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Review Article

Application of Orthodontic Techniques for Managing Dental Luxations: A Scoping Review

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ABSTRACT

Managing dental luxation injuries remains a complex challenge for clinicians, as such injuries represent 18–33% of traumas to permanent teeth and can be treated through various therapeutic strategies. This study had two primary objectives: (i) to perform a scoping review of current knowledge regarding orthodontic interventions—specifically repositioning and stabilization splints—applied immediately after trauma, and (ii) to assess the prevalence and types of pulp outcomes following these injuries. A literature search was carried out between June and December 2020 across PubMed/MEDLINE, SCOPUS, and Web of Science. Research questions were structured using the PICO framework (Population, Intervention, Comparison, Outcomes), addressing the type of luxation and root development stage, utilization of orthodontic repositioning and splinting, occurrence and type of pulp responses, and adherence of interventions to international guidelines. Initial database searches with selected keywords retrieved 587 articles, but only 8 met all inclusion criteria. Further examination of these 8 studies revealed insufficient data for meta-analysis, necessitating a focus on six specific aspects: number and type of injuries, initial treatment methods, follow-up duration, and number and type of pulp outcomes. Orthodontic approaches are widely applied for managing dental intrusions, but are less commonly used for extrusive and lateral luxations, where their role is generally limited to stabilization. Among pulp outcomes, most studies report only pulp canal obliteration (PCO) and pulp necrosis (PN), often overlooking natural pulp healing or the potential for PN to develop after PCO. These findings highlight the urgent need for well-designed clinical studies with systematic, standardized data collection to better inform management strategies.

Keywords: Permanent teeth, Splinting technique, Physiological healing, Luxation injuries, Root development, Pulp necrosis

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Introduction

Epidemiological research indicates that between 10.5% and 17.3% of individuals experience traumatic dental injuries [1, 2], which can occur at any age, although the 11–15-year age group is most commonly affected, representing approximately 13% of cases [3]. Luxation injuries, which involve the pulp and/or supporting tissues, are considered severe dental traumas and account for 18–33% of injuries to permanent teeth [4, 5]. In dentistry, luxation is defined as a "displacement of a tooth from its alveolar position without complete avulsion, caused by acute trauma" [6], and can manifest as intrusive, extrusive, or lateral luxations.

Intrusive luxation, or dental intrusion, occurs when a tooth is displaced apically into the alveolar socket [7, 8], representing the most severe type of luxation. Clinically, the affected tooth appears shorter than its contralateral counterpart, and prognosis is generally poor, though teeth with immature root systems have a higher likelihood of survival [9, 10].

Extrusive luxation, also known as partial avulsion [8, 11], involves near-complete disruption of the periodontal ligament and rupture of the apical neurovascular bundle [12], resulting in increased tooth mobility. Clinically, the tooth may appear elongated, often displaced palatally, and may cause occlusal interference [8].

Lateral luxation is a non-axial, eccentric displacement of the tooth [12], often associated with apical neurovascular injury, labial bone fracture, and compression of surrounding tissues in both the apical and cervical regions [13].

Therapeutic strategies for luxation injuries, as outlined by the International Association of Dental Traumatology (IADT) guidelines [7], include passive repositioning (particularly for intrusive luxations), manual repositioning (all luxation types), intentional replantation, orthodontic repositioning, and splinting.

Treatment of dental intrusions varies according to root development, with options including passive repositioning to allow spontaneous re-eruption, orthodontic repositioning, and surgical repositioning [7]. For extrusive luxation, if acute intervention is possible within 3 hours post-trauma, manual repositioning followed by passive, flexible splinting is preferred. When immediate treatment is not feasible, surgical or orthodontic repositioning can be considered. Intentional replantation entails extracting the extruded tooth and reinserting it into the socket promptly [14, 15]; however, this approach carries risks such as inflammatory, external, or replacement root resorption [16–24] and should be reserved for selected cases [18]. Orthodontic repositioning offers a promising alternative [25–29], gradually moving the tooth to its original position over 40–60 days, followed by stabilization with a splint [26].

Lateral luxations are managed by manual repositioning after disengaging the tooth from the cortical bone, followed by a stabilization period of approximately 4 weeks [7, 30, 31]. Dental splinting is essential after luxation, and IADT recommends using passive, flexible splints [7]. Nevertheless, studies indicate that neither splint type nor stabilization duration significantly affects healing outcomes [32, 33], although splinting can reduce stress on traumatized teeth compared with unsplinted controls [34].

