Review Article

Outcomes of luxation injuries to primary teeth-a systematic review

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ABSTRACT

Objective: Luxation injuries are one of the most prevalent type traumatic dental injuries in primary dentition. The impact of these injuries may not only be limited to the primary teeth but may also have adverse effects on the developing succedaneous tooth bud resulting in various unfavorable consequences. This systematic review aims at compiling the evidence of available literature regarding luxation injuries to primary teeth, etiology, treatment modalities, outcomes and sequelae on permanent teeth.

Methodology: Search of PubMed, Google Scholar, Cochrane Database of Systematic Reviews, SCOPUS and LILACS virtual health library was conducted for the literature published from January 1, 2007 to December 31, 2017. Two authors separately reviewed the literature and extracted the data from the included studies.

Results: After screening 224 articles, 13 articles fulfilled the inclusion criteria. Most common etiological factor for injury (up to 44.8%) is fall while walking or running. The unfavorable outcomes which are mostly associated with luxation injuries are pulp canal obliteration ranging from 8.6% to 43.3% and pulp necrosis 8.6% – 78.9%. Sequelae on succedaneous teeth vary with a high incidence of white or yellow brown discoloration of enamel (78%) and enamel hypoplasia (7.8%–28.3%).

Conclusion: Fall is the most common cause and regular monitoring is recommended for most of the luxated teeth. Pulp canal obliteration, pulp necrosis and tooth loss due to trauma are prevalent complications observed following luxation. White or yellow brown discoloration of enamel and enamel hypoplasia are the most common undesirable sequelae to permanent teeth.

1. Introduction

Among all the orofacial injuries, Traumatic dental injuries (TDI) are one of the most prevalent. Amounting to 18% of all injuries in children from 0 to 6 years of age.¹

The primary teeth are highly liable to luxation (displacement) injuries constituting 21%–81% of all the TDI.² These injuries may present with minimal symptoms as in concussion to serious injuries as in intrusion. Luxation injuries can be classified into various types according to the degree of displacement viz. : concussion, subluxation, lateral luxation, extrusion, intrusion and avulsion.³ Avulsion or ex-articulation of tooth is the most severe form of displacement injury where the tooth is completely knocked out of the socket. Thus, due to this unique presentation avulsion is considered as a separate entity and has not been discussed in this review.

TDI to the primary teeth often go unnoticed or are overlooked by parents mainly due to the perception that they will eventually be replaced by permanent ones.⁴ These injuries are usually seen among 2-3 year-old children as they tend to be physically more active but without

fully matured motor coordination.⁵ Such young children are also mentally immature to cope with the stress and painful situations ultimately evoking dental fear and anxiety even in adult life. Therefore, the aim should be to choose such a treatment for young children which is least stressful.

The root of the primary and the permanent tooth germ lies in close proximity, so, long-term complications of TDIs, such as infection of the primary teeth may also damage the developing succedaneous teeth. Therefore, it is of utmost importance to determine the prognosis of the injured primary teeth and also to evaluate the chances of future complications before deciding the treatment plan to either preserve or extract.⁵

Prevalence of luxation injuries is high among young children because of the resilient nature of their alveolar bone and supporting structures. Intrusion injuries have been reported to cause more mineralization disturbances in successor teeth as compared to other sub types of luxation injuries. Mineralization disturbances are mostly associated with an esthetic concern which in particular is critical for the permanent incisors.

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Fig. 1. PRISMA flow chart.

Immediate care, appropriate treatment and follow-up are important to minimize the risk of immediate and long term unfavorable outcomes in primary as well as permanent dentition.⁵

So, the present review is conducted with the following objectives:

- (1) To conduct a systematic review of the topic “outcomes of luxation injuries to primary teeth” and compile the evidence of the studies available.
- (2) To assess the etiology, treatment modalities, sequelae and outcomes of luxation injuries to primary teeth.

2. Methods

This systematic review was performed according to guidelines of PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis).⁶

2.1. Review methods

Electronic database search from PubMed (Medline), Google Scholar, Cochrane Database of Systematic Reviews, SCOPUS and LILACS was done using MeSH terms (Medical Subject Headings).

Hand-searching of the references derived from original articles was performed to ensure that no studies were missed.

2.2. Eligibility criteria's

2.2.1. Inclusion criteria

Articles in English language published between year 2000–2017.

Articles specifically dealing with etiology, treatment modalities, outcomes of injury and sequelae seen on permanent teeth followed by luxation injuries of primary teeth.

