

Use of splinting in traumatized primary teeth: A systematic review of case reports

Uso de esplintagem em dentes primários traumatizados: Uma revisão sistemática de relatos de casos

Uso de férulas en dientes primarios traumatizados: Una revisión sistemática de casos clínicos

Received: 12/02/2023 | Revised: 12/12/2023 | Accepted: 12/13/2023 | Published: 12/15/2023

Shirlei Borges França

ORCID: <https://orcid.org/0009-0004-8838-9635>

Tiradentes University, Brazil

E-mail: shirlei_borges01@hotmail.com

Ayla Kelle Araújo Guimarães

ORCID: <https://orcid.org/0009-0009-0554-4529>

Tiradentes University, Brazil

E-mail: aylakellyguimaraes@gmail.com

Jane dos Santos Oliveira da Silva

ORCID: <https://orcid.org/0009-0005-1190-2995>

Tiradentes University, Brazil

E-mail: jane.doliveira@souunit.com.br

Matheus dos Santos Fernandez

ORCID: <https://orcid.org/0000-0001-7781-3083>

Federal University of Santa Catarina, Brazil

E-mail: mathsantos.f@gmail.com

Jamille Alves Araújo

ORCID: <https://orcid.org/0000-0002-8687-1047>

Tiradentes University, Brazil

E-mail: jamillealves@hotmail.com

Abstract

The aim of this study was to explore the use of splinting in the management of traumatized primary dentition in case reports published in the literature. Systematic searches were performed in the main health databases to identify case reports (a) with children presenting trauma in primary teeth, and (b) those that described any outcomes related to the use of splints in the management of traumatized primary teeth. The stages of study selection, data extraction and risk of bias analysis were performed. Descriptive data analysis was described. The reporting of information from this review was based on the PRISMA 2020 guidelines. Of the total number of studies initially found (n=246), eight were case reports. Outcomes of splint immobilization in primary teeth with luxation (intrusion, extrusion, and lateral displacement), intra-alveolar root fracture and/or alveolar fracture were reported. All case reports described splinting as a viable technique for immobilizing traumatized primary teeth, regardless of the type of traumatic dental injury (TDIs) and splinting technique used. Only case report verified the effectiveness of the splinting in the management of dentoalveolar trauma and demonstrated the clinical effectiveness of the contentive approach. Based on low evidence studies with a moderate risk of bias, it was observed that the use of splints for the management of alveolar bone fractures and intrusive root fractures, and in specific cases of teeth with lateral luxation, can bring additional benefits to the dento-alveolar health of traumatized primary teeth.

Keywords: Splinting; Dental trauma; Children.

Resumo

O objetivo deste estudo foi explorar o uso da esplintagem no manejo da dentição decídua traumatizada em relatos de casos publicados na literatura. Foram realizadas buscas sistemáticas nos principais bancos de dados de saúde para identificar relatos de casos (a) com crianças que apresentavam trauma na dentição primária e (b) àqueles que descreviam quaisquer resultados relacionados ao uso da esplintagem no tratamento de dentes primários traumatizados. Foram empregadas as etapas de seleção de estudos, extração de dados e análise de risco de viés. Foi realizada uma análise descritiva dos dados. O relato das informações desta revisão foi baseado nas diretrizes PRISMA 2020. Do número total de estudos inicialmente encontrados (n=246), oito eram relatos de casos. Foram relatados os resultados da imobilização com tala em dentes primários com luxação (intrusão, extrusão, deslocamento lateral), fratura de raiz intra-alveolar e/ou fratura alveolar. Todos os relatos de casos descreveram a imobilização com esplintagem como uma técnica viável para imobilizar dentes primários traumatizados, independentemente do tipo de lesão dentária traumática (TDIs) e da técnica de imobilização utilizada. Apenas um relato de caso verificou a eficácia da esplintagem no tratamento do trauma dentoalveolar e demonstrou a eficácia clínica da abordagem contentiva. Com base em estudos de baixa evidência e com moderado risco de viés, observou-se que o uso da esplintagem no manejo de fraturas do

osso alveolar e fraturas radiculares intrusivas, e em casos específicos de dentes com luxação lateral, pode trazer benefícios adicionais para a saúde dento-alveolar de dentes primários traumatizados.

Palavras-chave: Esplintagem; Trauma dentário; Crianças.

Resumen

El objetivo de este estudio fue explorar el uso de férulas en el tratamiento de dientes temporales traumatizados en informes de casos publicados en la literatura. Se realizaron búsquedas sistemáticas en las principales bases de datos sanitarias para identificar informes de casos de (a) niños con traumatismos en la dentición temporal y (b) aquellos que describieran cualquier resultado relacionado con el uso de férulas en el tratamiento de dientes temporales traumatizados. Se emplearon las etapas de selección de estudios, extracción de datos y análisis del riesgo de sesgo. Se realizó un análisis descriptivo de los datos. La información reportada en esta revisión se basó en las guías PRISMA 2020. Del número total de estudios encontrados inicialmente (n=246), ocho eran informes de casos. Se informaron los resultados de la inmovilización con férula en dientes temporales con luxación (intrusión, extrusión, desplazamiento lateral), fractura radicular intraalveolar y/o fractura alveolar. Todos los informes de casos describían la inmovilización con férula como una técnica viable para inmovilizar los dientes de leche traumatizados, independientemente del tipo de lesión dental traumática (TDI) y de la técnica de inmovilización utilizada. Sólo un informe de caso verificó la eficacia de la ferulización en el tratamiento del traumatismo dentoalveolar y demostró la eficacia clínica del enfoque contentivo. Conclusión: A partir de estudios con baja evidencia y moderado riesgo de sesgo, se observó que el uso de ferulización en el tratamiento de fracturas óseas alveolares y fracturas radiculares intrusivas, y en casos específicos de dientes con luxación lateral, puede aportar beneficios adicionales a la salud dentoalveolar de los dientes primarios traumatizados.