Pulp responses to luxation injuries include pulp canal obliteration (PCO), pulp necrosis (PN), and physiological healing (pulp survival, PS) [10, 35]. The incidence of these outcomes depends on injury severity and root development stage. PCO occurs in 3–24% of luxated teeth [10]; PN occurs in 64% and 77% of extrusive and lateral luxations, respectively, and can reach 100% following avulsion or intrusion [35, 36], while physiological healing has been observed in about 20% of cases [10].

Reports on luxated teeth treated with orthodontic repositioning are limited. Field and Christensen (2013) [37] showed that a laterally luxated tooth could be repositioned shortly after trauma using a NiTi wire appliance generating light forces, typically achieving full repositioning in 3–5 days, though longer periods may be required. Similarly, few studies [27–29] have investigated immediate or delayed post-traumatic orthodontic repositioning of extruded teeth and their long-term survival. These observations indicate that orthodontic repositioning still plays a minor role in dental luxation treatment guidelines.

This study aims to provide a scoping review of the current literature regarding orthodontic techniques—repositioning and stabilization splinting—used for managing dental luxation injuries. The review also examines pulp outcomes, comparing teeth with open versus closed apices, and analyzes the frequency of PCO, PN, physiological healing, and PN following PCO.

Materials and Methods

A scoping review was conducted to map the existing literature and identify areas where meta-analytical studies could be developed. This review followed the framework proposed by Arksey and O'Malley [38] and further refined by Zachary Munn *et al*. [39], which organizes the process into five stages: defining the research question, locating relevant studies, selecting studies, extracting and charting data, and synthesizing and reporting the findings.

The review protocol adhered to the PRISMA 2015 guidelines [40], establishing a clear sequence of steps: (1) designing the study and formulating specific questions; (2) selecting keywords for database searches; (3) determining inclusion and exclusion criteria; (4) performing the literature search and compiling relevant citations; (5) screening and selecting eligible studies; (6) extracting and organizing key data; (7) summarizing and analyzing the collected information; and (8) discussing the results based on the included studies.

Research questions

This review focused on several central questions: (1) the type of luxation injury sustained (intrusive, extrusive, or lateral) and the developmental stage of the tooth root (open apex [OA] versus closed apex [CA]); (2) application of orthodontic repositioning and splinting techniques; (3) incidence and nature of pulp outcomes, including pulp canal obliteration (PCO), pulp necrosis (PN), pulp survival, and PN occurring after PCO; and (4) alignment of treatments with IADT recommendations.

Inclusion and exclusion criteria

The PICO framework [41] guided the search strategy:

- Population: Patients with permanent teeth experiencing one or more luxation injuries.
- Intervention: Orthodontic repositioning and stabilization using flexible, semi-rigid, or rigid splints.
- Comparison: Differences among intrusive, extrusive, and lateral luxation injuries.
- Outcomes: Occurrence of PCO, PN, physiological pulp healing, and PN following PCO in each luxation type.

Eligible studies included English-language publications after 2000 and encompassed randomized controlled trials, observational studies (cohort, case-control, cross-sectional), case series, and case reports. Excluded were reviews, in vitro or animal studies, editorials, conference abstracts, letters, and commentaries. A summary of the inclusion criteria is presented in **Figure 1**.

