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# Extrusive and Lateral Luxation Injuries in permanent teeth: Literature Review and Treatment Complications Update

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## INTRODUCTION

Dental trauma remains a significant global health concern, impacting both permanent and deciduous teeth. It represents the most common orofacial injury, with an incidence ranging from 18% to 30% [Ranalli, 2002; Andreasen and Ravn, 1972]. Studies on the general population indicate that 10.5% to 17.3% are affected by dental trauma [Soriano et al. 2007; Traebert et al. 2006]. Adolescents, particularly those aged 11 to 15, are most vulnerable, with a prevalence of 13%, according to Bass et al, 2004, which increases to 25% for the 8 to 15 age group (Flanders and Bhat, 1995). Approximately 25% of such injuries in this age bracket occur during sports activities [Flanders and Bhat, 1995; Spinas et al. 2021], followed by domestic accidents [Lam et al. 2016; Spinas et al. 2020]. There are no significant sex differences in prevalence. Central incisors are the most commonly affected teeth (60%), followed by lateral incisors [Lam et al, 2016; Spinas et al 2018], Angle's class II malocclusion is among the major risk factors associated with dental trauma [Glendor, 2009; Spinas et al. 2021]

Tooth luxation, comprising 18-33% of all trauma in permanent dentition [Schatz et al, 2012; Glendor et al, 1996], often leads to severe damage to the pulp and supporting tissues. It involves the displacement of a tooth from its original socket position due to acute trauma [McClanahan et al. 2020], without complete avulsion. Luxation can occur in three main directions: intrusive, extrusive, or lateral [Andreasen et al., 2012]. Intrusive luxation is characterised by the displacement of the tooth element in the apical direction within the socket. Clinically, it is evident by the visually shorter crown of the intruding tooth compared to the contralateral. This form of luxation is deemed the most severe due to its consistently poor prognosis [Andreasen et al. 1999; Andreasen et al. 2002]. Extrusive luxation, also known as partial avulsion, involves the displacement of a dental element, often in the palatal direction, potentially causing damage to the vascular-nervous bundle and stretching of the periodontal fibers [Herman et al, 2012]. Clinically, this condition is characterised by an elongated tooth, increased anterior-posterior mobility, and occlusal interference due to the palatal displacement [Andreasen, 1970]. Lateral luxation involves an eccentric displacement caused by laterally directed forces [Andreasen et al. 2002]. This type of trauma often leads to damage to the vascular-nerve bundle, potentially complicated by fracture of the buccal bone cortex and compression of periodontal tissues at the apical and cervical levels [Lauridsen et al. 2012]. The degree of dislocation can be quantified in millimetres using intraoral radiographic references, particularly by measuring the distance between the apical foramen of the traumatised tooth and the base of the alveolus.

Classification based on this measurement includes:

- Mild (0-2 mm),
- Moderate (3-5 mm),
- Severe (>6 mm) [Andreasen et al. 1970; Spinas et al. 2020].

The latest update of the 2020 IADT guidelines, authored by Bourguignon C et al., recommend specific therapeutic approaches following a thorough clinical diagnosis involving sensitivity tests, mobility assessment, palpation of apical tissues and bone cortical, and evaluation of crown discoloration. Radiographic assessment, conducted via intraoral x-rays, is also advised to assess the degree of extrusion and identify concomitant fractures:

- Extrusive luxation: the recommended therapeutic approach involves the manual repositioning of the traumatised tooth under local anaesthesia, followed by flexible and passive splinting for a duration of 2 weeks. If extrusive trauma is accompanied by a fracture of the bone cortex, splinting may be extended for an additional 4 weeks. Endodontic intervention is indicated in instances of pulp necrosis and infection, tailored to the root's maturation stage. Treatment typically involves traditional root canal therapy for teeth with a Closed Apex (CA) and apexification for those with an Open Apex (OA).
- Lateral luxation: the recommended approach includes manually repositioning the traumatised tooth under local anaesthesia, followed by passive and flexible splinting for a minimum duration of 4 weeks, provided there is no fracture of the bone cortex. In cases of lateral luxation, an endodontic assessment is recommended at 2 weeks post-trauma to evaluate sensitivity, apical reactions, and signs of suppuration, aiming to distinguish root maturation stages. Teeth with an Open Apex (OA) typically have a better prognosis due to the likelihood of spontaneous revascularisation. Conversely, for teeth with a Closed Apex (CA), an intermediate dressing with calcium hydroxide followed by root canal treatment is advised [Spinas et al., 2020; Spinas et al., 2021].
- Regarding Intrusive luxation, given its severity and the diverse intervention approaches that may arise depending on the age of the affected individual, this type of luxation will not be addressed in this study's detailed examination. In the context of luxation trauma, both extrusive and lateral, various outcomes can occur based on the severity of the injury and the stage of root maturation.
- Pulp canal obliteration (PCO), occurring in 3-24% of cases, is characterised by the progressive and excessive deposition of reparative dentin within the pulp chamber and root canals. This

| Authors and Year | N° of Samples | Age (Years) | N° of Extr. Lux. | N° of Lat. Lux | Manual Repositioning |
|---|---|---|---|---|---|
| Lee,2003 | 55 (24 OA-31 CA) | 7.1-17.8 | 55 | | 55 |
| Nikoui,2003 | 58 (35 OA-23 CA) | 6.3-17-8 | | 58 | 58 |
| Cehreli,2012 | 2 (2 OA) | 8.5 | 2 | | 2 |
| Ferrazzini Pozzi, 2008 | 47 (10 OA- 37 CA) | 7-59 | | 47 | 47 |
| Ramirez,2018 | 2 (2 OA) | 9 | 2 | | 2 |
| Spinas,2020 | 13 (8 OA-5 CA) | 8-16 | 13 | | 4 |
| Mokhtari,2021 | 1 (1 OA) | 7 | 1 | | 1 (S) |
| Sakly,2021 | 2 (2 CA) | 16 | 2 | | 2 |
| Coste,2024 | 233 (137 OA-96 CA) | 10-61 | 76 | 157 | 233 |
| Legend: OA = Open Apices; CA = Closed Apices; wk = Weeks; mo = Months; A= Acute treatment; S= Subacute treatment; D= Delayed treatment. | | | | | |

TAB. 1A The table shows the type of treatment choice, materials, and time of use.

| Authors and Year | Surgical Repositioning | Orthodontic Repositioning | Treatment time | Time of Splinting | Type of Splinting |
|---|---|---|---|---|---|
| Lee,2003 | 0 | 0 | NS | 7-14 days | SS 0.016 wire composite |
| Nikoui,2003 | 0 | 0 | NS | 14-21 days | SS 0.014/0.016 wire composite |
| Cehreli,2012 | 0 | 0 | NS | 3 weeks | Fishing line + composite |
| Ferrazzini Pozzi, 2008 | 0 | 0 | NS | 7-28 days | TTS composite |
| Ramirez,2018 | 0 | 0 | NS | 3 months | SS wire composite 0.4mm |
| Spinas,2020 | 0 | 9 | A;S;D; | 14-21 days | Bracket Ni-Ti wire |
| Mokhtari,2021 | 0 | 0 | S | 4 weeks | Wire composite 0.7mm |
| Sakly,2021 | 0 | 0 | S | 2 weeks | Wire composite 0.7mm |
| Coste,2024 | 0 | 0 | A; S; | 2-4 weeks | Not Specified |
| Legend: OA = Open Apices; CA = Closed Apices; wk = Weeks; mo = Months; A= Acute treatment; S= Subacute treatment; D= Delayed treatment. | | | | | |

TAB. 1B The table shows the type of treatment choice, materials, and time of use.

phenomenon is regarded as a para-physiological process [Andreasen et al. 1987; Spinas et al, 2021];
- Pulpal Necrosis (PN), with incidence rates ranging from 64% (extrusion) to 77% (lateral luxation), represents a pathological response of the pulp requiring prompt treatment according to IADT guidelines [Bourguignon C et al., 2020; Spinas et al., 2021; Andreasen et al., 1985; Andreasen et al., 1970].
- Physiological healing, observed in 20% of luxated cases, is also reported [Andreasen et al., 1987].