Palabras clave: Ferulización; Traumatismos dentales; Niños.

1. Introduction

Dental trauma stands as a significant catalyst for the demand for dental care, potentially influencing the oral health-related quality-of-life for both children and their families. Estimates indicate a prevalence of approximately 24 per cent for Traumatic Dental Injuries (TDI) during childhood (Patnana et al., 2021). The International Association of Dental Traumatology (IADT) 2020 recommends the implementation of splinting, in particular, for primary traumatised teeth, as an approach to address specific conditions such as alveolar bone fractures. Additionally, splinting is advocated in cases involving root fractures and lateral luxations (Day et al., 2020). This technique involves the stabilization of the affected tooth within its bone socket, facilitating revascularization of the periodontal ligament. Furthermore, splinting serves to prevent potential harm to both the affected tooth and adjacent tissues, while also promoting the healing of soft tissues (Kahler et al., 2016).

During the last decade, some studies have adopted the use of splinting in investigations exploring its applicability in the management of primary teeth with luxation (intrusion, extrusion and lateral displacement), intra-alveolar root fracture, and/or alveolar fracture (Cho et al., 2018; Song et al., 2017; Kim et al., 2012). A recent systematic review demonstrated, based on low quality evidence, that it can bring additional benefits to primary teeth with root fractures. This systematic review also highlighted the notable gap in the literature on the management of trauma in the primary dentition. Only three retrospective studies have explored the use of splinting in the treatment of traumatised teeth and were included in this review (Fernandez et al., 2023). In general, it is understandable that there are limitations when it comes to carrying out research related with TDI, especially in relation to emergency causalities and ethical aspects (Andreasen et al., 2012).

In fact, it is essential to explore all available information on these health approach, including the evaluation of the effect of splinting in specific cases of dental trauma in the primary dentition (Day et al., 2020). Some case reports have already shown that the use of the technique can reduce the mobility of primary teeth with intrusion (Di Giorgio et al., 2021), alveolar fracture (Akin et al., 2011) and root fracture (Bonanato et al., 2009). Therefore, the global synthesis of these findings may provide important insights about the applicability of splinting in the dental trauma (Fernandez et al., 2023), according to the degree of the traumatic injury in primary teeth (Day et al., 2020; Di Giorgio et al., 2021). Thus, the aim of this study was to explore the use of splinting in the management of traumatized primary dentition in case reports published in the literature.

2. Methodology

This manuscript follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement checklist 2020 (Page et al., 2021). The authors declare no potential conflict of interest with respect to the research, authorship, and/or publication of this study. All data and information related to this study may be requested from the corresponding author (JAA), according to the FAIR Data Principles (Wilkinson et al., 2016).

This investigation answers the following question: "*Can splinting traumatized primary teeth have additional benefits for clinical prognosis?*". The problem question was based on the PICO strategy, where: P (Population): children who have suffered trauma to their primary teeth; I (Intervention): use of any type of dental splinting; C (Comparator): not applicable; O (Outcome): clinical and radiographic parameters - i.e. mobility, pulp necrosis, pathological root resorption, pathological tooth loss, ankylosis, pathological bone resorption and resorption of fractured roots.

Search strategies were developed using a combination of free terms and, where applicable, index terms specifically to be applied to the databases in December 12, 2023 (Table 1). The following databases were included: PubMed/MEDLINE, Web of Science, Scopus, Scielo, Embase, and EBSCO. Manual searches were also performed in all issues published between 2003-2023 in Dental Traumatology, International Journal of Pediatric Dentistry and European Archives of Pediatric Dentistry. For other searches, any restrictions related with date of publication and/or language of studies were applied. Searches of grey literature records were also performed using an adapted search strategy in Google Scholar; the first 100 records were evaluated considering the eligibility criteria. The following inclusion criteria were considered: case-reports (a) with children presenting trauma in primary teeth, and (b) those that described any outcomes related to the use of splint in the management of traumatized primary teeth. No implications related to the date of publication or language of the studies were applied.

The literature searches were uploaded in Endnote© X9, and duplicate records were removed in manual step. Two blinded-researchers independently screened all titles/abstracts and the full-texts in two phases (AKAG; SBF). Disagreement between the investigators were resolved with a third (JAA) reviewer. Kappa coefficients between the two researchers were, respectively, $\kappa = .71$ and $\kappa = .89$ for title/abstract and full-text selection phases.

A data extraction spreadsheet was developed using Excel software (Microsoft®). Information related to the following items were analyzed jointly by three researchers: (AKAG; SBF; JSOS): (a) author; (b) year; (c) country; (d) study design; (e) sample size; (f) age group and sex; (g) type of trauma; (h) millimetres of luxation; (i) diagnostic methods used in the first examination; (j) type of splinting; (k) protocol; (l) other details; (m) period of treatment; (n) duration of treatment; (o) follow-up time; (p) diagnostic methods used in the last/follow-up examination; (q) main results/effect measurements; and (r) main conclusions. A third reviewer (JAA) checked all the extracted data and described the qualitative synthesis of the data.