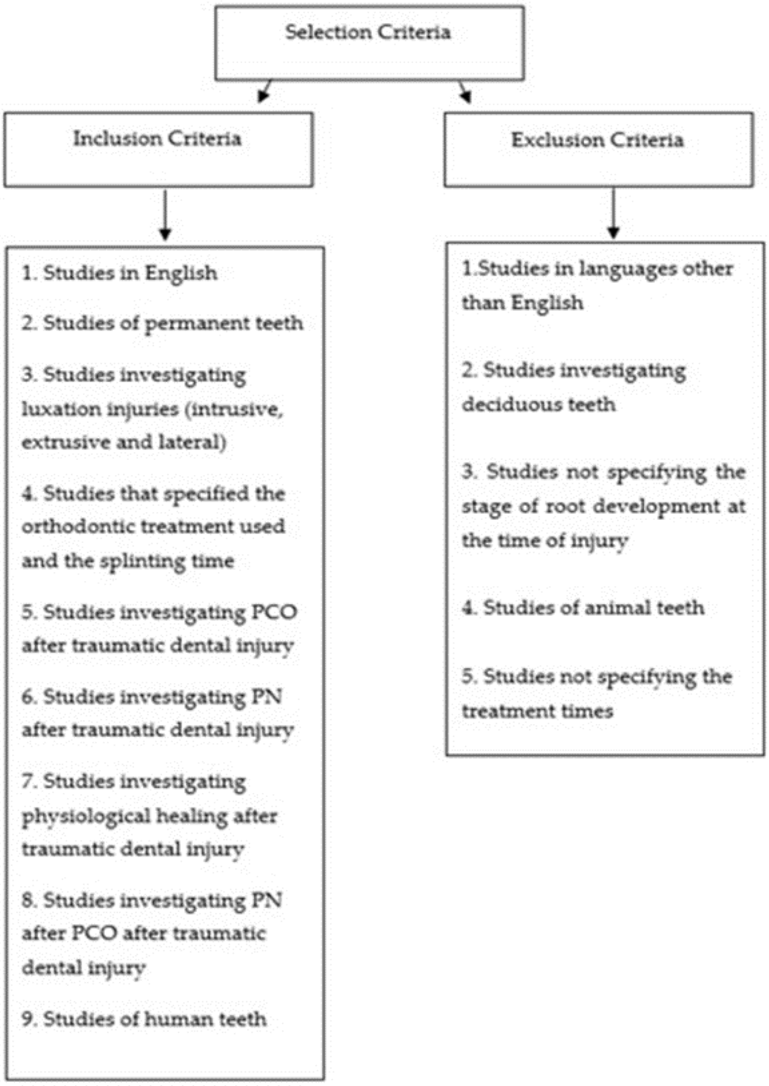

Figure 1. The figure summarizes the criteria used to include or exclude studies in the review.

Literature search

The literature review was conducted over six months, from June to December 2020, across three electronic databases: PubMed/MEDLINE, SCOPUS, and Web of Science. Search terms were combined to capture relevant studies and included: "Luxation Dental Injuries AND Permanent Tooth/Teeth," "Luxation Dental Injuries AND Splint," "Extrusive Luxation AND Obliteration," "Lateral Luxation AND Splint," "Intrusive Luxation AND Resorption," and "Pulp Canal Obliteration AND Luxation Injuries."

Two independent reviewers (LP and SM) screened studies first by title and abstract and, if necessary, by reviewing the full text. After independent screening, the reviewers compared their selections and resolved differences through discussion. When consensus could not be reached, a third reviewer (ES) made the final determination regarding inclusion.

Assessment of study quality

All three reviewers (LP, SM, and ES) independently assessed the methodological quality of the pre-selected studies. Inter-reviewer agreement was quantified using Cohen's kappa statistic, which indicated moderate agreement [42]. Any disagreements were resolved through discussion until all reviewers reached a mutual decision.

Data collection and handling

For each included study, LP and SM extracted the following information: publication year, first author, type of luxation (intrusive, extrusive, or lateral), root development stage at the time of injury (open apex [OA] or closed apex [CA]), use of orthodontic repositioning and type of splinting, and the main pulp outcomes—pulp canal obliteration (PCO), pulp necrosis (PN), pulp survival, or PN following PCO.

Risk of bias was evaluated following the recommendations of the Cochrane Handbook for Systematic Reviews of Interventions, version 5.1.0 [43]. While the calculated risk of bias prevented conducting a full systematic review, it was compatible with a scoping review approach. The agreement between the two primary reviewers was assessed using Cohen's kappa, yielding a value of 0.61, indicating moderate reliability. All extracted data were compiled into a Microsoft Excel 2016 spreadsheet for analysis, as summarized in **Tables 1 and 2**.

Table 1. The table shows data from the included studies, summarizing diagnostic and clinical information.

