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REVIEW

Orthodontic management of intrusive and lateral luxation of permanent incisors: a scoping review

Mariagrazia Verrone[1], Eugenio Guidetti[2], Marco Maroni[1], Erica Lipani[1,*], Enrico Spinas[1,*]

[1] Department of Surgical Sciences, Orthodontics School, University of Cagliari, 09124 Cagliari, Italy
[2] Private Practice at Studio Dentistico Guidetti, 80133 Naples, Italy

***Correspondence**
erica.lipani@outlook.it
(Erica Lipani);
enricospinas@tiscali.it
(Enrico Spinas)

Abstract

Intrusive and lateral luxations are among the most severe traumatic dental injuries affecting permanent maxillary incisors in children and adolescents. Their management remains complex and controversial, with orthodontic repositioning increasingly regarded as a conservative alternative to surgical or manual methods. This scoping review aimed to map current evidence on orthodontic repositioning for these injuries, emphasizing treatment protocols, clinical outcomes, and the influence of root development on prognosis. A scoping search of PubMed, Embase, Scopus, and Web of Science was conducted up to July 2025, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines. Eligible studies included case reports and case series on orthodontic repositioning of intrusive and/or lateral luxations in permanent maxillary incisors of patients aged ≤18 years. Study quality was assessed using the Joanna Briggs Institute (JBI) checklist for case reports. Fourteen studies comprising 16 patients and 23 affected incisors were included. Eight teeth exhibited closed apices (CA) and 15 had open apices (OA). Orthodontic strategies varied; most employed light, continuous forces via multibracket appliances. All CA teeth and 10 OA teeth underwent root canal treatment, while 5 OA teeth healed without intervention (3 developed pulp canal obliteration, and 2 maintained sensibility). Reported complications included pulp necrosis (n = 11), root resorption (n = 4), ankylosis (n = 2), and pulp canal obliteration (n = 3), but overall tooth survival remained high. Although the methodological quality was acceptable, substantial heterogeneity existed in treatment protocols and follow-up durations. Orthodontic repositioning appears to be biologically favorable and minimally invasive for managing intrusive and lateral luxations of permanent maxillary incisors, particularly when surgical repositioning is not feasible. Prognosis is influenced by root maturity, treatment timing, biomechanics, and trauma severity. Well-designed prospective studies are warranted to establish standardized, evidence-based protocols for pediatric patients.

Keywords

Tooth luxation; Orthodontics; Tooth injuries; Incisor; Pediatric dentistry

1. Introduction

Traumatic dental injuries (TDIs) constitute a substantial clinical and public health concern in pediatric and adolescent populations, reflecting the increasing prevalence of sports-related and accidental trauma affecting the orofacial region [1, 2]. Such injuries often impose multifaceted burdens, such as biological, functional, psychological, and economic consequences on both patients and their families [3]. The peak incidence of TDIs occurs between 8 and 12 years of age, when the permanent maxillary incisors are most vulnerable to trauma [2, 4]. Epidemiological data consistently indicate that males are affected more frequently than females, and that predisposing anatomical or behavioral factors, such as increased overjet, lip incompetence, and systemic conditions like attention-deficit/hyperactivity disorder (ADHD), may further increase the risk [5].

Among TDIs, intrusive luxation and lateral luxation are considered the most severe types of displacement injuries due to their complex impacts on the pulp and periodontal tissues. Intrusive luxation is characterized by the apical displacement of a tooth into the alveolus following axial trauma, typically presenting as a shortened clinical crown, lack of mobility, and ankylotic sound on percussion [6]. Lateral luxation, which involves non-axial displacement, is often associated with cortical bone fractures and apical locking [7]. Both injuries commonly elicit a negative response to pulp sensibility testing, emphasizing the need for individualized and time-sensitive management strategies.

According to the International Association of Dental Traumatology (IADT) guidelines, treatment approaches differ between these two injury types. For immature teeth with open apices (OA) and intrusive luxation, spontaneous re-eruption for up to four weeks is advised. Conversely, in mature teeth with closed apices (CA), management may include observation, surgical repositioning, or controlled orthodontic repositioning based on the severity of intrusion [6, 8]. For lateral luxation, the standard treatment protocol includes manual repositioning followed by flexible splinting for four weeks, combined with prompt endodontic evaluation [9]. Orthodontic forces are generally not recommended but may be considered in delayed or complex cases where conventional repositioning is not feasible [10, 11].

Despite these distinct guidelines, clinical and literature reports often describe cases where intrusive and lateral luxations coexist or are managed using similar orthodontic approaches. These injuries frequently overlap in presentation and decision-making parameters, particularly regarding root maturity and timing of intervention. Therefore, analyzing them within a single review provides a broader and clinically relevant synthesis of orthodontic management strategies. However, the available evidence remains fragmented, consisting mainly of case reports and small series with heterogeneous treatment protocols and variable follow-up periods [12]. As a result, standardized recommendations for orthodontic management are still lacking.