The lack of widely accepted therapeutic protocols for the treatment of extrusive and lateral luxation, particularly in cases where the time elapsed since the trauma exceeds 3 to 12 hours, is a common challenge encountered in clinical practice. This gap in knowledge has prompted the undertaking of this review, which aims to address the following research questions:

1. To assess the existence of standardised protocols in the literature that advocate for orthodontic repositioning of luxated teeth as a viable alternative to manual repositioning.
2. To evaluate the common complications that arise following extrusive and lateral luxation trauma, as well as the most appropriate therapeutic strategies for managing these complications.

## MATERIALS AND METHODS

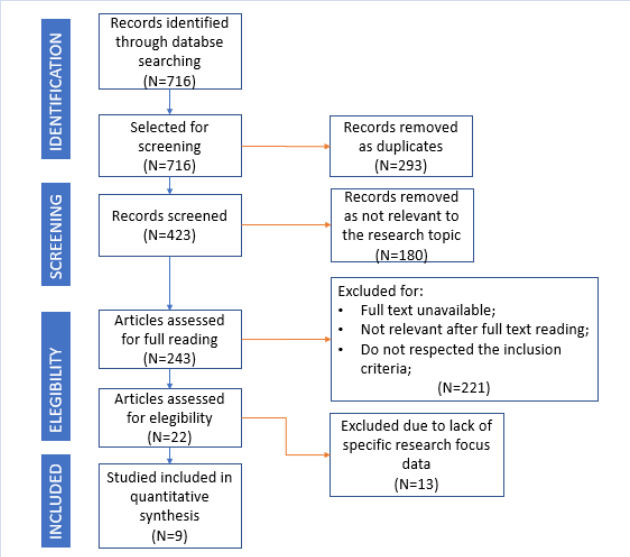
The research was conducted from November 2023 to March 2024, by two independent reviewers (L.C. e T.M.) with a K-Cohen coefficient of 0.70, showing a significant level of agreement. The screening was performed using various databases such as PubMed, Medline, Scopus and Web of Science, using proper keywords: Luxation Dental Injuries AND Permanent Tooth/Teeth, Luxation Dental Injuries AND Splint, Extrusive Luxation AND Obliteration, Lateral Luxation AND Splint, Intrusive luxation AND Resorption, Pulp Canal Obliteration AND Luxation Injuries. Idoneous criteria of inclusion and exclusion were applied, specifically were included studies:

- Studies in English;
- Studies on permanent teeth;
- Studies investigating luxation injuries (intrusive, extrusive and lateral);
- Studies that specified the orthodontic treatment used at the splinting time;
- Studies investigating PCO after traumatic dental injury;
- Studies investigating PN after traumatic dental injury;
- Studies investigating physiological healing after traumatic dental injury;
- Studies of human teeth.

Furthermore, were excluded instead scientific works:

- Studies on primary teeth;
- Studies non in English;
- in vitro studies or based on animal models;
- non relevant to the topic;
- unavailable full text;
- Studies non specifying the stage of root development at the time of injury;
- Studies non specifying the treatment times.

In accordance with the 2015 PRISMA (Preferred Reporting Items for. Systematic Reviews and Meta-Analyses) guidelines [Moher et




TAB. 2 Flowchart of data extraction.

al., 2015], a work protocol was drawn up, setting out the steps in the literature review process: (1) research design and formulation of the questions; (2) selection of the keywords for the database searches; (3) definition of the inclusion and exclusion criteria; (4) literature search and listing of bibliographic citations deemed pertinent; (5) study selection process; (6) charting the data; (7) selected data collation and summarising; and finally (8) discussion of the results drawn from the included articles. The search strategy was based on the PICO method [Cumpston et al., 2019], as follows:

- Population. We considered studies in humans presenting permanent dentition and one or more teeth affected by extrusive or lateral luxation injuries.
- Intervention. We considered patients treated with orthodontic repositioning and stabilisation splinting, with the use of flexible, semi-rigid, or rigid splints.
- Comparison. We compared patients presenting with extrusive and lateral luxation injuries.
- Outcomes. We considered the number of cases of PCO and of PN in teeth affected by extrusive and lateral luxations; we also considered the number of teeth that showed physiological healing (pulp survival) and the appearance of PN after PCO in both the two types of trauma. We selected articles written in English and published after 2000. Included studies could be randomised clinical trials, observational studies (with cohort, case-control, or cross-sectional designs), clinical case series, or case reports. Reviews, in vitro, or animal studies, editorials, conference abstracts, letters, and comments were excluded. The procedures of data extraction were performed through the realisation of a scoping review flowchart, that could be consulted in Table 2.

## RESULTS

An initial search of the literature revealed 716 potential relevant articles; From these, 243 were selected, as reported in the flowchart, for a complete reading, 22 following the application of the inclusion and exclusion criteria; for a total of 9 final articles for the purpose of analysis.

## DISCUSSION

### *Treatment approach*

In accordance with the IADT guidelines, lateral and extrusive luxative traumas offer three potential therapeutic approaches:

- manual repositioning;
- surgical repositioning;
- orthodontic repositioning [Andreasen et al, 2002; Spinas et al. 2021].

The selection of treatment is influenced by various factors, including the timing of intervention relative to the trauma, categorised as acute (within 3 hours), subacute (within 24 hours), or delayed (after 24 hours) [Andreasen et al, 2002]. While the timing of intervention significantly influences therapeutic decisions, there is a lack of comprehensive studies addressing this aspect. The scarcity of uniform data underscores the necessity for standardised research methodologies to facilitate statistical analyses and enhance understanding in this area. Among the studies reviewed, insufficient uniformity and data quantity hinder the derivation of high-quality insights regarding this parameter. Spinas et al. [2020] clearly advocate for orthodontic repositioning in subacute cases or those beyond 24 hours, whereas Costa [2024] exclusively considers acute manual repositioning without addressing subacute or delayed. If a patient presents to the clinician within 3 hours of sustaining a luxative trauma, manual repositioning of the affected tooth element, performed under local anaesthesia, is both feasible and optimal as an acute treatment. This approach aligns with the recommendations outlined in the IADT guidelines and is consistently the most frequently implemented treatment across the studies reviewed. Manual repositioning is particularly advantageous in cases where the traumatised tooth is displaced in the palatal direction, leading to occlusal interference. Timely intervention is crucial to mitigate the challenges associated with achieving a physiological occlusal relationship between the dental arches [Spinas et al., 2021; Spinas et al., 2020]. Following the initial acute phase, regardless of the chosen treatment approach, it is imperative to implement a flexible splinting regimen for a minimum duration of 2 weeks. In cases where there is concomitant alveolar cortical fracture and/or lateral luxation trauma, the splinting period may be extended up to 4 weeks. It is noteworthy that there is no compelling evidence in the literature suggesting that longer splint durations yield greater benefits. The primary objective of splinting both deciduous and permanent teeth, is to stabilise the affected tooth by connecting it to at least two adjacent healthy teeth, thereby reducing stress and the risk of further damage. Moreover, splinting facilitates the regeneration of periodontal ligament fibers following trauma [Ebeleseder et al., 1995; von Arx, 2005; Spinas et al. 2022]. In accordance with the IADT protocols and the findings of the reviewed studies, flexible splinting materials such as wire-composite and TTS composite are commonly utilised. Additionally, semi-rigid splinting options such as stainless steel wires (0.014/0.016), brackets, and NiTi wires are employed. Splinting therapy could be associated with laser therapy as it promotes healing, reduce pain and has a bactericidal and detoxification effect [Caprioglio et al. 2017]. However, there are instances where manual repositioning may not be feasible, especially in cases of significant extrusion exceeding 3mm, often due to the formation of a blood clot within the socket. This scenario, particularly common in cases of delayed treatment beyond 24 hours, necessitates consideration of alternative therapeutic options. Surgical repositioning, including intentional re-implantation, and orthodontic repositioning are among the potential alternatives to be evaluated in such cases [Grossman, 1966; Sübay et al., 2007]. Intentional re-implantation involves the extraction of the dislocated tooth, followed by its immediate reinsertion into the socket in the correct position, accompanied by irrigation and gentle cleaning of the alveolus to ensure a proper fit [Weine, 1980]. Additionally, it is strongly advised to perform root canal treatment on the traumatised tooth within 15 days of the injury event. This proactive approach aims to mitigate the risk of developing Internal Root