Two independent reviewers appraised the risk of bias of the case report studies (JSOS; AKAG). Disagreements between the reviewers were resolved by discussion with a third reviewer (JAA). This evaluation was assessed using the Joanna Briggs Institute Critical Appraisal Checklist for Case Reports (Moola et al., 2017), which consists of eight questions with three answer options (yes; no; unclear). In this evaluation step, the kappa coefficient between the two researchers was $\kappa = .92$.

Table 1 - Search strategy according to databases (December 12th, 2023).

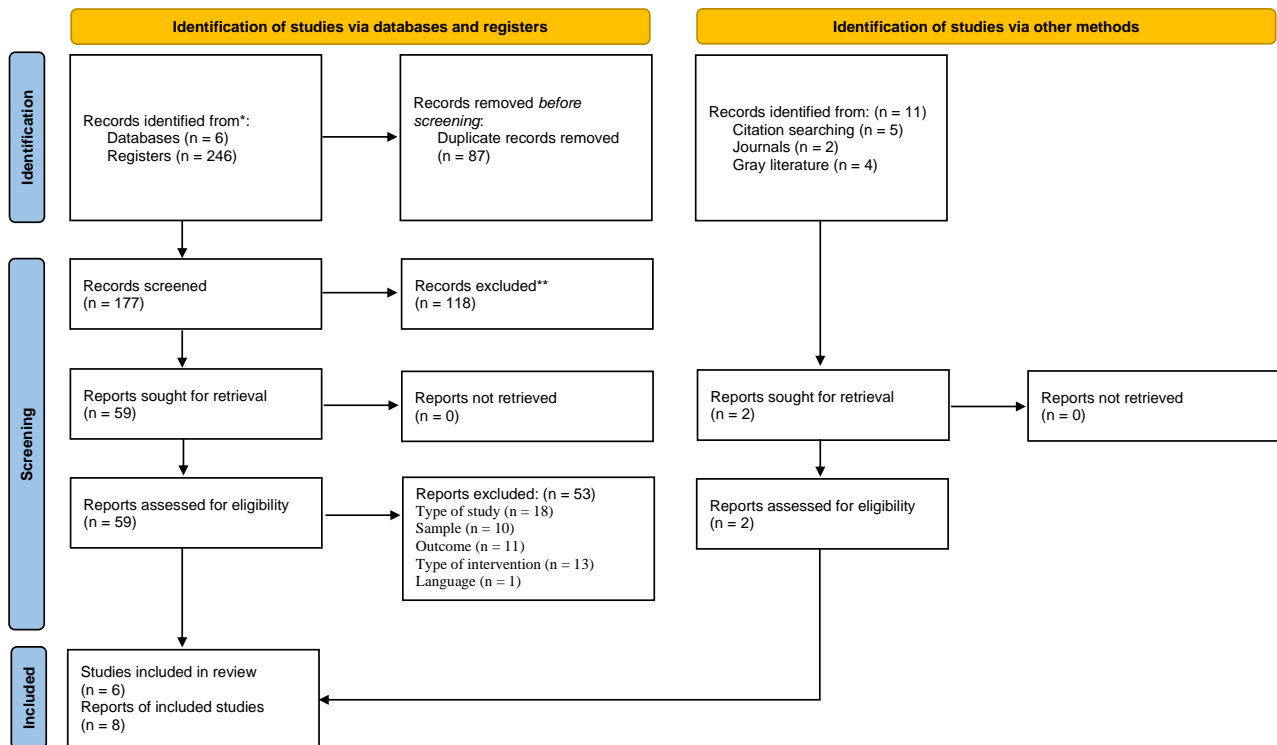
Database	PICO	Search strategy
PUBMED/MEDLINE	Population	"Child"[MeSH Terms] OR "child, preschool"[MeSH Terms] OR "Infant"[MeSH Terms]
	Trauma	((((((((((((((((((("Tooth Injuries"[Mesh]) OR ("tooth injuries"[Text Word])) OR ("teeth injuries"[Text Word])) OR ("tooth injury"[Text Word])) OR ("teeth injury"[Text Word])) OR ("Tooth Avulsion"[Mesh])) OR ("tooth avulsion"[Text Word])) OR ("tooth avulsions"[Text Word])) OR ("avulsed tooth"[Text Word])) OR ("tooth Dislocation"[Text Word])) OR ("tooth dislocations"[Text Word])) OR ("tooth luxation"[Text Word])) OR ("tooth luxations"[Text Word])) OR ("Tooth Fractures"[Mesh])) OR ("tooth fractures"[Text Word])) OR ("tooth fracture"[Text Word])) OR ("lateral luxation"[Text Word])) OR ("lateral luxations"[Text Word])) OR ("intruded tooth"[Text Word])) OR ("intruded teeth"[Text Word])) OR ("dental trauma"[Text Word])) OR ("traumatic dental"[Text Word])) OR ("root fracture"[Text Word])) OR ("root fractures"[Text Word]))
	Treatment	("Splints"[Mesh]) OR ("splinting system" [Text word]) OR ("stabilization" [Text word]) OR ("splint*" [Text word]) OR ("tooth splinting" [Text Word])
	Primary dentition	("Tooth, Deciduous"[Mesh]) OR ("deciduous teeth"[Text Word]) OR ("primary tooth"[Text Word]) OR ("primary teeth"[Text Word]) OR ("primary dentition"[Text Word]) OR ("deciduous dentition"[Text Word]) OR ("primary dentitions"[Text Word]) OR ("deciduous dentitions"[Text Word]) OR ("baby teeth"[Text Word]) OR ("baby tooth"[Text Word]) OR ("milk teeth"[Text Word]) OR ("milk tooth"[Text Word]) OR ("deciduous tooth"[Text Word])
WEB OF SCIENCE	Population	((ALL=(TS=(Child OR Infant OR Child, preschool))) AND ALL=(TS=(Tooth Injuries OR Tooth Avulsion OR Tooth Dislocation OR Tooth Luxation
	Trauma	OR Tooth Fractures OR Lateral Luxation OR Intruded Tooth OR Root Fracture OR Dental Trauma))) AND ALL=(TS=(Splints OR Splinting System
	Treatment	OR Split* OR Tooth Splinting OR Dental Splinting OR Stabilization))) AND ALL=(TS=(Deciduous tooth OR Deciduous Teeth OR Primary Dentition
	Primary dentition	OR Deciduous Dentition OR Baby Teeth OR Milk Tooth))
SCOPUS	Population	(TITLE-ABS-KEY (child OR infant OR preschool) AND TITLE-ABS-KEY (injuries OR avulsion OR dislocation OR luxation OR fractures OR
	Trauma	luxation OR intruded OR root AND fracture OR trauma) AND TITLE-ABS-KEY (splints OR dental AND splinting) AND TITLE-ABS-KEY (
	Treatment	deciduous OR deciduous OR primary AND dentition OR deciduous AND dentition))
	Primary dentition	
SCIELO	Population	(Child OR Infant OR Child, preschool) AND (Tooth Injuries OR Tooth Avulsion OR Tooth Dislocation OR Tooth Luxation OR Tooth Fractures OR
	Trauma	Lateral Luxation OR Intruded Tooth OR Root Fracture OR Dental Trauma) AND (Splints OR Splinting System OR Split* OR Tooth Splinting OR
	Treatment	Dental Splinting OR Stabilization) AND (Deciduous tooth OR Deciduous Teeth OR Primary Dentition OR Deciduous Dentition OR Baby Teeth OR
	Primary dentition	Milk Tooth)
EMBASE	Population	'Child' OR 'Infant' OR 'preschool child'
	Trauma	'Tooth Injuries' OR 'Tooth Avulsion' OR 'Tooth Dislocation' OR 'Tooth Luxation' OR 'Tooth Fractures' OR 'Lateral Luxation' OR 'Intruded Tooth' OR 'Root Fracture' OR 'tooth injury'
	Treatment	'Splints' OR 'Splinting System' OR 'Split' OR 'Tooth Splinting' OR 'Dental Splinting' OR 'Stabilization'
	Primary dentition	Child OR Infant OR Child, preschool
COCHRANE LIBRARY (Only trials)	Population	Child OR Infant OR Child, preschool
	Trauma	Tooth Injuries OR Tooth Avulsion OR Tooth Dislocation OR Tooth Luxation OR Tooth Fractures OR Lateral Luxation OR Intruded Tooth OR Root Fracture OR Dental Trauma
	Treatment	Splints OR Splinting System OR Split* OR Tooth Splinting OR Dental Splinting OR Stabilization
	Primary dentition	Deciduous tooth OR Deciduous Teeth OR Primary Dentition OR Deciduous Dentition OR Baby Teeth OR Milk Tooth