The objective of this scoping review was to comprehensively map the existing literature on the orthodontic management of intrusive and/or lateral luxation of permanent maxillary incisors in pediatric patients.

Specifically, we aimed to evaluate how the stage of root development—open apex (OA) versus closed apex (CA)—influences treatment strategies and outcomes, and to summarize reported complications, including pulp necrosis (PN), root resorption (RR), ankylosis (A), pulp canal obliteration (PCO), and tooth survival.

2. Materials and methods

2.1 Protocol and reporting guidelines

This scoping review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines [13].

The inclusion criteria were structured using the PICO framework:

- Population (P): pediatric patients (≤18 years) presenting with intrusive luxation, lateral luxation, or combined injuries of permanent maxillary incisors;

- Intervention (I): orthodontic repositioning;

- Comparison (C): open apex (OA) versus closed apex (CA) teeth;

- Outcomes (O): orthodontic protocols and clinical complications, including pulp necrosis (PN), root resorption (RR), ankylosis (A), pulp canal obliteration (PCO), and tooth survival.

Eligible study designs included case reports, case series, and retrospective studies reporting orthodontic repositioning of luxated permanent maxillary incisors. Exclusion criteria were studies involving adult patients (>18 years), deciduous or non-incisor teeth, patients with systemic or local confounding conditions, as well as reviews, meta-analyses, *in vitro*, or animal studies.

2.2 Information sources and search strategy

An electronic search was performed across PubMed, Embase, Scopus, and Web of Science, covering all records up to 15 July 2025. No filters were applied for language, publication type, or date. The search strategy combined keywords, Medical Subject Headings (MeSH) terms, and Boolean operators related to dental luxation and orthodontic management.

The complete PubMed search string was as follows:

(“tooth luxation”[All Fields] OR “dental trauma”[All Fields] OR “tooth injuries”[MeSH Terms] OR “intrusive luxation”[All Fields] OR “lateral luxation”[All Fields] OR “dental intrusion”[All Fields] OR “tooth displacement”[All Fields]) AND (“Orthodontics”[MeSH Terms] OR “orthodontic treatment”[All Fields] OR “orthodontic repositioning”[All Fields] OR “bracket repositioning”[All Fields]) AND (“Incisor”[MeSH Terms] OR “permanent incisor”[All Fields] OR “maxillary incisor”[All Fields] OR “central incisor”[All Fields]) AND (“pulp necrosis”[All Fields] OR “root resorption”[All Fields] OR “ankylosis”[All Fields] OR “pulp canal obliteration”[All Fields] OR “tooth survival”[All Fields] OR “treatment outcome”[All Fields]).

Equivalent search strategies were adapted for the Embase, Scopus, and Web of Science corresponding indexing systems. In addition, grey literature searches and manual backward and forward citation tracking were conducted to identify any eligible studies not captured by database searches. Detailed search strategies for all databases are provided in Table 1.

2.3 Selection of sources of evidence

Two authors (EL and MV) independently conducted the electronic search and screened all retrieved records. Inter-reviewer reliability was calculated using Cohen’s kappa (κ = 0.66), indicating substantial agreement [14]. Discrepancies were discussed and resolved by consensus, with final decisions confirmed by the senior author (ES).

An initial screening based on titles and abstracts was conducted to identify potentially eligible studies focusing on orthodontic repositioning of luxated permanent maxillary incisors. Subsequently, full-text screening was carried out in accordance with the predefined inclusion and exclusion criteria.

2.4 Data charting process

Data were independently extracted by two authors (EL and MM) and recorded in a structured Microsoft Excel datasheet (Microsoft Office for Mac, version 16.102.1; Microsoft Corporation, Redmond, WA, USA), following the Cochrane Consumers and Communication Review Group’s data extraction template. Before full data collection, the extraction form was piloted on three studies to ensure clarity, consistency, and inter-reviewer reliability.

TABLE 1. Search strategies for the considered databases.