FIG. 1A


FIG. 1B


FIG. 2


FIG. 3A

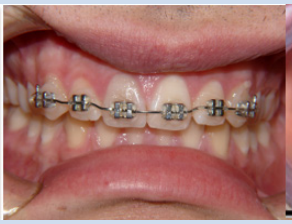


FIG. 3B


FIG. 4

FIG. 1A, 1B Figure 1. Male, aged 14, sports-related injury. Examination conducted 12 hours post-trauma (subacute treatment); tooth 11 shows a 3 mm extrusive luxation and palatal displacement. Clinical assessment involved intraoral examination from both vestibular and occlusal perspectives, along with periapical X-ray examination revealing the status of the closed apex. FIG. 2 Fixed orthodontic splint placement of repositioning of luxated tooth 11 to 12h after trauma FIG. 3A, 3B Intraoral image 30 days after the trauma, the repositioning of the extruded tooth 11 was completed. Slight discoloration of the tooth 11. FIG. 4 At 60 days after the trauma, debonding of the post-trauma stabilization orthodontic splint (1.1 discoloration remains, evolution towards PN is suspected).

Resorption (IRR), external resorption, or ankylosis [Camp, 1991]. Given the inherent risks associated with intentional re-implantation, this therapeutic approach is currently infrequently utilised in clinical practice. Indeed, none of the literature papers reviewed for this research opted for this treatment method. Orthodontic repositioning emerges as a promising and viable alternative. This method involves a gradual and controlled process aimed at returning the traumatised tooth to its original position over a timeframe of approximately 40 to 60 days. This process typically comprises an active movement phase lasting 30 to 40 days followed by a stabilisation phase involving splinting for approximately 14 to 21 days [Spinas et al., 2020]. During splinting period it is mandatory to mantain an optimal oral hygiene, with specific home instructions and professional protocols (Pasini et al. 2016).

Delayed repositioning offers three main advantages:

1. Controlled force application: Utilising a gentle force of approximately 40 grams generated by the orthodontic arch [Spinas et al. 2020] reduces the risk of additional damage to the vascular-nervous bundle [Ebrahim et al. 2013].
2. Respect for biological healing times: The gradual nature of delayed repositioning allows tissues to adapt slowly, ensuring optimal healing.
3. Minimal discomfort: Since the placement of brackets and orthodontic thread is non-invasive and generally painless, analgesia or local anaesthesia is typically unnecessary, enhancing patient comfort [Spinas et al.2021].

Similarly to orthodontic splints placed after manual repositioning, when opting for delayed repositioning, it is essential to include at least two healthy adjacent teeth alongside the traumatised tooth (typically involving an average of 6 teeth). Although a standardised protocol has not yet been established, delayed repositioning has proven to be a viable alternative in cases where manual repositioning during the acute phase is not feasible. Among the studies reviewed, only 9 of all traumatised teeth were repositioned using fixed orthodontics, involving the application of brackets and a NiTi 0.16 arch [Spinas et al., 2020].

