

Luxation injuries of primary anterior teeth — prognosis and related correlates

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Abstract

This study investigated the prognosis and related correlates of 307 luxation injuries of primary anterior teeth sustained by 222 patients. Primary anterior teeth that had sustained luxation injuries were identified from the dental records of a pediatric dental practice. Data collected included: the child's birth date, sex, and occlusion; date, etiology, and type of injury; treatment rendered; and post-traumatic sequelae. The mean age of children at the time of injury was 3.8 years, and the most common etiology was a fall. Those children sustaining intrusions were significantly younger than those sustaining extrusions or avulsions. Sports accidents were more likely to cause lateral luxations, while bike accidents were more likely to cause extrusions and avulsions. Root fractures were significantly associated with lateral luxations. The risk of sustaining a lateral luxation increased as age increased. There was an association between the development of post-traumatic sequelae and the repositioning of displaced teeth. Lateral luxations had a marked increase risk of necrosis when repositioned; conversely, intrusions had a decreased risk of necrosis when repositioned. Those groups with the best post-trauma tooth survival during the first year postinjury were those > 5 years old and < 2 years old. Hypoplastic defects were noted on 7.7% of the succedaneous teeth and their prevalence was not statistically associated with the type of luxation injuries. (Pediatr Dent 16:96-101, 1994)

Introduction

Injuries to the primary dentition occur frequently.^{1,2} Kenwood and Seow³ reported that in children < 7 years old, more than 30% have experienced trauma to their primary dentition. These injuries occur most often to anterior teeth.^{2,4} In contrast to injuries of the permanent anterior teeth — where fractures are the most prevalent type of injury — the majority of injuries to the primary anterior dentition are luxations.^{1, 5, 6} Meadow, et al.'s⁶ epidemiologic study of injuries to the primary and permanent teeth demonstrated that: 1) 50% of subluxation injuries involved primary teeth; 2) 28% of all injuries were luxation, 72% of which involved the primary dentition; and 3) 7% of all injuries were intrusions, 85% of which involved primary teeth. Garcia-Godoy⁷ evaluated the etiology, distribution, and occurrence of injuries to primary teeth and reported that 14.4% of the 114 teeth injured were luxations.

Few studies have reported the prognosis for luxation injuries to the primary dentition. Ravn⁸ reviewed the sequelae of acute mechanical trauma to the primary dentition. Of 88 intruded teeth, 72 re-erupted after the injury, four needed to be extracted immediately at the time of evaluation, and four were over-retained. Of a subset of 40 intrusions, 19 teeth developed calcific degeneration, ten developed periodontal defects, four remained vital, and two were lost to followup. Of the six luxated teeth evaluated, four were extracted immediately, and two were repositioned and later needed extraction. In 1976 Ravn¹³ reported on the outcomes of 100 intruded teeth. Eighty-six teeth re-erupted with 35 demonstrating calcific degeneration, 22 developing

periapical pathology, and 29 demonstrating no post-traumatic sequelae. Eight teeth were removed immediately and six never re-erupted. Andreasen¹ followed 88 intruded primary teeth and found that 80 erupted spontaneously with 30 developing calcific degeneration. No data were presented on the prevalence of pulp necrosis. Of the 52 subluxated teeth followed, 9.6% were extracted immediately with 48% demonstrating pulpal obliteration. Kenwood and Seow³ followed 69 injured primary incisors, 15.9% of which had luxation injuries. Displacement injuries were associated with a higher rate of necrosis than fractures. Nearly 50% of the 11 displacement injuries developed periapical radiolucencies after 44 weeks of followup. Of the seven cases of extrusion, intrusion, and lateral displacement, three teeth developed necrosis, two remained vital, and two were lost to followup.

The purpose of this study is to document the prognosis of a large sample of luxation injuries to primary anterior teeth and to investigate what variables might be associated with their prognosis.

Methods and materials

Primary anterior teeth that had sustained luxation injuries were identified from dental records of a private pediatric dental practice of one of the authors (HLN). Data regarding the date and type of the injury, treatment rendered, and post-traumatic sequelae were collected on a standardized data collection form by the principle author (NJS). Post-traumatic sequelae recorded included pulpal necrosis, calcific degeneration, ankylosis, and hypoplasia of the secondary successor.

In addition, data were recorded regarding the child's date of birth and gender, etiology of the accident, description of the injury, patient's molar classification (Angle Class I or mesial step/end-end, Class II or distal step or Class III), overbite, and overjet at the time of injury. Clinical diagnoses noted in the dental record were recorded and all radiographs of the traumatized teeth were reviewed by the principal author (NJS) to confirm the chart diagnoses made by the child's dentist of record (either HLN or one of the other pediatric dentists in the private practice). Not all injuries studied had a post-trauma radiograph, and any cases with questionable diagnoses were excluded from the study.

Luxation injuries were categorized as:

- Intrusions, displacement apically into the socket
- Extrusions, displacement incisally out of the socket
- Lateral luxation, displacement in a mesial, distal, labial or palatal direction
- Avulsion, complete displacement of the tooth from its socket.