Database	Search Strategy
PubMed	(“tooth luxation”[All Fields] OR “dental trauma”[All Fields] OR “tooth injuries”[MeSH Terms] OR “intrusive luxation”[All Fields] OR “lateral luxation”[All Fields] OR “dental intrusion”[All Fields] OR “tooth displacement”[All Fields]) AND (“Orthodontics”[MeSH Terms] OR “orthodontic treatment”[All Fields] OR “orthodontic repositioning”[All Fields] OR “bracket repositioning”[All Fields]) AND (“Incisor”[MeSH Terms] OR “permanent incisor”[All Fields] OR “maxillary incisor”[All Fields] OR “central incisor”[All Fields]) AND (“pulp necrosis”[All Fields] OR “root resorption”[All Fields] OR “ankylosis”[All Fields] OR “pulp canal obliteration”[All Fields] OR “tooth survival”[All Fields] OR “treatment outcome”[All Fields])
Scopus	ALL (“tooth luxation” OR “dental trauma” OR “tooth injuries” OR “intrusive luxation” OR “lateral luxation” OR “dental intrusion” OR “tooth displacement”) AND ALL (“orthodontic treatment” OR “orthodontic repositioning” OR “bracket repositioning”) AND ALL (“permanent incisor” OR “maxillary incisor” OR “central incisor”) AND ALL (“pulp necrosis” OR “root resorption” OR “ankylosis” OR “pulp canal obliteration” OR “tooth survival”)
Web of Science	(ALL = (tooth luxation OR dental trauma OR tooth injuries OR intrusive luxation OR lateral luxation OR dental intrusion OR tooth displacement) AND ALL = (orthodontic treatment OR orthodontic repositioning OR brackets OR orthodontics) AND ALL = (permanent incisor OR maxillary incisor OR central incisor) AND ALL = (pulp necrosis OR root resorption OR ankylosis OR pulp canal obliteration OR tooth survival))
Embase	(“tooth luxation”/exp OR “tooth luxation” OR “dental trauma”/exp OR “dental trauma” OR “intrusive luxation” OR “lateral luxation” OR “dental intrusion” OR “tooth displacement”/exp OR “tooth displacement”) AND (“orthodontic treatment”/exp OR “orthodontic treatment” OR “orthodontic repositioning” OR “bracket repositioning”) AND (“permanent incisor” OR “maxillary incisor”/exp OR “maxillary incisor” OR “central incisor”/exp OR “central incisor”) AND (“pulp necrosis” OR “root resorption”/exp OR “root resorption” OR “ankylosis”/exp OR “ankylosis” OR “pulp canal obliteration” OR “tooth survival”)

The following data were extracted:

(a) Author and year of publication;

(b) Study design;

(c) Patient age and gender;

(d) Number and type of luxated teeth;

(e) Root development stage (open *vs.* closed apex);

(f) Type (intrusion and/or lateral luxation) and severity (in mm, when reported) of trauma;

(g) Time elapsed between trauma and initiation of orthodontic repositioning;

(h) Type of appliances (fixed or removable) and orthodontic biomechanics applied;

(i) Endodontic treatment and timing (before, during, or after orthodontic repositioning);

(j) Follow-up duration;

(k) Clinical outcomes.

2.5 Critical appraisal

The methodological quality of the included studies was independently assessed by two authors (MV and EG) using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Case Reports [15].

The checklist evaluates eight domains: clarity of patient demographic characteristics, clinical history, initial condition, diagnostic assessment, therapeutic interventions, post-treatment outcomes, identification of adverse events, and the presence of a clear take-home message. Each item was rated as “Yes”, “No”, “Unclear”, or “Not applicable”.

3. Results

3.1 Selection of sources of evidence

The initial search retrieved 940 articles across the four electronic databases: PubMed (n = 150), Scopus (n = 419), Web of Science (n = 276), and Embase (n = 95). After removing duplicates, 570 articles were screened based on title and abstract. Subsequently, 43 full-text articles were reviewed for eligibility, of which 29 were excluded and 14 studies were ultimately included in the final review. The detailed selection process is illustrated in the PRISMA flowchart (Fig. 1).

3.2 Characteristics of sources of evidence

A total of 14 case reports were included in this scoping review. Each described clinical cases of orthodontic repositioning of traumatized permanent maxillary incisors following intrusive and/or lateral luxation. The main characteristics of these studies are detailed in Table 2 (Ref. [16–29]).

Overall, 16 clinical cases, involving 23 traumatized incisors (20 central and 3 lateral) were analyzed. Among these, 8 teeth exhibited closed apices (CA) and 15 had open apices (OA). The patients ranged from 7 to 15 years of age, with a pronounced gender disparity: 14 males and 2 females.