Author and Year	**N° of Samples**	**N° of Intr. Lux.**	**N° of Extr. Lux.**	**N° of Lat. Lux**	**Mm of lux**	**PCO in IL**	**PCO in EL**	**PCO in LL**	**PN in IL**	**PN in EL**	**PN in LL**	**PS**	**PN after PCO**	**First Clinical Examination**
Lee, 2003	55	/	55 (24 OA 31 CA)	/	<2 mm >2 mm n° NS	/	19 (16 OA 3 CA)	/	/	23 (11 OA 12 CA)	/	NS	2	Clinical examination, X-ray (Periapical+ Occlusal)
Nikoui, 2003	58	/	/	58 (35 OA 23 CA)	<2 mm >2 mm n° NS	/	/	23 (6 OA 17 CA)	/	/	23 (3 OA 20 CA)	NS	0	Clinical examination, X-ray (Periapical+ Occlusal)
Wigen, 2008	51	51 (31 OA 20 CA)	/	/	<2 mm (8) >2 mm (22)	18 (13 OA 5 CA)	/	/	29 (14 OA 15 CA)	/	/	4	NS	Clinical examination, X-ray (Periapical)
Tsilingaridis, 2011	60	60 (27 OA 33 CA)	/	/	1–3 mm (16) 4–6 mm (22) >7 mm (22)	17 (16 OA 1 CA)	/	/	23 (4 OA 19 CA)	/	/	17	NS	Clinical examination, X-ray (Periapical)
Cehreli, 2012	2	/	2 (2 OA)	/	NS	/	/	/	/	2 (2 OA)	/	0	0	Clinical examination, X-ray (Periapical)
Ferrazzini Pozzi, 2008	47	/	/	47 (10	NS	/	/	9 (2 OA 7 CA)	/	/	19 (0 OA 19 CA)	19	NS	Clinical examination, DPT, X-ray

				OA 37 CA)										
Ramirez, 2018	2	/	2 (2 OA)	/	NS	/	2 (2 OA)	/	/	0	/	0	0	Clinical examination, X-ray (periapical), photo
Spinas, 2020	13	/	13 (8 OA 5 CA)	/	0–2 mm (4) 3–5 mm (7) >6 mm (2)	/	9 (7 OA 2 CA)	/	/	3 (1 OA 2 CA)	/	1	0	Clinical examination, DPT, X-ray (Periapical+ Occlusal), photo

Legend: PCO = pulp canal obliteration; PN = pulp necrosis; PS = physiological healing; IL = intrusive luxation; EL = extrusive luxation; LL = lateral luxation; wk = weeks; mo = months; yr = year; OA = open apices; CA = closed apices; NS = not specified; n° NS: Number of teeth not specified.

Table 2. The table shows the type of treatment choice, materials, and time of use.

Author and Year	**N° of Samples**	**Age (Years)**	**N° of Intr. Lux.**	**N° of Extr. Lux.**	**N° of Lat. Lux**	**Manual Repositioning**	**Surgical Repositioning**	**Orthodontic Repositioning**	**Time of Splinting**	**Type of Splinting**
Lee, 2003	55	7.1–17.8	/	55 (24 OA 31 CA)	/	55	0	0	7–14 days	SS 0.016 wire composite
Nikoui, 2003	58	6.3–17.8	/	/	58 (35 OA 23 CA)	58	0	0	14–21 days	SS 0.014/0.016 wire composite
Wigen, 2008	51	6–17	51 (31 OA 20 CA)	/	/	37	7	7	2–6 wk	Wire composite
Tsilingaridis, 2011	60	6–16	60 (27 OA 33 CA)	/	/	17	12	31	6–80 days (mean 28.9)	Kevlar + wire
Cehreli, 2012	2	8.5	/	2 (2 OA)	/	2	0	0	3 wk	Fishing line + composite
Ferrazzini Pozzi, 2008	47	7–59	/	/	47 (10 OA 37 CA)	47	0	0	7–28 days (mean 22)	TTS composite
Ramirez, 2018	2	9	/	2 (2 OA)	/	2	0	0	3 mo	SS wire composite 0.4 mm
Spinas, 2020	13	8–16	/	13 (8 OA 5 CA)	/	3	9	0	14–21 days	Bracket–NiTi wire

Legend: OA = Open Apices; CA = Closed Apices; wk = Weeks; mo = Months.

Results and Discussion

The preliminary screening of titles and abstracts identified 587 articles that appeared potentially relevant **(Figure 2)**.

