, 2010] were manually searched and consulted to enhance the understanding of intrusive trauma and its treatment approach.

Furthermore, it is imperative to note that the International Association of Dental Traumatology (IADT) guidelines were referenced, with specific emphasis on their latest update in 2020.

RESULTS AND DISCUSSION

Therapeutic Overview

The literature screening yielded 17 results from the search, with an additional 2 results from manual literature consultation, totalling 19 papers. It is evident, as anticipated, that there is a substantial consensus in the literature concerning the initial approach to this type of trauma. As suggested by the International Association of Dental Traumatology (IADT) guidelines in 2020 [Day et al, 2020], the intruded element should be given the opportunity to re-emerge spontaneously. Therefore, the preferred treatment is the watch & wait (w&w) approach, emphasising a vigilant observation strategy.

The most affected age group is between 0-3 years, with an average age of 2.3 years [Defabianis et al, 2022], This is particularly relevant for establishing an appropriate treatment plan. Some authors argue that there is no clear relationship between age and the likelihood of re-eruption, while others suggest that re-eruption, especially below 2 years of age, occurs normally with the restoration of the position in the arch (60%) [Colak et al, 2009]. However, between 2 and 3 years of age, re-eruption tends to be incomplete or absent [Gurunathan et al, 2016].

Additionally, the severity of intrusion appears to influence the prognosis and re-eruption timelines. Mild intrusions (<2 mm) are associated with re-eruption times ranging from 2 to 4 months. For moderate and severe intrusions (>4 mm), spontaneous re-eruption may occur, but it may take more than 4-6 months, up to a year. Nevertheless, outcomes seem favorable, with a re-eruption rate exceeding 40% [Gurunathan et al, 2016].

In his 2011 review, Gupta [2011] argues that in Grade I (mild) dental intrusions, there is a good chance of spontaneous re-eruption. However, in Grade II and III intrusions, the likelihood of reappearing in the arch is low. If there are no improvements within an acceptable timeframe or complications such as necrosis and suppuration arise in the traumatised deciduous tooth, a change in approach, such as extraction, may be necessary.

Similarly, if there are no re-eruptive movements observed within 4-8 weeks, ankylosis may be suspected, although the potential treatment for ankylosis is rarely discussed [Lauridsen et al, 2017]. Altun et al. [2009] reports that approximately 7% of deciduous teeth do not re-erupt at all, 15% re-erupt partially, and a significant 78% re-erupt completely [Altun et al, 2009].

Borum and Andreasen [1998] argue that deciduous tooth intrusion is accompanied by alveolar fracture in 54% of cases. If a fracture is present, Josell [1995] suggests reducing it through digital pressure. Ravn recommends watchful waiting (w&w) therapy in the absence of complications such as cortical perforation, as studies have shown that the percentage of post-traumatic damage is higher by about 20% when the approach is extractive rather than conservative (70% with immediate extraction, 50% with w&w) [Ravn, 1976]. Sometimes, inappropriate actions can cause damage to the permanent tooth.

In summary, the decision between watchful waiting (w&w) and an extractive approach following trauma hinges on accurately identifying the direction of intrusion. If the displacement is palatal, there is a higher risk of involving the permanent tooth germ, especially if the crown appears vestibularised. Conversely, if the crown appears palatalised, the root apex would be vestibularised, providing a safer margin for spontaneous re-eruption (80%) [Gupta, 2011] and a lower likelihood of affecting the permanent tooth germ [Spinas et al, 2006]. This clinical observation must be conclusively confirmed through radiographic examination (either periapical or occlusal), as outlined by the guidelines of the International Association of Dental Traumatology (IADT) [Day et al, 2020].

Clinical Approach to complications

Costa et al. (2016) conducted a retrospective study on complications following intrusive trauma. They estimated that the majority of these complications are clinically detectable (52.7%) rather than radiographically (32.7%). Among these, anomalies in re-eruption (ectopia), color variations, necrosis, and ultimately premature tooth loss (PTL), whether spontaneous or through extraction, were identified. Other complications included pathological resorption and obliteration of the pulp canal (PCO).

Lauridsen et al. 2017 confirm the aforementioned data from Costa et al. 2016, adding that the majority of complications in deciduous teeth occur between 6 and 12 months after trauma and during the first and second years of life. Both studies suggest a correlation between age and the occurrence of complications, attributed to the varying degree of maturation of the deciduous apex:

- children under 2 years old seem to have a lower risk of pulpal necrosis (PN), infection, and premature tooth loss

(PTL) because their open apex allows for greater vascularisation and enhanced healing and repair capabilities. Conversely, in cases of a closed apex (between 3 and 4 years of age), vascular supply is more easily compromised by intrusive trauma, potentially leading to radiolucencies and apical lesions that ultimately result in atypical or accelerated resorptions, especially if physiological root resorption has already initiated [Gurunathan et al,2016][Josell, 1995].

In cases of pulpal necrosis (PN), endodontic treatment may potentially improve the outcome following a watchful waiting (w&w) approach. However, if root resorption is already present, extraction is considered, especially considering the challenges of performing endodontic interventions in this age group, to prevent potential involvement of the permanent tooth germ. Nevertheless, there is currently insufficient clinical data to establish a standardised protocol [Lisboa et al, 2023].

Pulp canal obliteration (PCO) occurs more frequently in children under 2 years old, with an open apex. It does not compromise physiological resorption and, in the absence of acute symptoms, does not require treatment [Gurunathan et al,2016][Josell, 1995]. Furthermore, it presents a 38% risk of developing three years after trauma and tends to occur in teeth that persist for more than 24 months [Lisboa et al, 2023]. Color variations range from grayish darkening to yellow-amber discolorations of the crown, especially in the case of PCO. It's important to note that discoloration in deciduous teeth can be transient and not indicative of pulpal necrosis unless accompanied by abscess formation or radiographic radiolucencies [Costa et al, 2016].