Source: Authors.

3. Results

Initially, 246 relevant studies were found in MEDLINE/PubMed (n = 67), Web of Science (n = 49), Scopus (n = 22), SciELO (n = 6), Embase (n = 12), Cochrane Library (n = 16) and EBSCO (n = 74); 11 additional studies were identified in the manual search. Subsequently, a total of 118 duplicates were removed. Thus, 177 records were screened by title and abstract reading. Of these, 59 full texts were evaluated and eight case reports were included in this systematic review (Figure 1).

Figure 1 - Flowchart of the search process according to PRISMA guidelines.



Source: Authors.

Five case report studies described adequately the patient's demographic characteristics, clinical history, the clinical condition on first examination, diagnostic tests or assessment methods, treatment results, as well as presented important lessons about the use of splinting techniques in the management of traumatized dentition (score = 7) (Figure 2). The detailed description of the splinting procedure was not observed in the Shanmugam et al. (2011) study, although it covered all the other JBI criteria considered in the quality assessment of this review (score = 6). In the Pathak et al., (2016), the description of the initial clinical condition of the patients in both clinical cases study was unclear. This report provides limited information to guide the clinical practice of professionals presented with similar cases (score = 5). In summary, all case reports covered at least 70% of the criteria assessed in the JBI checklist (minimum score = 5).