Flowchart

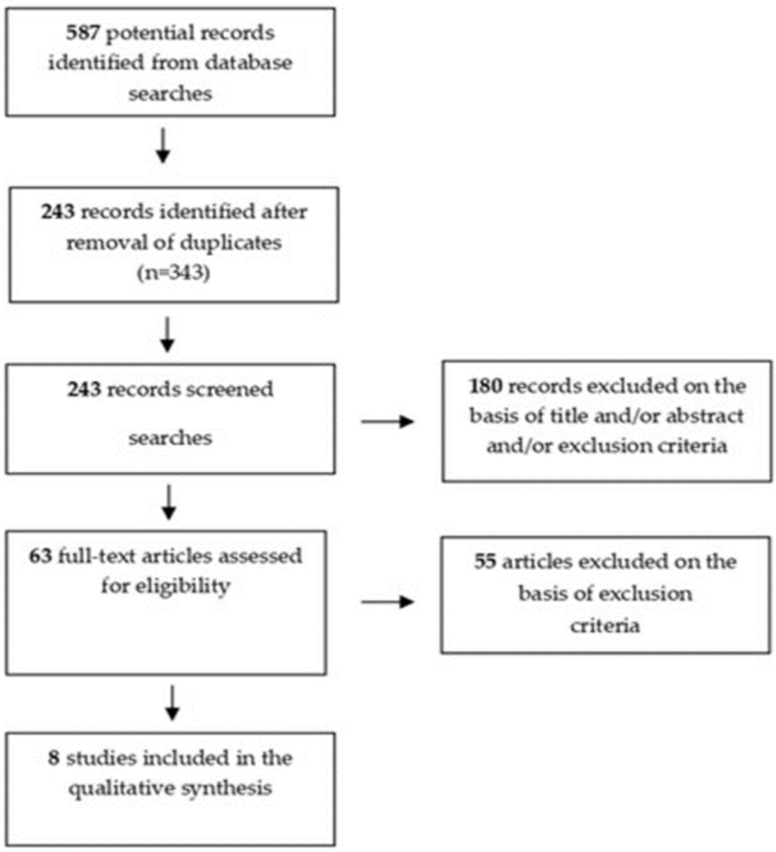

Figure 2. Flowchart depicting the search and selection process for the included studies.

Following a more detailed review, 343 articles were excluded as duplicates. Of the remaining 243, another 180 were removed based on their titles, abstracts, or failure to meet the exclusion criteria. This left 63 articles for full-text evaluation to determine eligibility. Upon full-text assessment, 8 studies fully met our inclusion criteria. Although 13 studies described the treatments applied, only these 8 provided detailed information on the types of equipment used, splinting durations, and the stage of root development at the time of trauma—an aspect critical to our study's aim of assessing its impact on pulp outcomes during follow-up.

Table 3 presents the key characteristics of the eight included studies, including the first author, year of publication, title, and study type, while **Table 4** organizes the reported pulp responses according to lesion type and the orthodontic intervention applied (repositioning or stabilization).

Table 3. Overview of the key characteristics of the studies included in the review.

Author, Year	Study Title	Study Design
Lee, 2003	Clinical outcomes of permanent incisor luxations in children. Part II: Extrusion	Longitudinal study
Nikoui, 2003	Clinical outcomes of permanent incisor luxations in children. Part III: Lateral Luxations	Longitudinal study
Wigen, 2008	Intrusive luxation of permanent incisors in Norwegian patients aged 6–17 years: retrospective analysis of treatment and outcomes	Retrospective study
Ferrazzini Pozzi, 2008	Healing of pulp and periodontal tissues in laterally luxated permanent teeth: 4-year follow-up results	Retrospective study
Tsilingaridis, 2011	Intrusive luxion of 60 permanent incisors: retrospective evaluation of treatment and outcomes	Retrospective study
Cehreli, 2012	Revascularization of immature permanent incisors following severe extrusive luxation	Case report

Ramirez, 2018	Four-year follow-up of extrusive luxation in a patient with cerebral palsy	Case report
Spinas, 2020	Extrusive luxations in children: retrospective study with five-year follow-up	Retrospective study

Table 4. The table shows the pulp responses after luxation injuries and the therapeutic approach used.