Only Systematic reviews, Cohort studies, Randomized controlled trials and Longitudinal studies were included.

2.3. Exclusion criteria

Articles considering avulsion of primary teeth.

Textbooks, dissertations, case reports, case series were excluded.

Articles describing all types of traumatic dental injuries (not specifically luxation injuries).

Studies with insufficient data. Editorials or opinions, animal studies.

2.4. Information sources and search

The search strategy included appropriate Mesh terms, keywords, and other terminologies related to luxation injuries, primary teeth and sequelae. Boolean operators (OR, AND) were used to combine searches. The terms used were 'luxation injuries', 'tooth luxation', 'tooth displacement', 'tooth subluxation', 'concussion', 'dental intrusion', 'intrusive luxation', 'extrusive luxation', 'lateral luxation', 'concussion', 'primary teeth', 'deciduous tooth', 'primary tooth', complications, sequelae. Duplicate articles were identified and removed.

2.5. Study selection

The selection of articles was carried out in two phases i.e. search and evaluation performed by two investigators independently and blinded to each other. If there was any controversy between these two investigators it was settled by their joint decision.

In first round of **SEARCH**, all abstracts related to luxation injuries to primary teeth were assessed by the two investigators independently. After applying inclusion and exclusion criteria full text was obtained for all relevant articles.

In second round of **EVALUATION** using the eligibility criteria, full text of all the articles were reviewed by the same two investigators independently.

A total of 218 articles were recorded from electronic information. The articles provided by Google Scholars was 148, PubMed (Medline) provided 69 and 1 article was found in Cochrane Database of Systematic Reviews (Evidence-Based Medicine). No articles were retrieved from SCOPUS and LILACS. 6 articles were identified from hand searching of references.

Fig. 1 summarizes the study selection process.

2.6. Review results

2.6.1. Study selection

After screening 224 articles 13 articles fulfilled the inclusion criteria. Out of the included articles 8 articles were about intrusion, 2 were on subluxation, one dealt with concussion, one about extrusion and four articles discussed luxation injuries to primary teeth as a whole. Also, the study design of 9 included articles was retrospective and 4 were observational studies.

The characteristics of the included studies and their summary are recorded in Table 1.

2.7. Synthesis of results

Fall or collision while walking is considered as the most common etiologic factor ranging from 37.7% to 44.8% (Table 2). The choice of treatment ranges from monitoring to extraction depending upon the severity, nature and direction of displacement (Table 3). Frequency of unfavorable outcomes such as necrosis of pulp, obliteration of pulp canal, root resorption, or premature tooth loss associated with concussion, subluxation, lateral luxation and extrusion is described in Table 4.

The unfavorable outcomes associated with intrusive injuries is given in Table 5. Pulp canal obliteration (PCO) was found to be most prevalent complication in concussion, subluxation, lateral luxation and intrusive luxation in the frequency of 8.6%, 23.2%, 43.3% and 38.9%

respectively. Where as in cases with extrusive luxation premature tooth loss is most prevalent with 43.3% chances followed by PCO with 39.8% frequency. Pulpal necrosis is another complication associated with all subtypes of luxation injuries with frequency ranging from as low as 8.6% in concussion to 78.9% in totally intruded teeth. (Table 4 and Table 5). Frequency of coronal discoloration of tooth that has undergone trauma varies from 3.1% to 48%. The unfavorable outcomes of traumatized tooth are not only confined to the primary teeth but may cause permanent damage of underlying successors, in turn leading to consequences like crown discoloration, enamel hypoplasia, crown or root dilacerations, sequestration of permanent tooth germ, eruption disturbances and even non eruption of teeth. Table 6 describes various types of sequelae seen on successor teeth with intrusive type of luxation injury. Commonly associated are enamel hypoplasia ranging from 7.8% to 28.3% to crown or root dilacerations exceeding up to 16.7%. Developmental disturbances seen with all types of luxation injuries include clinical disturbances such as white or yellow brown discoloration of enamel (78.0%), white or yellow-brown discoloration of enamel with circular hypoplasia (18.0%). On radiographic analysis; Hypoplasia was seen with 86%, crown dilacerations 9%, root malformation 5%.