The case reports included in this review described the use of dental splinting in Brazilian (Di Giorgio et al., 2021; Bonanato et al., 2009; Santos et al., 2021), Indian (Pathak et al., 2016; Shanmugam et al., 2011), Turkish (Akin et al., 2011), Chinese (Liu et al., 2013), and Greek (Chatzidimitriou et al., 2017) children (Table 2). Two studies described the use of splinting for the immobilization of laterally displaced teeth (Akin et al., 2011; Pathak et al., 2016), and four in teeth with root fractures (Bonanato et al., 2009; Liu et al., 2013; Santos et al., 2021; Di Giorgio et al., 2021). One study investigated the use of splints in the immobilization of a primary maxillary right central incisor with extrusive luxation - associated with the presence of root fracture (Di Giorgio et al., 2021). Other studies evaluated the use of splinting in the treatment of intrusive luxation

(Shanmugamet al., 2011), and mandibular alveolar fracture (Chatzidimitriou et al., 2017). Composite and wire splints were adopted in most of the case reports included in this review (Akin et al., 2011; Bonanato et al., 2009; Santos et al., 2021; Pathak et al., 2016; Shanmugam et al., 2018; Liu et al., 2013). One study reported the use of a novel method of dental immobilization using soft splints thermoformed from EVA copolymer, fixed on the tooth surface with light-cured composite resin (Chatzidimitriou et al., 2017). Most studies described the follow-up period of the patient after removal of the dental splint (Mean: 25.8 months) (Akin et al., 2011; Bonanato et al., 2009; Santos et al., 2021; Shanmugam et al., 2018; Liu et al., 2013; Chatzidimitriou et al., 2017), whereas only one study did not provide this information (Pathak et al., 2016).

Figure 2 - Critical appraisal of case-reports included in this review.

Author (Year)	Joanne Briggs Institute (JBI)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Akin, Uysal & Cehrel (2010)	+	+	+	+	+	+	NA	+
Bonanato et al. (2009)	+	+	+	+	+	+	NA	+
Chatzidimitriou et al. (2017)	+	+	+	+	+	+	NA	+
Giorgio et al. (2021)	+	+	+	+	+	+	NA	+
Liu et al. (2013)	+	+	+	-	-	?	NA	-
Pathak et al. (2016)	+	+	+	+	+	+	NA	+
Santos, Hora & Alves (2021)	+	+	+	+	?	+	NA	-
Shanmugam et al. (2011)	+	+	+	+	?	+	NA	+

JBI - Critical appraisal checklist for Case Reports	
(1) Were patient's demographic characteristics clearly described?	
(2) Was the patient's history clearly described and presented as a timeline?	
(3) Was the current clinical condition of the patient on presentation clearly described?	
(4) Were diagnostic tests or assessment methods and the results clearly described?	
(5) Was the intervention(s) or treatment procedure(s) clearly described?	
(6) Was the post-intervention clinical condition clearly described?	
(7) Were adverse events (harms) or unanticipated events identified and described?	
(8) Does the case report provide takeaway lessons?	

Legend	
+	Yes
-	No
?	Unclear
NA	Not applicable

Source: Authors.

All case reports described splinting as a viable technique for immobilizing traumatized primary teeth, regardless of the type of TDI (lateral dislocation, intrusive root fracture, and mandibular alveolar fracture) and splinting technique (rigid or semi-rigid) used. After the last follow-up evaluation (12–57 months), the main outcomes related to splinting of traumatized teeth were biofunctional dental preservation without pathological signs and symptoms, integral maintenance of the periodontal ligament, and adequate occlusion. No clinical or radiographic evidence of adverse effects to the use of splinting was reported.

Table 2 - Data extracted from the original case-reports (n = 8).

Author (Year) Country	Sample (n) - Age; Sex	Type of trauma	Splinting (type and duration treatment)	Follow-up	Main results
Akin, Uysal & Cehrel (2011)¹⁰ Turkey	(n = 1) 5-year-old; Boy.	Fracture involving laterally luxated primary incisors.	Composite and wire splints: a semi-rigid, round 0.5-mm orthodontic wire splint between primary canines during 3 weeks.	24 months	After removal of the semi-rigid splint, the affected primary incisors remained asymptomatic until natural exfoliation.
Bonanato et al. (2009)¹¹ Brazil	(n = 1) 3-year-old; Girl.	Horizontal intra-alveolar root fracture in the central maxillary left incisor.	Composite and wire splints: a semi-rigid with a 0.5 orthodontic wire affixed with photopolymerizable resin during 3 weeks.	12 months	At the one-year follow-up, the soft tissues remained healthy, with no sign of inflammation or tooth discoloration. The radiographic examination found no periapical lesion in central maxillary left incisor and the periodontal ligament was revealed to be integral.
Chatzidimitriou et al. (2017)¹⁹ Greece	(n = 1) 4.5-year-old; Girl.	Mandibular alveolar fracture.	Ethylene-Vinyl Acetate copolymer (EVA copolymer) splint during 4 weeks: EVA splint was immobilized in the patient's first and second primary molars using the acid-etch/adhesive technique and photopolymerized flowable resin composite.	12 months	Clinical and radiographic follow-up showed no pathological signs and symptoms, absence of mobility, normal occlusion, no crown discoloration and no signs of apical pathology, external inflammatory root resorption or root canal obliteration of the traumatized primary teeth.
Giorgio et al. (2021)⁹ Brazil	(n = 1) 3.5-year-old; Boy	Intra-alveolar root fracture and extrusive luxation of the primary maxillary right central incisor.	Orthodontic flexible splint.	12 months	Splinting proved to be effective, resulting in better outcomes. At 1 year follow-up, the primary teeth showed no sensitivity to percussion nor pulp alteration, and the crown showed no signs of alteration in color. Common signs of early pulp canal obliteration were present.
Liu et al. (2013)¹⁸ China	(n = 1) 3-year-old; Girl.	Primary maxillary central incisors with mid-root and apical third horizontal root fractures.	Composite and wire splints: splint made up of orthodontic brackets and 0.5-mm stainless steel wire were during 3 months.	30 months	In 3 months, the root resorption of both apical fragments was almost completed, and the traumatized primary teeth were no longer tender to percussion with their mobility returning back to physiologic levels.
Pathak et al. (2016)¹⁰ India ¹⁵	(n = 2) Case 1: 6 year- old; Boy. Case 2: 5 year-old; Gil.	Lateral luxation of primary anterior teeth.	Composite and wire splints: teeth were splinted from canine to canine with composite resin and a 0.7mm orthodontic wire during 2-3 weeks.	Not reported.	Case 1: Teeth were present in a better occlusal relationship. On the following recall examinations, teeth presented physiologic mobility, with no sensitivity to percussion. Surrounding soft tissues were intact and the patient did not report any pain or discomfort. Case 2: After clinical and radiographic examination of periodontal and bone healing, the splint was removed. The soft tissues had healed, and a better occlusion was established.
Santos, Hora & Alves (2021) Brazil ¹⁵	(n = 1) 2.5-years-old. Boy.	Horizontal apical root fracture. of the upper right primary central	Composite and wire splints: splinting was performed by using a 0.5 mm orthodontic wire and composite resin after acid	57 months.	The tooth was preserved without needing endodontic intervention until its physiologic exfoliation and normal eruption of its permanent successor. As sequelae to the fractured tooth, there was