Premature loss of the intruded element

Premature loss of the intruded element (PTL) can occur spontaneously or as a result of an extraction procedure, often occurring within the first year post-trauma (in 95% of cases of prematurely lost teeth). However, by the third year post-trauma, the risk of PTL decreases to 39% [Lisboa et al, 2023]. According to a retrospective study conducted by Lisboa et al. [2022], the survival rate of deciduous teeth affected by intrusive trauma is 65%. Nevertheless, this percentage decreases in children aged over 3 years and 8 months, as they approach the age of exfoliation and reparative capacities diminish, making it more challenging to address physiological root resorption.

Despite the encouraging survival rate, it is known that 15-20% of intruded elements do not fully re-erupt into the arch [Defabianis et al, 2022], while 7% fail re-eruption [Gupta,2011; Altun et al,2009]. A portion of these may experience ankylosis, and 35% 22of deciduous elements that undergo intrusive trauma are prematurely lost, leading to various issues related to maintaining space in the arch. This is primarily due to the natural closure process initiated by adjacent teeth, compounded by reduced maxillary growth in the presence of a resorbed alveolus. Additionally, eruptive difficulties for the permanent tooth may arise, including ectopia and delays due to the lack of guidance from the deciduous counterpart [Spinas et al, 2006]. Despite the significant impact of these conditions on the alignment of the future permanent dentition, as well as on function, phonetics, and aesthetics, only 2 out of the 19 studies produced and analysed in this research have proposed appropriate treatment:

- Gupta [2011] presents a case report involving a 3-year-old patient where, following the early extraction of the traumatised tooth, the same natural tooth was fixed onto an orthodontic wire, which was in turn attached to bands. This approach aimed to maintain good aesthetics in the patient, avoiding the risk of lingual interposition and the induction of detrimental habits. The choice of a fixed prosthesis on orthodontic bands was made for better clinician management, while the use of a removable appliance was recommended after the age of 3.
- Spinas [2006]: Addresses not only the importance of preserving adequate eruptive space but also proposes, in the case of premature loss, the use of an activatable removable plate until the time of exfoliation. This allows for the reopening of sufficient space for the eruption of the permanent tooth.

Overview of long-term effects on permanent teeth

In relation to sequelae on permanent teeth, there is a strong association with various factors, including the child's age at the time of trauma, the degree of root resorption of the deciduous tooth, the type and extent of the traumatic injury, and the developmental stage of the permanent tooth. The more advanced the development of the permanent tooth germ, the less damage is likely to occur. However, regardless of this, intrusions and avulsions are consistently identified as the traumas causing the most significant damage 23 [do Espírito Santo Jácomo, 2009].

There are two mechanisms through which the permanent tooth can be damaged due to trauma to the deciduous tooth: the first involves the direct impact of the deciduous tooth's apex on the permanent tooth at the time of trauma, and the second results from periapical infection due to pulp necrosis of the deciduous tooth as a long-term complication [Bardellini et al, 2017]

Regarding the first scenario, the direct involvement of the permanent tooth germ at the time of trauma, a retrospective study by Bardellini et al. in 2017 indicates an incidence of anomalies in 23% of cases in children under 2 years old and 26% between 2 and 4 years of age. Additionally, Andreasen and Ravn's study [1971] reveals that the permanent tooth is involved in 63% of cases under 2 years and 53% between 3 and 4 years old.

There is a consensus in the literature that long-term sequelae on permanent teeth are predominantly enamel hypoplasia and hypomineralisation (found in 46% of cases with sequelae). This is followed by eruption defects such as ectopic eruption, delayed eruption (18%) [do Espírito Santo Jácomo, 2009], and rarer malformations as odontoma-like formations and root bending.

Below are explanatory images of a Grade III (severe) intrusive trauma, as per Andreasen's classification [Andreasen et al, 2007], treated at the University Traumatology Center of Cagliari and Verona. Figures 1 and 2 depict the case at time 0. At the 1-year follow-up, extraction was performed due to the lack of spontaneous re-eruption (Fig. 3). Subsequently, an active space maintainer was placed (Fig. 5), and eruption occurred without complications (Fig. 6), presumably due to effective therapeutic planning.

CONCLUSIONS

Regarding the questions addressed in this research, the review has highlighted the following:

Concerning complications in deciduous teeth, there is agreement in the literature regarding the types of treatments useful for their mitigation.

The data are also sufficiently consistent regarding therapeutic approaches applicable to reduce sequelae in the permanent successor of the intruded deciduous tooth.

In contrast, for the third research question, only a few authors have proposed therapeutic guidelines for maintaining space and emphasised its importance in the proper future development of the orthognathic apparatus in paediatric patients affected by severe intrusive deciduous tooth trauma leading to early tooth

FIG. 1 Intraoral View of Grade III intrusive trauma of element 6.1.

FIG. 2 RX at T0 of intrusive trauma of element 6.1.

FIG. 3 12 months follow up rx post extraction of non-re-erupted 6.1.

FIG. 4 Intra-oral view of 12 months post-extraction follow up, evidence of insufficient space.

FIG. 5 Intra-oral view of Active space maintainer; 24 months follow up.

FIG. 6 Normal eruption of element 21 without any evidence of sequalae.

loss. In conclusion, this research underscores that, despite extensive discussions on trauma in deciduous dentition, there is a need for more retrospective clinical and cohort studies. Such studies could fill gaps in the literature and enhance therapeutic approaches concerning these not infrequent paediatric pathologies.

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