3. Discussion

Direct or indirect impact on teeth may result in traumatic dental injuries. Various factors such as force and direction of impact, shape and resilience, direction of the impacting object and the reaction of the surrounding tissues determine the extent of damage. The trauma to primary teeth more often results in displacement injuries because the underlying bone structure in primary teeth is less mineralized as compared to permanent dentition. Also, greater range of trauma associated due to fall and collisions is seen in children with primary dentition due to the increase of independent movements and lack of motor co-ordination in age group between 0 and 6 years. In 7-15 years age group traumatic injuries happen usually due to accidents while playing. Sport injuries and violence resulted in dental injuries most frequently in individuals 21–25 years of age.⁷

Assunção LR (2011)⁸ categorized various possible etiologic factors as 'fall' and 'other factors'. Further falling was categorised as falling while walking or running, from a high place (e.g., bed, gate, cot), onto any object (e.g., table, bathtub, stairs) or from a moving object (e.g., bike, pram). Other factors causing traumatic injuries include causes that were rare, such as trauma caused by biting a toy⁸ and concluded fall while walking or running as the major cause of luxation injury followed by impact against any hard object. Similarly, Atlun C (2009)⁹ and Spinas. E (2005)¹⁰ also reported traumatic injuries due to fall being the most common cause.

The most common age group of children affected with luxation injuries ranges from 0 to 3 years as described by Assunção LR (2011)⁸ whereas Atlun C (2009)⁹ Diab M (2000)¹¹ & Spinas E (2005)¹⁰ described the increased incidence of intrusive luxation among age range of 1–4 years.

The most commonly affected teeth were the maxillary central incisors followed by the maxillary lateral incisors and then mandibular incisors. The primary canines were affected in very few cases.⁹

Anne B.S (2014) categorized the types of luxation injuries where displacement of teeth is noticed as severe injury as found in extrusion, lateral luxation and intrusion and non-severe injuries are the ones with no displacement such as in concussion and subluxation.¹² They reported subluxation as most common type of injury followed by intrusion, contradicting that from Carvalho V (2010)¹³ and Diab M (2000)¹¹ who described intrusion as the most common type of luxation injury seen followed by subluxation in primary teeth.

Treatment for all the injured tissues can be provided in different phases. The initial or emergency phase includes care provided for the symptomatic relief and to restore aesthetics and function. The second phase is the follow up phase which is required to monitor the healing of

Table 1
Characteristics of included studies.

Author & year	Study design	Type of injury	Evaluation Criteria	Inference and conclusion
Diab M, 2000 ¹¹	Review	Intrusion	Review and management	Peak occurrence of intrusion injury is between 1 and 3 years of age. Out of all luxation injuries the incidence of intrusion is 4.4–22%. Spontaneous re-eruption is expected within 1–6 months if intrusive tooth is displaced labially. In case of lingual displacement, extraction is the treatment of choice.
Diab M, 2000 ¹⁷	Review	Intrusion	Sequelae affecting the intruded primary incisors	Outcome of intrusion injuries to the primary incisor include coronal discoloration, pulp canal obliteration, pulpal necrosis, pathologic root resorption and ankylosis.
Diab M, 2000 ²	Review	Intrusion	Effects on the permanent successors	The developmental defects to permanent tooth range from mild alteration in enamel mineralization, dilacerations of crown or root, root duplication, root formation cessation, odontoma like malformations, sequestration of the developing germ or eruption disturbances of successor tooth.
Spinas E, 2007 ¹⁰	Clinical follow up study	Intrusion	Different therapeutic approaches	Incidence is high between 1 and 4 years of life. Spontaneous repositioning occurs in most of cases, if excessive mobility or local infection is present extraction is advised.
Altun C, 2009 ⁹	Observational	Intrusion	Consequences for the intruded primary teeth	The majority of intruded primary incisors where immediate extraction is not indicated will re-erupt. Following the intrusion of a primary incisor, over 50% permanent successors are likely to have developmental defects
Da Silva Assunção LR, 2009 ¹⁸	Retrospective	Luxation	Effects on permanent teeth after luxation injuries to the primary predecessors	Special attention is required for children who suffered dental trauma at an early age, especially in cases of intrusive luxation and avulsion.
Vivian Carvalho, 2010 ¹³	Retrospective	Intrusion	Prevalence and sequelae of partial and total intrusive luxation whether the sequelae on both deciduous and permanent teeth were related to the child's age at the time of the intrusion.	No significant correlation between the child's age at the time of intrusion and the frequency of subsequent sequelae on primary injured teeth and the developmental disturbances on permanent teeth.
Assunção LR, 2011 ⁸	Retrospective	Luxation	Age, gender, etiologic factors, type of injury, injured teeth, treatment and time interval between injury and treatment	"Monitor only" is the most eligible treatment despite the severity of luxation injuries to primary teeth.
Anne B, 2014 ¹²	Retrospective	Luxation	Study frequency of enamel defects in permanent successors	Minor luxation injuries and indirect trauma may cause enamel defects in permanent successors.
Aya Qassem, 2015 ¹⁴	Retrospective	Intrusion and subluxation	Kinds of sequelae resulting from intrusive luxation and subluxation injuries in primary anterior teeth as well as the timing of such sequelae	Type of sequelae and frequency, remains similar for both intrusion and subluxation injuries
Eva Lauridsen, 2017 ⁵	Retrospective study	Concussion and subluxation	Reported the risk of pulp necrosis, pulp canal obliteration, repair-related resorption, infection-related resorption, ankylosis-related resorption, and premature tooth loss	A significant percentage of sequelae were diagnosed within 6 months after TDI
Eva Lauridsen, 2017 ¹⁵	Retrospective	Extrusion and lateral luxation	Reported the risk of pulp necrosis, pulp canal obliteration, infection-related resorption, ankylosis-related resorption and premature tooth loss	Concussion or subluxation injury carry a low risk of pulp necrosis and infection with periapical inflammation, root resorption, and premature tooth loss.
Eva Lauridsen, 2017 ¹⁶	Retrospective	Intrusion	Reported the risk of pulp necrosis, pulp canal obliteration, infection-related resorption, ankylosis-related resorption and premature tooth loss	The healing potential for laterally luxated teeth which were left untreated is high. More than 50% of repositioned extruded teeth showed long-term survival. Over 80% of intruded primary teeth re-erupt spontaneously. Complications such as pulp infection/periapical inflammation or ankyloses were seen in nearly 1/3 of injured teeth.