		incisor	enamel conditioning during 3 months.		some coronal color alteration and dystrophic calcification of the root canal. This tooth did not develop ankylosis or mobility during the follow-up period. After 57 months of follow-up, repositioning and splinting were appropriate ways to manage this horizontal intra-alveolar root fracture in the apical third of this primary tooth. It allowed the tooth to be preserved in the arch with normal function without visible color, position, or shape alterations.
Shanmugam et al. (2011) India¹²	(n = 1) 4-year-old; Girl.	Intrusion luxation of the maxillary left central incisor.	Composite and wire splints: tooth was splinted with rectangular stainless-steel wire and composite during 2 weeks.	20 months.	Splinting the tooth with lateral luxation was shown to have a better outcome. Clinical and radiographic examination were carried out periodically to rule out any mobility, ankylosis, and periapical pathosis in splinted tooth.

Source: Authors.

4. Discussion

This review summarized the outcomes of splinting in the management of dental trauma in the primary dentition reported in case reports. All case reports described splinting as a viable technique for immobilizing traumatized primary teeth in specific cases of intrusion and extrusion and lateral displacement of the primary teeth stabilized with rigid or semi-rigid devices. No failures in the management of traumatic cases were reported, which can be understood by the absence of pulp necrosis, pathological root resorption, pathological loss of teeth, ankylosis, and pathological bone resorption. Only one register was reported the use of splinting in the management of alveolar fracture. No studies included have evaluated the use of the splints in the concussed or subluxated primary teeth.

Firstly, it is recognised that splinting can promote tooth revascularisation and periodontal tissue health when used to stabilise traumatised primary teeth. Although its use is recommended by the IADT only in cases of alveolar fracture, lateral luxation and root fracture, the applicability of splinting in clinical practice can go beyond the indications in specific cases of trauma in the primary dentition, as identified in the case reports included. In this review, the records reported that the use of splinting promote benefits to the management of primary teeth with alveolar bone fracture and root fracture, which is in line with IADT recommendations (Day et al., 2020), and corroborates previous results (Fernandez et al, 2023), respectively.

Injuries to the primary dentition may present either exclusively to the hard dental tissues and the pulp or in association with the periodontal tissues and the dentoalveolar bone (Day et al., 2020; Flores et al., 2002; Gassner et al., 2003). Management of dentoalveolar fractures in the primary dentition is challenging; some aspects, such as the small size of the mandible, the presence of active mandibular growth centers and the proximity of the teeth to the germs of the permanent dental elements and the local nervous system are factors that should be evaluated in mandibular dentoalveolar fractures in children (Myall, 2009; Aizenbud et al., 2009). Overall, the management of dentoalveolar fractures should be performed by (a) repositioning displaced bone segments that are mobile and/or causing occlusal interference³, followed by (b) splinting with a flexible retainer on adjacent uninjured teeth for at least four

weeks (Kahler et al., 2016). This management has always been recommended in the IADT guidelines, and seeks to promote stable restoration of bone continuity to the perjury position (McTigue, 2009). In this systematic review, only one case report described the use of splinting in alveolar fractures of primary dentition. An alternative splinting method with the placement of a 3 mm thickness EVA copolymer was used (Chatzidimitriou et al., 2017). During monitoring after one year of the TDI, clinical and radiographic exams showed no pathological signs and symptoms in the mandibular bone and traumatized primary tooth, reinforcing the IADT recommendation for the management of this type of TDI (Day et al., 2020).