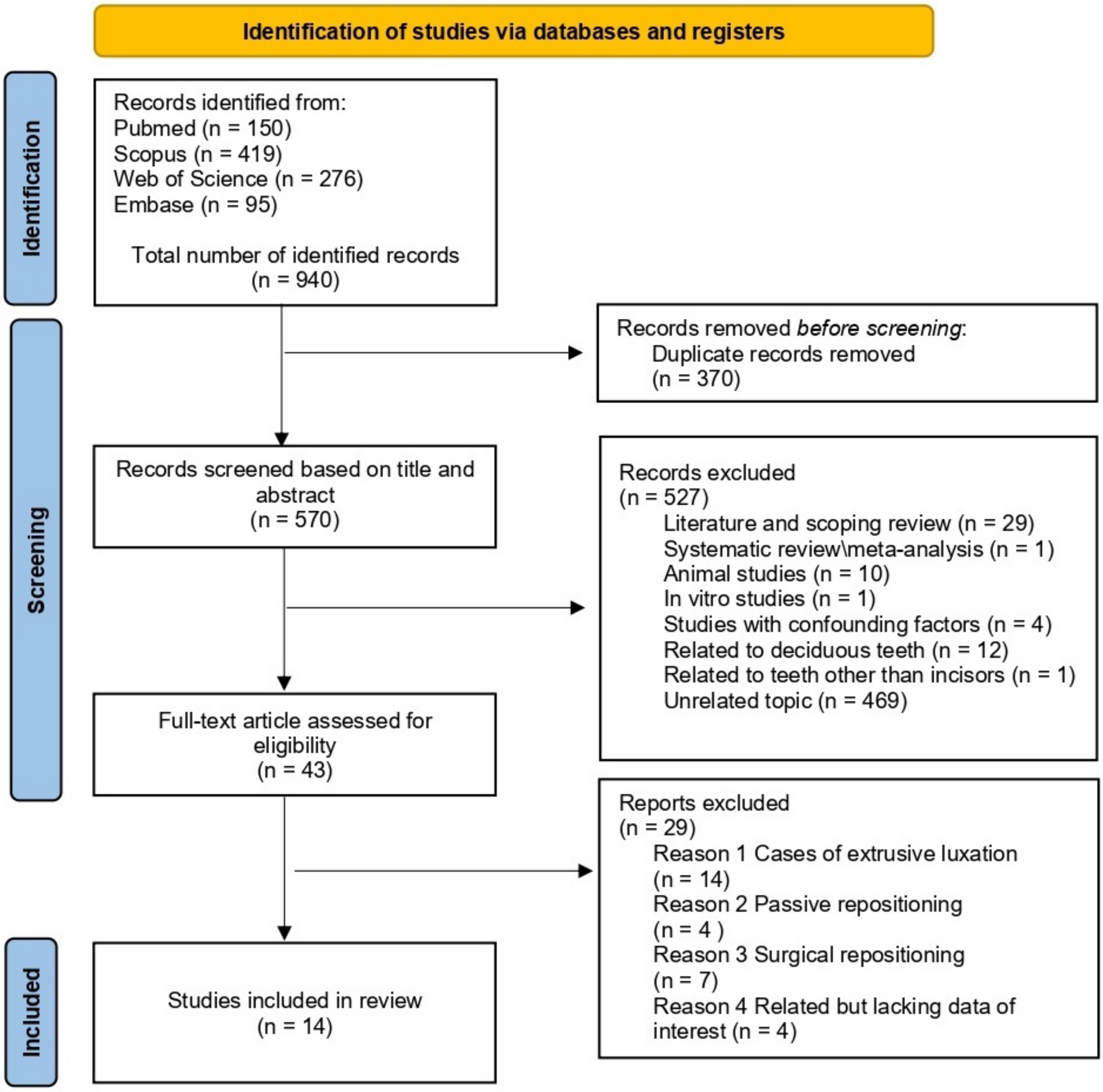

FIGURE 1. PRISMA flow diagram of the study selection process. The diagram shows the number of records identified, screened, assessed for eligibility, and included in the review, with detailed reasons for exclusion at each stage.

3.3 Critical appraisal within sources of evidence

Methodological quality was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Case Reports (Table 3, Ref. [16–29]).

Of the 14 studies included, 11 were rated as high quality [17–20, 22–26, 28, 29], 2 as moderate [16, 27], and 1 as low quality [21]. The most frequently unmet items concerned the reporting of clinical lessons and adverse events, particularly in less detailed reports.

3.4 Synthesis of results

Among the 23 traumatized permanent maxillary incisors included in this scoping review, all presented intrusive luxation [16–29]. In three cases, intrusion coexisted with lateral luxation [17, 20, 29], but no cases of isolated lateral luxation were identified. The severity of intrusion ranged from moderate (≈4 mm) [17, 24] to severe or complete (>7 mm) [16, 17, 21, 27]. Although IADT guidelines recommend surgical repositioning for intrusions >7 mm [6, 9], several such cases were successfully managed orthodontically, yielding favorable outcomes.

Most patients underwent treatment with fixed multibracket appliances, though biomechanics varied. In several reports, superelastic nickel–titanium (NiTi) archwires were used during the active phase to deliver light, continuous forces [17, 22, 23, 25, 27–29]. As treatment progressed, these were often supplemented or replaced by stainless steel (SS) wires, providing improved root control during later extrusion phases [22, 27–29]. Other studies used SS wires alone, either sectional or full-arch, as the primary active mechanics [16, 18, 21, 24, 26].