Table 2
Etiological factors.

Etiological factors	Assunção LR et al. (2011) ⁸	Altun C (2009) ⁹
Category 1: falls		
Fall while walking or running	37.7%	44.8%
Falling from high place	16.4%	–
Falling against objects	18.8%	32.1%
Falling from moving objects	9.5%	9.0%
Category 2: other factors	4.2%	14.1%
Unknown	13.4%	–

different traumatized tissues and also suitable treatment options are assessed that can be provided to prevent further complications. The monitoring of pulpal health involves evaluation of any clinical signs or symptoms of pain, tenderness to pressure, colour changes and the development of a sinus or swelling and also radiographs at each follow up visit for atleast 12 months.³

In cases of luxation injuries to teeth, the treatment of choice mainly depends on the severity of the trauma. Diab M (2000)¹¹ classified the intrusive injuries into 3 grades; Grade I represents mild partial intrusion where half (50%) of the crown is visible, Grade II represents moderate partial intrusion where less than half (50%) of the crown is visible and Grade III denotes severe or complete intrusion of the crown. Spontaneous re eruption is anticipated within 6 months if intrusive tooth is labially displaced, but in cases where there is lingual displacement of primary tooth careful extraction is the treatment of choice. Assunção LR et al. (2011)⁸ in their retrospective study of 679 luxated primary teeth provided monitoring only in 74% of cases as treatment of choice, followed by splinting in 9%, 7% installation of prosthesis, 5% extraction, 3% repositioning and splinting and 2% only repositioning.⁸ Supporting this treatment plan Altun C (2009)⁹ also reported wait and watch for spontaneous re eruption as the treatment of choice for most of the intrusive injuries and extraction for extensively dislocated lateral injuries.⁹

The impact of traumatic injuries may lead to the damage of neurovascular apical bundle leading to necrosis of pulp, which can be diagnosed with clinical signs such as sinus or fistula and radiographic presentation of periapical bone rarefaction. Pulp hyperemia and pulpal hemorrhage following trauma release hemoglobin and erythrocytes which subsequently results in discoloration of crown. A phenomenon of amorphous calcification can be seen specially in subluxated and intruded teeth due to formation of a coagulum of apical tissues leading to odontoblastic stimulation.¹⁴