Conversely to the results of previous retrospective studies with moderate and high risk of bias (Cho et al., 2018; Song et al., 2017; Kim et al, 2012), the use of the technique in the treatment of intruded, extruded or laterally displaced teeth was useful in providing dento-periodontal health. In fact, the aim of this review is not to counter the evidence presented by Fernandez et al. (2023) study, but to discuss the general applicability of current knowledge of the findings. It is obvious that the results of both reviews would be different, considering the type of studies included. However, it is important to understand that the individualised application of splinting can be used in other specific cases without harming dento-alveolar health. During the search and literature selection stages of this systematic review, no studies that verified the effectiveness of splinting in the management of concussed or subluxated primary teeth were found. This may be related to the fact that the main approach for both types of luxation injuries is based on monitoring the traumatized tooth, since mobility is not observed in concussed teeth or low mobility in subluxated teeth (Kahler et al., 2016). Moreover, considering that international guidelines recommend that avulsed primary teeth should not be reimplanted (Day et al., 2020), we did not include any study that reported the outcomes of the use of this conservative approach in teeth completely detached from their sockets.

The authors are mindful of the barriers in conducting studies in traumatology, especially in TDI in primary teeth. However, carefully documenting all steps of the management of TDI cases will be beneficial not only to monitoring the development of the case and its potential sequelae but it also may allow the conducting of more original research in the field. Even though case reports are useful, all case reports included in this review reported splinting as a viable technique. This is expected, considering the authors are reporting on the management they adopted. This finding, however, differs in retrospective studies, which point out that monitoring only may lead to better outcomes than splinting laterally dislocated and extruded teeth. Thus, given the low number and low quality of the studies identified in the global literature, there is a notable need for further research into the use of splinting for the treatment of TDIs in primary teeth. We suggest that new studies explore the outcomes associated with different types of TDIs, use longer follow-up periods and report on aspects of dental pain, patient and family cooperation.

The strengths of this systematic review merit emphasis. The review employed exhaustive search methodologies encompassing the main health sciences research databases. Further, all stages of the review - data extraction and risk of bias assessment - were employed in duplicate, reducing the risk of individual bias. Lastly, reporting methods and systematic evaluations internationally recognized in the literature were used in the design and execution stages of this study.

5. Conclusion

Urgent care of traumatic dental injuries in the primary dentition may pose challenges for clinicians. The present review evaluated the indications and possible benefits of splinting in traumatized primary teeth in case reports. Based on low evidence studies with moderate and low risk of bias, it was possible to conclude that, the findings of this systematic review support the conservative approach suggested by the IADT guidelines, which recommend the use of splint for the management of alveolar bone fractures, and, only in some specific cases, for immobilization in cases of root fractures extrusive and laterally dislocated primary teeth. Further properly designed clinical studies should be conducted to elucidate the effectiveness of splinting in the management of traumatic injuries in the primary dentition.