In fewer cases, removable appliances, such as an acrylic plate with extrusion arm [19] or a Hawley plate with springs [20] were used. In one case, a removable appliance was used initially, followed by conversion to a fixed multibracket system [24].

TABLE 2. Summary of study characteristics.

Author and Year	Participants (age/gender)	Luxated Teeth	Apex	Trauma Type and Severity	Trauma-to-Treatment Interval	Orthodontic appliance and Biomechanics	Repositioning Duration	Follow-up	RCT (timing)	Outcome
De Alencar *et al.* [16], 2007	1 patient 15 y/o, F	1.1	CA	INTR, Total	>15 d	Fixed multibracket appliance (N/A biomechanics)	N/A	3.6 yr	RCT 15 d pt	S
Ebrahim *et al.* [17], 2013	1 patient 7 y/o, M	1.1	OA	INTR, 4 mm + LL	>14 d	Edgewise brackets on incisors + deciduous teeth; Arch sequence: 0.015 SS → 0.016 × 0.022 NiTi Hawley retainer	19 mon	19 mon	No RCT	S+
Haimed *et al.* [18], 2023	1 patient 10 y/o, M	2.1	OA	INTR, 6 mm + FCRC	4 wk	Passive bonded brackets; 0.19 × 0.25 SS with elastic traction passive phase 12 wk	2 mon	4 yr	RCT 3 h pt (FCC)	S
Jacobs [19], 1995	1 patient 9 y/o, M	1.1	CA	INTR + FCC	4 wk	Removable acrylic device with extrusion arm on 11 6 mon retention after arm removal	3 mon	7 yr	RCT 7 d pt (PN, RR)	RR
Mamber [20], 1994	1 patient 11 y/o, M	1.1 2.1	CA	INTR, Severe + LL + FCNC	6 d	Hawley plate with springs for 1.1 and 2.1 extrusion, activated every 2–3 wk	1.1 3 mon 2.1 5 mon	1 yr	RCT 3 wk pt (PN)	1.1 A 2.1 S
Marczuk-Kolada *et al.* [21], 2017	1 patient 7.5 y/o, M	1.1	OA	INTR, >7 mm	4 wk	Fixed multibracket appliance (N/A biomechanics); passive phase 9 mon	9 mon	4.5 yr	RCT 9 mon pt (PN)	S
Nazzal *et al.* [22], 2014	2 patients P1 8.11 y/o, M P2 8 y/o, M	1.1 2.1 1.1	OA OA	- P1 INTR 1.1 4 mm, 2.1 7 mm + FCNC - P2 INTR, 7 mm	P1 5 d P2 14 d	P1: Fixed multibracket appliance + SS archwire + elastic traction P2: Fixed multibracket appliance + NiTi archwire (button → brackets on 11)	P1 6 mon P2 14 wk	P1 18 mon P2 18 wk	P1 RCT 1.1 8 wk pt, 2.1 10 wk pt (PN) P2 No RCT	P1: 1.1 S, 2.1 A P2: S+
Roberts *et al.* [23], 2001	1 patient 8 y/o, M	1.1	OA	INTR, 6 mm	17 d	Bands on 16 and 26 Brackets on 54, 53, 11, 21, 63, 64 + 0.016 NiTi archwire	4 wk	10 mon	No RCT	PB, S−
Seddon [24], 1997	1 patient 9 y/o, M	1.1 2.1	OA	- INTR 1.1 4 mm + FCNC - INTR 2.1 4 mm + FR**	10 d	Removable appliance for 3 mo to achieve extrusion, then fixed multibracket + 0.0175″ multistrand wire)	4 wk	10 yr	RCT a few days pt, before extrusion	S

TABLE 2. Continued.