Lateral luxations and intrusion injuries are more often associated with serious complications like external or replacement root resorption due to the severe damage caused to the surrounding tissue including the periodontal ligament, neurovascular bundle as well as hard tissues of the teeth (cement, dentin). Apart from damage to periodontal tissues, luxation injuries to teeth may also lead to fracture of the labial bone plate. The nature of intrusion injuries is unique from other sub-types of luxation as they are associated with severe disruption of the periodontal membrane and root surfaces resulting in a high risk of external root resorption and doubtful long term survival.⁷

Lauridsen E. (2017)^{5,15,16} in his three studies estimated the chance

of unfavorable outcomes in primary teeth with all subtypes of luxation injuries with one year follow up as pulp necrosis (PN), pulp canal obliteration (PCO), premature tooth loss (PTL), repair related resorption (RRR), ankylosis related resorption (ARR) and infection related resorption (IRR). Diab M. (2000)¹⁶ also reported the outcome of intruded primary incisor as coronal discoloration, grey discoloration, yellow discoloration pulpal necrosis, pathological external root resorption, abscess or cellulitis formation, failure of re eruption and ankylosis.

Carvalho V. (2010)¹³ investigated the sequelae associated with total and partial intrusion injuries of primary anterior teeth and also estimated the risk factors of disturbances seen on successor teeth due to trauma to its predecessor separately in both the conditions. However, Altun C (2009)⁸ presented post traumatic consequences of intrusion on successors as 50% successors have developmental disturbances such as enamel hypoplasia in 28.3%, dilacerations in 16.7% and ectopic eruption with 6.7% of teeth.⁸ Da Silva Assunção LR (2009)¹⁸ reported developmental disturbances following luxation injury in 20.2% of all cases such as white or yellow brown discoloration of enamel with or without hypoplasia, crown dilacerations and root malformations.

Qassem et al. (2015)¹⁴ evaluated the type as well as timing of sequelae resulting from intrusion and subluxation injuries in primary anterior teeth. They found out that in cases of subluxation, more than 50% of crown discoloration, pulp obliteration, fistula, and internal root resorption cases occurred within 6 months. And among the sequelae following intrusion, fistulae were frequently within 3–6 months after the injury. Most cases of internal root resorption, crown discoloration and pulp obliteration were observed within the 6–12 months and the 1–2 years time period.¹⁵

4. Conclusion

The review emphasizes on the need for special attention required for children who suffer luxation injuries to teeth at early ages (up to 5 years). Injury due to fall and collision is the most common cause and regular monitoring is the preferred management approach for most of the luxated teeth. PCO, PN and tooth loss due to trauma are prevalent complications observed following luxation. Due to irreversible damage at the time of trauma, enamel hypoplasia and white-brown discolorations of enamel are the most common undesirable sequelae to permanent teeth.

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Declaration of competing interest

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Table 3
Treatment options following luxation injuries.

Treatment	Assunção LR et al. (2011) ⁸ (All types of luxation)	Diab M (2000) ¹¹ (Intrusion)	Altun C (2009) ⁹ (Intrusion)
Monitoring	74%	For labially displaced	Most intrusive cases
Splinting	9%	–	–
Installation of prosthesis	7%	–	–
Extraction	5%	For lingually displaced	For extensive dislocation cases (alongwith intrusion)
Repositioning and splinting	3%	–	–
Only splinting	2%	–	–

Table 4

Frequency of complications following luxation injuries to primary teeth (Lauridsen 2017).

Type of complication	Concussion	Subluxation	Lateral luxation	Extrusive luxation
Pulp canal obliteration (PCO)	8.6%	23.2%	43.3%	39.8%
Pulp necrosis (PN)	5.7%	8.3%	19.8%	15.6%
Repair related resorption (RRR)	0	1.3%	3.7%	4.4%
Infection related resorption (IRR)	0	2.6%	7.3%	3.8%
Ankylosis related resorption (ARR)	0	0	1.5%	0
Premature tooth loss (PTL)	5.6%	9.5%	24.8%	43.3%

Table 5

Frequency of complications following intrusive luxation injury to primary teeth.

Type of complication	Frequency			
	Diab M. (2000) ¹⁷	Carvalho (2010) ¹³		Lauridsen (2017) ¹⁶
		Partial intrusion	Total intrusion	
Pulp necrosis	22–35%	23.6%	78.9%	24.2%
Pulp canal obliteration	–	0.0%	0.8%	38.9%
Repair related resorption	14%	4.3%	2.3%	3%
Infection related resorption				8.8%
Ankylosis related resorption				3.6%
Coronal (enamel) discoloration	33–48%	17.2%	3.1%	
Alveolitis		2.2%	0.0%	
Failure of re eruption	20–22%			
Ankylosis	4–6%			

Table 6

Frequency of disturbances seen on permanent teeth.