References

- Aizenbud, D., Hazan-Molina, H., Emodi, O., & Rachmiel, A. (2009). The management of mandibular body fractures in young children. *Dental traumatology*, 25(6), 565–570. <https://doi.org/10.1111/j.1600-9657.2009.00815.x>
- Akin, A., Uysal, S., & Cehreli, Z. C. (2011). Segmental alveolar process fracture involving primary incisors: treatment and 24-month follow up. *Dental traumatology*, 27(1), 63–66. <https://doi.org/10.1111/j.1600-9657.2010.00953.x>
- Andreasen, J. O., Lauridsen, E., Gerds, T. A., & Ahrensburg, S. S. (2012). Dental Trauma Guide: a source of evidence-based treatment guidelines for dental trauma. *Dental traumatology*, 28(2), 142–147. <https://doi.org/10.1111/j.1600-9657.2011.01059.x>
- Bononato, K., Sardenberg, F., Santos, E. R., Ramos-Jorge, M. L., & Zarzar, P. M. (2009). Horizontal root fracture with displacement in the primary dentition. *General dentistry*, 57(4), 31–34.
- Chatzidimitriou, K., Lygidakis, N. N., & Lygidakis, N. A. (2017). Eva Vacuum-Formed Alternative Splinting of Alveolar Fractures in Primary Dentition: A Case Report. *The Journal of clinical pediatric dentistry*, 41(5), 327–331. <https://doi.org/10.17796/1053-4628-41.5.327>
- Cho, W. C., Nam, O. H., Kim, M. S., Lee, H. S., & Choi, S. C. (2018). A retrospective study of traumatic dental injuries in primary dentition: treatment outcomes of splinting. *Acta odontologica Scandinavica*, 76(4), 253–256. <https://doi.org/10.1080/00016357.2017.1414956>
- Day, P. F., Flores, M. T., O'Connell, A. C., Abbott, P. V., Tsilingaridis, G., Fouad, A. F., Cohenca, N., Lauridsen, E., Bourguignon, C., Hicks, L., Andreasen, J. O., Cehreli, Z. C., Harlamb, S., Kahler, B., Oginni, A., Semper, M., & Levin, L. (2020). International Association of Dental Traumatology guidelines for the management of traumatic dental injuries: 3. Injuries in the primary dentition. *Dental traumatology*, 36(4), 343–359. <https://doi.org/10.1111/edt.12576>
- Di Giorgio, G., Zumbo, G., Saccucci, M., Luzzi, V., Ierardo, G., Biagi, R., & Bossù, M. (2021). Root Fracture and Extrusive Luxation in Primary Teeth and Their Management: A Case Report. *Dentistry journal*, 9(9), 107. <https://doi.org/10.3390/dj9090107>
- Fernandez, M. S., Schuch, H. S., Araújo, A. B. G., & Goettems, M. L. (2023). Splinting in the management of dental trauma in the primary dentition: a systematic review. *European archives of paediatric dentistry*, 24(2), 167–175. <https://doi.org/10.1007/s40368-023-00792-4> Flores, Marie Therese. “Traumatic Injuries in the Primary Dentition.” *Dental Traumatology*, 18(6), 287–298, <https://doi.org/10.1034/j.1600-9657.2002.00153.x>.
- Gassner, R., Tuli, T., Hächl, O., Rudisch, A., & Ulmer, H. (2003). Cranio-maxillofacial trauma: a 10 year review of 9,543 cases with 21,067 injuries. *Journal of cranio-maxillo-facial surgery*, 31(1), 51–61. [https://doi.org/10.1016/s1010-5182\(02\)00168-3](https://doi.org/10.1016/s1010-5182(02)00168-3)
- Kahler, B., Hu, J. Y., Marriot-Smith, C. S., & Heithersay, G. S. (2016). Splinting of teeth following trauma: a review and a new splinting recommendation. *Australian dental journal*, 61 Suppl 1, 59–73. <https://doi.org/10.1111/adj.12398>
- Kim, G. T., Sohn, M., Ahn, H. J., Lee, D. W., & Choi, S. C. (2012). Intra-alveolar root fracture in primary teeth. *Pediatric dentistry*, 34(7), 215–218.
- Liu, X., Huang, J., Bai, Y., Wang, X., Baker, A., Chen, F., & Wu, L. A. (2013). Conservation of root-fractured primary teeth--report of a case. *Dental traumatology*, 29(6), 498–501. <https://doi.org/10.1111/edt.12009>
- McTigue D. J. (2009). Managing injuries to the primary dentition. *Dental clinics of North America*, 53(4), 627–v. <https://doi.org/10.1016/j.cden.2009.07.002>
- Moola, S., Munn, Z., Sears, K., Sfetcu, R., Currie, M., Lisy, K., Tufanaru, C., Qureshi, R., Mattis, P., & Mu, P. (2015). Conducting systematic reviews of association (etiology): The Joanna Briggs Institute's approach. *International journal of evidence-based healthcare*, 13(3), 163–169. <https://doi.org/10.1097/XEB.0000000000000064>
- Myall R. W. (2009). Management of mandibular fractures in children. *Oral and maxillofacial surgery clinics of North America*, 21(2), 197–vi. <https://doi.org/10.1016/j.joms.2008.12.007>
- Ouzzani, M., Hammady, H., Fedorowicz, Z., & Elmagarmid, A. (2016). Rayyan-a web and mobile app for systematic reviews. *Systematic reviews*, 5(1), 210. <https://doi.org/10.1186/s13643-016-0384-4>
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., & Moher, D. (2021). Updating guidance for reporting systematic reviews: development of the PRISMA 2020 statement. *Journal of clinical epidemiology*, 134, 103–112. <https://doi.org/10.1016/j.jclinepi.2021.02.003>
- Pathak, A., Kaur, J., Dogra, M., Verma, J., & Jain, K. (2016). Conservative management of trauma to deciduous maxillary anterior teeth: a case report. *International Journal of Medical and Oral Research*, 3, 206-209.
- Patnana, A. K., Chugh, A., Chugh, V. K., Kumar, P., Vanga, N. R. V., & Singh, S. (2021). The prevalence of traumatic dental injuries in primary teeth: A systematic review and meta-analysis. *Dental traumatology*, 37(3), 383–399. <https://doi.org/10.1111/edt.12640>
- Santos, L. V., da Hora, K. C., & Alves, A. C. (2021). Successful minimally invasive intervention in a primary central incisor after root fracture: A case report. *Dental traumatology*, 37(6), 807–812. <https://doi.org/10.1111/edt.12681>
- Shanmugam, H. V., Arangannal, P., Vishnurekha, C., Nichani, M. H., & Vijayaprabha, K. (2011). Management of intrusive luxation in the primary dentition by surgical repositioning: an alternative approach. *Australian dental journal*, 56(2), 207–211. <https://doi.org/10.1111/j.1834-7819.2011.01325.x>
- Song, K., Nam, O., Kim, M., Lee, H., Kim, K., & Choi, S. (2017). A retrospective study of luxation injuries in primary teeth: prognosis with splinting. *Journal of the Korean Academy of Pediatric Dentistry*, 44(2), 194-199. <https://doi.org/10.5933/JKAPD.2017.44.2.194>
- Wilkinson, M. D., Dumontier, M., Aalbersberg, I. J., Appleton, G., Axton, M., Baak, A., Blomberg, N., Boiten, J. W., da Silva Santos, L. B., Bourne, P. E., Bouwman, J., Brookes, A. J., Clark, T., Crosas, M., Dillo, I., Dumon, O., Edmunds, S., Evelo, C. T., Finkers, R., Gonzalez-Beltran, A., & Mons, B. (2016). The FAIR Guiding Principles for scientific data management and stewardship. *Scientific data*, 3, 160018. <https://doi.org/10.1038/sdata.2016.18>