Author and Year	Participants (age/gender)	Luxated Teeth	Apex	Trauma Type and Severity	Trauma-to-Treatment Interval	Orthodontic appliance and Biomechanics	Repositioning Duration	Follow-up	RCT (timing)	Outcome
Sian [25], 2009	1 patient 8 y/o, M	2.1 2.2	OA	- INTR 2.1, 7 mm - INTR 2.2 severe	3 wk	Brackets on 16, 55, 54, 53, 12, 11, 21, 22, 63, 64, 65, 26; arch sequence 0.012, 0.014, and 0.016 NiTi	7 wk	4 yr	RCT 6 wk pt (PN)	RR
Sönmez *et al.* [26], 2008	1 patient 8 y/o, F	2.1	OA	INTR, 5 mm	12 wk	Fixed multibracket appliance + elastic traction	20 wk	5 yr	No RCT	PCO
Suprabha *et al.* [27], 2008	1 patient 13 y/o, M	1.2	CA	INTR, Total + FCNC	4 wk	0.016 SS archwire with helix for 5 wk; 0.016 NiTi for 4 wk	9 wk	6 mon	RCT 9 wk pt	S
Umesan *et al.* [28], 2014	1 patient 8 y/o, M	2.1	OA	INTR, >7 mm	9 wk	Piggy-back 0.018 SS + sectional wire + button on 2.1, then brackets on 21 + base 0.016 SS + 0.014 NiTi overlay wire, reactivated every 6 wk, finished with a 0.018 SS sectional	7 mon	1 yr	No RCT	Partial PCO
Zhang *et al.* [29], 2022	2 patients P1 7.3 y/o, M P2 12.1 y/o, M	1.1 2.1 1.2 1.1 2.1	OA CA	- P1 INTR, 8–9 mm - P2 INTR 1.2, 7 mm + LL; 1.1–2.1 partial INTR, 21 + FCNC	P1 4 wk P2 4 wk	P1: Brackets on 55, 65, 53, 63, buttons 11 and 21 → 0.016 SS utility arch + 0.012 NiTi auxiliary arch; fixed lingual retainer P2: Brackets on 16, 55, 54, 53, 12, 11, 21, 22, 63, 64, 65, 26; 0.014 NiTi → 0.016 NiTi → 0.016 Australian	P1 12 mon P2 10 mon	P1 44 mon P2 19 mon	P1 RCT 1.1 7 wk pt, 2.1 5 wk pt P2 RCT (PN) 1.1 7 wk pt, 2.1 5 wk pt, 1.2 4 mon pt	P1: S P2: 2.1 RR, 1.1 & 2.1 S

A, ankylosis; CA, closed apex; FCC, complicated crown fracture; FCNC, uncomplicated crown fracture; FCRC, crown-root fracture; FR, root fracture; INTR, intrusion; LL, lateral luxation; N/A, data not currently available; NiTi, nickel–titanium; OA, open apex; P1, patient 1; P2, patient 2; PB, pulp–bone healing; PCO, pulp canal obliteration; PN, pulp necrosis; pt, post-trauma; RCT, root canal treatment; RR, root resorption; S, survival; S+, survival with retained sensibility; S−, survival with loss of pulp sensibility; SS, stainless steel; d, day(s); mon, month(s); yr, year(s); y/o, years old; F, Female; M, Male.

***, fracture diagnosed after extrusion.*

TABLE 3. JBI critical appraisal checklist for case reports.

Author and Year	1. Patient Demographics	2. History & Timeline	3. Initial Clinical Condition	4. Diagnostic Tests	5. Intervention	6. Post-Intervention Clinical Condition	7. Adverse Events	8. Clinical Relevance	Overall Quality
De Alencar *et al*. [16], 2007	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Moderate
Ebrahim *et al*. [17], 2013	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High
Haimed *et al*. [18], 2023	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High
Jacobs [19], 1995	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High
Mamber [20], 1994	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High
Marczuk-Kolada *et al*. [21], 2017	Yes	No	No	No	Yes	Yes	No	No	Low
Nazzal *et al*. [22], 2014	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High
Roberts *et al*. [23], 2001	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High
Seddon [24], 1997	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High
Sian [25], 2009	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	High
Sönmez *et al*. [26], 2008	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High
Suprabha *et al*. [27], 2008	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Moderate
Umesan *et al*. [28], 2014	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	High
Zhang *et al*. [29], 2022	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High

Root canal treatment (RCT) was performed in all CA teeth (n = 8) [16, 17, 19, 20, 27, 29] and in OA teeth (n = 10) [18, 21, 22, 24, 25, 29], totaling 18 treated incisors. In contrast, several OA teeth were monitored and healed without RCT, demonstrated pulp canal obliteration (PCO) or retained vitality [17, 23, 26, 28], reflecting the greater healing potential of immature teeth.

The trauma-to-treatment interval varied widely, from 5 days [23] to 12 weeks [26]. Duration of orthodontic repositioning ranged from 8 weeks [16, 18] to 19 months [17], while follow-up periods extended from 18 weeks [23] to 10 years [24].

Reported complications included pulp necrosis (PN, n = 11) [16, 19–22, 24, 25, 27, 29], root resorption (RR, n = 4) [19, 25, 29], ankylosis (A, n = 2) [20, 23], and pulp canal obliteration (PCO, n = 3) [23, 26, 28]. PN occurred predominantly in CA teeth, whereas several OA teeth maintained vitality or developed PCO. Despite these events, tooth survival was high across studies, confirming orthodontic repositioning as a conservative, biologically favorable treatment option, especially in pediatric patients with immature teeth.