Intrusive Luxation				
Total	PCO	PN	PS	PN after PCO
111 58 OA–53 CA	35 29 OA–6 CA	52 18 OA–34 CA	19	-
Extrusive Luxation				
Total	PCO	PN	PS	PN after PCO
72 36 OA–36 CA	30 25 OA–5 CA	28 14 OA–14 CA	1	2
Lateral Luxation				
Total	PCO	PN	PS	PN after PCO
105 45 OA–60 CA	32 8 OA–24 CA	42 3 OA–39 CA	19	0

Intrusive Luxation			
Total	Manual repositioning	Orthodontic repositioning	Surgical repositioning
111 58 OA–53 CA	54	19	38
Extrusive Luxation			
Total	Manual repositioning	Orthodontic repositioning	Surgical repositioning
72 36 OA–36 CA	62	12	0
Lateral Luxation			
Total	Manual repositioning	Orthodontic repositioning	Surgical repositioning
105 45 OA–60 CA	105	0	0

Orthodontic extrusion is a well-established and widely recognized approach for managing intrusive luxation injuries and has become a routine part of clinical practice [7]. In contrast, there is limited literature on employing orthodontic repositioning for extrusive and lateral luxations.

Although relatively few clinicians use orthodontic repositioning, it can be particularly valuable when manual repositioning of the displaced tooth is not feasible. Reports indicate that orthodontic repositioning is often performed several days or weeks after trauma, frequently involving teeth that are already necrotic [27–29, 44].

The advantages of orthodontic repositioning stem from three main factors: (a) the use of very light, carefully controlled forces; (b) the promotion of tissue reorganization through these gentle forces [26, 28]; and (c) the elimination of the need for local anesthesia, which is especially important when treating anxious or distressed pediatric patients [37].

As noted, orthodontic repositioning can serve as an alternative when manual repositioning is impossible. Additionally, both manual and surgical repositioning involve forces that cannot be precisely controlled, potentially causing further trauma to an already injured tooth [28]. Modern orthodontic appliances are minimally invasive and apply light, gradual, and controlled forces, reducing the risk of additional damage to the apical neurovascular supply [28, 37, 45].

For splinting, the device should be bonded to the two healthy adjacent teeth, as larger splints involving more teeth have not shown additional benefits [46]. In all reviewed studies, splint selection followed IADT guidelines, employing either flexible/elastic types (e.g., Kevlar splint, elastic orthodontic wire, TTS composite, wire-composite) or semi-rigid types (e.g., stainless steel 0.014/0.016 wire composite, 0.9 mm fishing line, bracket with NiTi wire), with the wire-composite splint being the most commonly used.

The primary goal of stabilization splinting is to maintain tooth stability, prevent further damage, and support regeneration of periodontal fibers [7, 47]. The recommended duration depends on the method of repositioning: 4–8 weeks for intrusions, 2 weeks for extrusive luxations, and 4 weeks for lateral luxations, with the possibility of extending splinting by an additional 4 weeks in cases of marginal bone fracture or breakdown [7].

Our review found that only a minority of authors adhered to these guidelines from the early diagnostic stage. Many studies failed to report critical details, such as the severity of the injury, time elapsed between trauma and treatment, and the clinical or radiographic assessments conducted, all of which are important factors in treatment planning [7, 48, 49]. These omissions make it difficult to interpret clinical decisions, particularly in cases of delayed treatment, where the reasons—whether due to clinical choice or late patient presentation—were often unspecified. Treatment delays can significantly affect both pulp outcomes [9, 26] and the selection of repositioning methods [50].

Regarding pulp outcomes **(Figure 3)**, among the 111 teeth with intrusive luxation [51, 52], 87 exhibited signs of pulp canal obliteration (PCO) or pulp necrosis (PN). Specifically, PCO was observed in 35 of 111 teeth (29 associated with open apex [OA] and 6 with closed apex [CA]), while PN was diagnosed in 52 of 111 teeth (18 with OA and 34 with CA) **(Table 4)**.

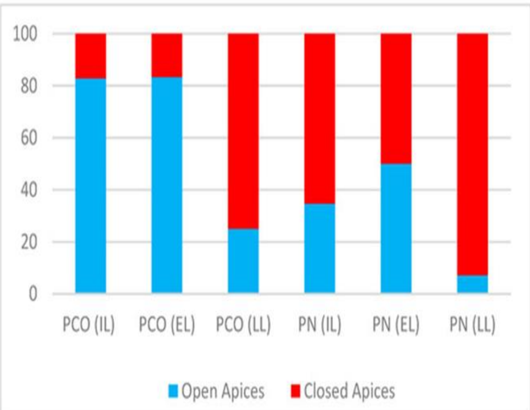

Figure 3. The figure illustrates the percentages of pulp necrosis (PN) and pulp canal obliteration (PCO) observed in intrusive luxation (IL), extrusive luxation (EL), and lateral luxation (LL).