**Pulp Response**

Following luxation trauma, various pulp responses have been observed, including pulp necrosis (PN). PN typically manifests as a pathological response within 3 months of trauma, often resulting in an unfavorable outcome for the affected tooth. In the studies analysed Pulp necrosis (PN) occurred in 31 out of 75 confirmed cases of extrusive trauma, with 16 cases involving teeth with Open Apex (OA) and 15 with Closed Apex (CA). However, it was not feasible to determine the exact prevalence of PN following extrusive trauma in the 2024 study by Coste et al., which reported 76 cases of extrusive trauma. Regarding lateral luxation, PN was reported in 42 out of 105 cases, with 3 involving teeth with OA and 39 with CA. Additionally, the study by Costa et al. [2024] reported 157 cases of traumatised teeth, but the necessary data for PN analysis could not be extrapolated from this study. Pulp canal obliteration (PCO) is considered a para-physiological response to trauma, marked by the deposition of reaction dentin within the pulp canals. Unlike pulp necrosis, PCO usually does not require endodontic treatment. From the studies reviewed, it is noted that PCO typically develops over a period of approximately 16 months [Costa et al., 2024]. Specifically, among 151 dental elements affected by extrusive dislocation, 49 exhibited PCO. Similarly, among 232 elements affected by lateral dislocation, 54 showed PCO. Physiological healing: this refers to a restoration with the preservation of pulp sensitivity and the absence of any clinical or radiographic signs of pathology, such as suppuration or apical resorption. Among the studies reviewed, healing was observed in 94 injured teeth out of 232 following lateral luxation, which is approximately double the rate reported in the literature (20%) [Andreasen et al., 1987]. However, further verification of this data is deemed necessary through studies involving more controlled age groups. Conversely, regarding extrusive luxation, there is an incidence of 22%, consistent with findings from previous scientific research. From the descriptive analysis of the data extracted from the studies, it is evident that pulp necrosis (PN) is the most common pulp response following lateral luxation trauma, particularly in cases with a closed root apex (39 cases of closed apex CA compared to 3 cases of open apex OA). This finding underscores the nature of the trauma, which often leads to disruption of the vascular-nervous bundle. In cases with a closed apex, the chances of spontaneous revascularisation are low, further contributing to the prevalence of PN [Spinas et al., 2020; Coste et al., 2024]. On the other hand, pulp canal obliteration (PCO) accounts for approximately one-third (49 out of 151 cases) of pulp responses in cases of extrusive luxation, with a higher prevalence observed in cases with an open apex. In the adolescent age group, variations in root maturation stages can be influenced

by ethnic and genetic factors. Therefore, achieving uniformity in studies becomes even more crucial. Accurate classifications, such as the European formula of Cameriere for estimating age based on dental development, provide valuable frameworks for standardisation and comparison across studies [Spinas et al., 2022; Cameriere et al., 2007].

## CONCLUSIONS

The review findings suggest that orthodontic repositioning can serve as a viable alternative to manual and surgical repositioning in cases of extrusive and lateral luxation trauma, particularly when these approaches are not indicated, such as in subacute (more than 3 hours after trauma) or delayed (more than 24 hours after trauma) treatments. The studies reviewed presented a diverse range of post-trauma splinting techniques, all showing similar efficacy. However, comprehensive data on techniques and protocols for orthodontic repositioning as the primary therapeutic approach were lacking. Therefore, there is a need for improved collection and standardisation of data from the literature regarding this promising therapeutic option. On the topic of pulp response, there is a consensus that pulp necrosis (PN) is the most prevalent outcome in teeth with a closed apex, whether due to extrusion or lateral dislocation, while pulp canal obliteration (PCO) is more commonly observed in teeth with an open apex. However, a comprehensive analysis of PN resulting from PCO was not feasible due to its rarity, as it is not typically considered for statistical purposes. Future in-depth research is warranted to explore this phenomenon further.

In conclusion, this research underscores the need for more high-quality studies with methodological uniformity, particularly retrospective and cohort studies, to address the evident gaps in the literature regarding the treatment of dental luxations. While traumatology in permanent dentition is a well-discussed topic, more focused studies are necessary to enhance our understanding and inform clinical practice effectively.

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