4. Discussion

The orthodontic management of luxation injuries in permanent incisors remains a challenging and debated issue due to biological complexity and heterogeneity in clinical protocols. Current IADT guidelines distinguish lateral and intrusive luxations as distinct entities: the former typically managed with manual repositioning and short-term splinting, while the latter depends on root maturity and intrusion severity, with orthodontic repositioning considered only as a second-line option in CA teeth with moderate intrusion (3–7 mm) [6]. However, clinical evidence suggests that this distinction is often blurred. The cases in this review confirm that lateral luxation rarely occurs in isolation and is commonly combined with intrusive displacement [20, 21, 29]. In these combined injuries, clinicians have successfully employed orthodontic extrusion beyond current guideline indications, highlighting a divergence between theoretical recommendations and real-world management. This discrepancy provides the key rationale for the present combined analysis.

Treatment timing consistently emerged as a determinant of prognosis. Early initiation of orthodontic forces reduces the risk of ankylosis and root resorption [30–33], whereas prolonged delays increase the likelihood of complications, such as pulp necrosis or pulp canal obliteration [27, 29].

In this review, trauma-to-treatment intervals varied widely (5 days–12 weeks), reflecting case-specific clinical decisions and the lack of standardized treatment protocols. In pediatric patients, delays are often aggravated by psychological and logistical barriers—such as post-traumatic anxiety, limited parental awareness, and restricted access to specialized orthodontic or radiological care—which may compromise timely management [34, 35]. For immature teeth, current recommendations advocate up to four weeks of observation to allow for spontaneous re-eruption, after which orthodontic repositioning should be initiated to minimize complications [6, 22, 24]. In mature teeth with CA, preventive endodontic therapy is often indicated to counteract the high risk of necrosis, with orthodontic treatment aimed at preserving alveolar support and facilitating endodontic access [16, 20, 28]. Even when orthodontic treatment is delayed, functional and esthetic recovery is often achievable, though frequently accompanied by late complications [36]. Moreover, recent studies have shown that in laterally luxated mature teeth, pulp revascularization may still occur depending on the patient's age, indicating greater biological potential than previously assumed [37].

Biomechanical strategies varied substantially across studies, yet a shared clinical principle was evident: the use of light, continuous forces to promote controlled movement and periodontal healing. In most cases, nickel–titanium (NiTi) archwires were employed in the initial phase to allow controlled extrusion with minimal load [17, 25, 28, 29]. When more precise control of root angulation or torque was required, sectional or full-arch stainless steel (SS) wires were preferred [16–20, 23, 27–29]. Removable appliances were rarely used and typically reserved for severe intrusions requiring gradual activation [19, 20, 24]. However, compared to fixed appliances, these approaches provided limited three-dimensional root control, potentially increasing the risk of relapse or incomplete repositioning.

Overall, while no standardized biomechanical protocol could be identified, the consistent emphasis across studies was on maintaining light forces (15–20 g) and minimizing lateral components of movement, in order to reduce iatrogenic damage and promote periodontal and pulpal healing [32, 33, 38].

An important clinical distinction should be drawn between trauma-directed extrusion and comprehensive orthodontic treatment. The former aims solely to stabilize the injured tooth and supporting pulpal and periodontal healing through light, controlled forces. Comprehensive orthodontic treatment, by contrast, aims to correct malocclusion and overall dentofacial harmony, and should be postponed until biological healing stabilizes [39, 40]. Overall, orthodontic repositioning demonstrated high tooth survival, though late complications, including PN (n = 11), RR (n = 4), As (n = 2), and PCO (n = 3) remained frequent [16, 19–21, 23–26, 28, 29]. Importantly, PCO should not be considered as a true complication, but rather a healing response reflecting pulp survival and odontoblastic activity [41, 42]. The heterogeneity in reported follow-up, ranging from months to over a decade, complicates the ability to draw firm conclusions regarding prognosis. Extended monitoring of at least five years remains essential to detect late complications that may otherwise go unnoticed [39].

This review has several limitations. First, the available evidence is limited to case reports and small case series, which inherently provide a low level of evidence and are subject to publication bias. Second, the overall sample size was small and unbalanced, showing a clear male predominance, thereby reducing the generalizability of findings. Third, considerable heterogeneity existed in diagnostic criteria, timing of intervention, biomechanical protocols, and follow-up duration, which hindered meaningful cross-study comparisons. Moreover, follow-up periods were inconsistently reported—ranging from a few months to over ten years—complicating the assessment of long-term prognosis.