Among 72 teeth with extrusive luxation [26, 53–55], 58 exhibited a pulp response: 30/72 developed PCO (25 with open apex [OA] and 5 with closed apex [CA]), while PN occurred in 28/72 teeth (14 with OA and 14 with CA) **(Table 4)**.

For the 105 laterally luxated teeth [30, 31], 74 demonstrated pulp responses. Specifically, 32/72 teeth showed PCO (8 OA, 24 CA), whereas PN was diagnosed in 42 teeth (3 OA, 39 CA) **(Table 4)**.

Descriptive analysis indicated that PN was the most common pulp outcome following both intrusive (52/111 teeth) and lateral luxations (42/105). In both injury types, PN was markedly more frequent in teeth with closed apices (34/52 and 39/42) than in those with open apices (18/52 and 3/42), consistent with the biological susceptibility of the periodontal ligament and pulp to damage in these luxations [8, 10, 13, 56].

Interestingly, our study found a higher incidence of PCO in laterally luxated teeth with closed apices, which contrasts with previous literature [10, 57, 58]; among 32 laterally luxated teeth exhibiting PCO, only 25% had open apices (8/32), while 75% had closed apices (24/32).

The study population primarily consisted of young patients aged 6–18 years, with Ferrazzini Pozzi's [31] sample being an exception, including patients aged 7–59 years.

Comprehensive analysis of pulp outcomes should also account for cases of physiological pulp survival and instances of PN occurring in teeth previously showing PCO. Although pulp survival as a post-traumatic outcome has been documented since 1987 [10], few authors report it, and definitions remain inconsistent. Among the reviewed studies, Tsilingaridis [52] and Ferrazzini Pozzi [31] reported pulp survival in 17/60 and 19/47 cases, respectively, though the diagnostic criteria were unclear. Physiological healing requires complete root development, vital pulp (responsive to testing), and absence of clinical or radiographic abnormalities [10, 26].

Similarly, few studies evaluated PN developing after initial PCO, and when assessed, it was extremely rare: 2/55 teeth in Lee [53], and none in Spinas [26], Ramirez [54], Cehreli [55], or Nikoui [30]. Literature reports the PN rate after PCO ranges from 1–27% and is generally considered uncommon [59]. PN following PCO may result from disruption of pulp vascularization, for example due to orthodontic intrusion or subsequent trauma in teeth with narrowed pulp canals [60–63]. Most authors agree that endodontic intervention should be reserved for primary PN, based on negative pulp sensitivity and clear clinical/radiographic evidence [58, 59, 64, 65].

The findings of this scoping review lead to several clinical considerations:

1. Stabilization splinting remains essential in managing luxated teeth, regardless of whether manual, surgical, or orthodontic repositioning is used. Orthodontic repositioning of intruded teeth is well-supported in the literature and may also be considered for extrusive and lateral luxations. Despite not worsening pulp outcomes and not requiring immediate application post-trauma, orthodontic repositioning is infrequently utilized, highlighting the need for further observational and retrospective studies to validate this approach.
2. Early adherence to guidelines, particularly regarding diagnosis, follow-up, and splinting duration, was generally poor. Insufficient reporting on injury severity and timing of treatment limited the ability to draw firm conclusions about clinical decision-making.
3. Pulp necrosis is the most common pathological response in teeth with intrusive or lateral luxation, showing prevalence rates of approximately 66% and 93%, respectively, in teeth with closed apices.
4. Pulp canal obliteration is a physiological response, particularly in extrusive luxations (around 42%), occurring mainly in teeth with open apices (approximately 83%).
5. PN following PCO remains rare, and physiological healing (pulp survival) should be more thoroughly investigated. The review revealed that this outcome is inconsistently reported and, when reported, often lacks clear diagnostic information.

Conclusion

The existing literature on the use of orthodontic dental repositioning for luxation injuries remains inconclusive. Inconsistent data collection and challenges in accurately compiling detailed clinical information prevent the formulation of clear clinical guidelines, underscoring the need for additional research in this area.

Findings from this scoping review emphasize the necessity for further clinical studies employing systematic and standardized data collection [48, 49], which would enable data harmonization, support meta-analyses, and provide more definitive evidence to guide therapeutic decision-making.

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