Disturbances on permanent teeth	Carvalho (2010) ¹³		Altun C (2009) ⁹
	Partial intrusion	Total intrusion	
White or brown enamel discoloration	12.9%	11.7%	
Enamel hypoplasia	15.1%	7.8%	28%
Crown dilacerations	3.2%	2.3%	16.7%
Root dilacerations	3.2%	1.6%	
Sequestration of the permanent tooth germ	0	0.8%	
Eruption disturbances	12.9%	6.3%	6.7%
Non-erupted teeth	11.8%	39.6%	

References

- Flores MT, Andersson L, Andreasen JO, et al. International Association of Dental Traumatology. Guidelines for the management of traumatic dental injuries. I. Fractures and luxations of permanent teeth. *Dent Traumatol.* 2007;23(2):66–71.
- Diab M, elBadrawy HE. Intrusion injuries of primary incisors. Part III: effects on the permanent successors. *Quintessence Int.* 2000;31(6):377–384.
- Belmonte FM, Macedo CR, Day PF, Saconato H, Fernandes Moça Trevisani V. Interventions for treating traumatized permanent front teeth: luxated (dislodged) teeth. *Cochrane Database Syst Rev.* 2013;30(4).
- Gupta M. Intrusive luxation in primary teeth – review of literature and report of a case. *Saudi Dent J.* 2011;23(4):167–176.
- Lauridsen E, Blanche P, Amaloo C, Andreasen JO. The risk of healing complications in primary teeth with concussion or subluxation injury-A retrospective cohort study. *Dent Traumatol.* 2017;33(5):337–344.
- Moher D, Liberati A, Tetzlaff J, Altman DG. Reprint-preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Phys Ther.* 2009;873–880 United States.
- Zaleckiene V, Peciuliene V, Brukiene V, Druktinis S. Traumatic dental injuries: etiology, prevalence and possible outcomes. *Stomatologia.* 2014;16(1):7–14.
- Assunção LR, Ferelle A, Iwakura ML, Nascimento LS, Cunha RF. Luxation injuries in primary teeth: a retrospective study in children assisted at an emergency service. *Braz Oral Res.* 2011;25(2):150–156.
- Altun C, Cehreli ZC, Güven G, Acikel C. Traumatic intrusion of primary teeth and its effects on the permanent successors: a clinical follow-up study. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2009;107(4):493–498.
- Spinass Enrico, et al. Therapeutic approach to intrusive luxation injuries in primary dentition. A clinical follow-up study. *Eur J Paediatr Dent: Off J Eur Acad Paediatr Dent.* 2006;74:179–186.
- Diab M, elBadrawy HE. Intrusion injuries of primary incisors. Part I: review and management. *Quintessence Int.* 2000 May;31(5):327–334.
- Skaare AB, Aas AL, Wang NJ. Enamel defects on permanent successors following luxation injuries to primary teeth and carers' experiences. *Int J Paediatr Dent.* 2015;25(3):221–228.
- Carvalho V, Jacomo DR, Campos V. Frequency of intrusive luxation in deciduous teeth and its effects. *Dent Traumatol.* 2010;26(4):304–307.
- Qassem A, Martins Nda M, da Costa VP, Torriani DD, Pappen FG. Long-term clinical and radiographic follow up of subluxated and intruded maxillary primary anterior teeth. *Dent Traumatol.* 2015;31(1):57–61.
- Lauridsen E, Blanche P, Yousaf N, Andreasen JO. The risk of healing complications in primary teeth with extrusive or lateral luxation-A retrospective cohort study. *Dent Traumatol.* 2017;33(4):307–316.
- Lauridsen E, Blanche P, Yousaf N, Andreasen JO. The risk of healing complications in primary teeth with intrusive luxation: a retrospective cohort study. *Dent Traumatol.* 2017;33(5):329–336.
- Diab M, elBadrawy HE. Intrusion injuries of primary incisors. Part II: sequelae affecting the intruded primary incisors. *Quintessence Int.* 2000;31(5):335–341.
- Da Silva Assunção LR, Ferelle A, Iwakura ML, Cunha RF. Effects on permanent teeth after luxation injuries to the primary predecessors: a study in children assisted at an emergency service. *Dent Traumatol.* 2009;25(2):165–170.