Although most of the included studies were rated as high quality according to the JBI checklist, the overall strength of the evidence remains limited because all were case reports or small case series. While these designs are valuable for illustrating clinical management, they lack control groups, standardized follow-up protocols, and quantitative outcome assessments. Consequently, the conclusions drawn from this review should be interpreted with caution, as they primarily reflect descriptive clinical patterns rather than statistically validated evidence. Nevertheless, a concise quantitative synthesis was performed to summarize the reported ranges of intrusion depth, trauma-to-treatment intervals, and related complications. However, due to the small number of cases and the intrinsic heterogeneity of the data, no statistical analysis was feasible. The synthesis, thus, served a descriptive purpose—to contextualize clinical outcomes and highlight how trauma severity and treatment timing influence prognosis.

Despite these limitations, the synthesis of available reports provides several practical insights regarding treatment timing, applied forces, and follow-up strategies. Orthodontic repositioning was typically initiated within the first few weeks after trauma, although reported intervals ranged from 5 days to 12 weeks, depending on case-specific factors and clinical judgment. Light continuous forces (15–20 g) were recommended to minimize periodontal stress and facilitate pulpal healing. Long-term clinical and radiographic follow-up, ideally extending for several years, remains essential for detecting late complications.

Although previously acknowledged, the psychological dimension of trauma management warrants greater emphasis. Dental fear and anxiety often play a decisive yet underestimated role in determining both treatment timing and patient cooperation in pediatric care. Previous research indicates that children who experience dental trauma frequently develop pronounced fear and anxiety, potentially delaying treatment initiation and compromising cooperation during orthodontic procedures [43]. In addition, limited caregiver awareness and restricted access to specialized trauma-oriented care can further postpone appropriate management. Educational programs targeting both children and parents—particularly those promoting trauma awareness and early referral—are crucial to improving adherence to follow-up and enhancing long-term outcomes [44, 45].

Given the unpredictable nature of dental trauma, future research should prioritize standardized diagnostic and therapeutic protocols, along with structured long-term follow-up schemes. Within this framework, well-designed comparative studies are needed to directly evaluate orthodontic extrusion with surgical repositioning, which currently remains the gold standard for severe intrusion. Furthermore, the role of orthodontic management in lateral luxations, often associated with intrusive injuries but rarely analyzed as an isolated entity, deserves further evaluation to clarify its indications and long-term outcomes.

5. Conclusions

This scoping review confirms that orthodontic repositioning represents a viable and conservative treatment option for permanent maxillary incisors with intrusive and/or lateral luxation, particularly when manual or surgical repositioning is contraindicated.

- Light, continuous forces applied through multibracket appliances emerged as the most common approach, with biomechanics adapted to the severity of displacement.

- Root development stage significantly influenced management; while all closed-apex teeth underwent endodontic treatment, approximately one-third of open-apex teeth healed without it.

- Treatment outcomes were favorable, showing high tooth survival and relatively few complications, including root resorption, ankylosis, and pulp canal obliteration, while pulp vitality was preserved in several open-apex cases.

Nevertheless, the exclusive reliance on case reports limits the strength of the current evidence. Prospective, multi-center studies are urgently needed to establish standardized protocols and guide clinical decision-making in pediatric patients.

ABBREVIATIONS

A, Ankylosis; CA, Closed Apex; FCC, Complicated Crown Fracture; FCNC, Uncomplicated Crown Fracture; FCRC, Crown-Root Fracture; FR, Root Fracture; IADT, International Association of Dental Traumatology; INTR, Intrusion; JBI, Joanna Briggs Institute; LL, Lateral Luxation; NiTi, Nickel–Titanium; OA, Open Apex; PB, Pulp–Bone Healing; PCO, Pulp Canal Obliteration; PN, Pulp Necrosis; PRISMA-ScR, Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews; P1/P2, Patient 1/Patient 2; RCT, Root Canal Treatment; RR, Root Resorption; S, Survival; S+, Survival with Retained Sensibility; S−, Survival with Loss of Sensibility; SS, Stainless Steel; TDI, Traumatic Dental Injury; WOS, Web of Science; y/o, Years Old; ADHD, attention-deficit/hyperactivity disorder; MeSH, Medical Subject Headings.

AVAILABILITY OF DATA AND MATERIALS

All data supporting the findings of this study are available within the published articles included in the review and are fully cited in the reference list. No new datasets were generated or analyzed for the purposes of this manuscript.

AUTHOR CONTRIBUTIONS

MV and EL—contributed to the design of this scoping review, literature search and article selection, data acquisition and analysis, and the drafting and revision of the manuscript, tables, and figures. EG and MM—participated in the study design, literature search and article selection, and data analysis. ES—contributed to the final proofreading, study design, article selection, and revision of the manuscript and tables. All authors have read and approved the final version of the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable. This study is a scoping review of previously published articles and did not involve new studies with human participants or animals.

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CONFLICT OF INTEREST

The authors declare no conflict of interest. Enrico Spinas is serving as one of the Editorial Board members of this journal. We declare that Enrico Spinas had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to ALG.

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