Chi-square, analysis of variance (ANOVA), Duncan's Multiple Range Test, and survival analysis were employed to evaluate the relationships among the variables of interest.

Results

Sample characteristics

Three-hundred and seven luxation injuries of primary anterior teeth sustained by 222 children were examined. Central incisors were involved in 80.8% of the injuries, while the remaining 19.2% involved lateral incisors. The vast majority (91.2%) of the injuries occurred in the maxillary arch. There was no significant difference between injuries occurring on the right (52.1%) and left (47.9%) sides of the dental arch. Table 1 shows the types of luxations of the sample with mean age at which child was injured, mean overjet, and types of treatment rendered.

Age

The ANOVA revealed an overall association between type of injury and age of the child. Duncan's Multiple

Range test demonstrated the specific association, i.e., those children who sustained intrusions were significantly younger than those sustaining extrusions or avulsions ($P < 0.01$). In addition, there was a significant association between the age of the children and the types of treatment received at the time of injury ($P < 0.01$). Those children whose injuries were treated by extraction were significantly older (4.8 years) than those requiring no treatment (3.9 years) or those requiring repositioning with or without splinting (3.0 years).

Gender

The majority of the sample consisted of males (62.6%), yielding a male/female ratio of 1.7/1. An analysis of the association between either gender and etiology of the injury ($P = 0.49$) or type of injury sustained by the children ($P = 0.16$) revealed no significant relationship.

Etiology

The cause of the injury was known for 96.4% (296/307) of the injuries. Falls accounted for the majority of luxation injuries (71.6%), followed by bike accidents (11.5%), sport-related accidents (3.7%) and the remainder of miscellaneous origin (13.2%). The type of injury was statistically significantly associated with the etiology of the injury sustained ($P < 0.01$). Bike accidents were more likely to result in extrusions and avulsions, while sports-related accidents were more likely to cause lateral luxations when compared to other causes. Of the types of associated injuries, etiology was significantly associated with extraoral soft tissue injuries ($P < 0.01$), while none was found for intraoral soft tissue trauma, crown fracture, root fracture, or bony fracture. Bike injuries were most frequently associated with extraoral trauma. All of the luxation injuries — regardless of etiology — were associated with intraoral soft tissue trauma.

Type of injury

The majority of the luxation injuries (57.0%) were lateral luxations (Table 1). Table 2 lists the results of the analyses between the type of injuries and other possible correlates. Root fractures were significantly associated with the type of injury sustained ($P = 0.02$), i.e., all 12 of the root fractures in this sample occurred with lateral luxations. In addition, the type of treatment rendered was significantly associated with the type of injury sustained ($P < 0.01$), i.e., the different types of injuries were treated differently (Table 1).

Occlusion

The mean overjet of the

Table 1. Characteristics of types of luxation injuries (N = 307)

Types of Luxations	%	Mean Age (years)	Mean Overjet (mm)	Types of Treatment Rendered (%)		
				Observed	Reimplanted or Repositioned	Extracted
All	100.0	3.8	3.0	59.6	22.5	17.9
Lateral	57.0	3.8	3.1	43.4	34.3	22.3
Avulsions	19.2	4.5	2.1	98.3	0.0	N/A
Intrusions	15.3	2.9	4.2	76.6	10.6	12.8
Extrusions	8.5	4.7	2.8	50.0	11.5	38.5

Table 2. Results of ANOVA of variables associated with type of tooth injuries

Variable	P Value
Treatment rendered	< 0.01*
Root fracture	0.02*
Crown fracture	0.07
Post-traumatic sequelae	0.20
+/- extraoral injury	0.25
Bony fracture	0.39

* Statistically significant.

Table 3. Sequelae of followed luxation injuries as a function of treatment rendered (%)

Sequelae	All Luxations		Lateral Luxations		Intrusions	
	Repositioned (N=33)	Observed (N=85)	Repositioned (N=28)	Observed (N=52)	Repositioned (N=3)	Observed (N=21)
Necrosis	44.8	18.8	50.0	17.3	0.0	33.3
Calcification	6.9	11.8	3.6	15.4	33.3	9.5
Ankylosis	10.3	7.1	7.1	7.7	33.3	0.0
None	38.0	62.3	39.3	59.6	33.3	57.1

children sustaining luxation injuries was 3.0 mm (range of 0–10 mm) and the mean overbite was 45.9% (range of 0–100%). The distribution of the sample's molar classification was as follows: 66.1% mesial step or end/end; 32.2% distal step; and 1.7% Class III. Since overjet was not normally distributed, it was ranked before performing the ANOVA, which demonstrated a significant association between overjet and type of injury ($P < 0.01$). Duncan's Multiple Range Test indicated that the overjet in children sustaining intrusions was significantly larger (4.2 mm) than that of avulsions (2.1 mm), however no other associations between any of the types of luxation injuries and overjet were significant. There was no significant increase in the risk of sustaining a luxation injury as overjet increased ($P = 0.5$).

Sequelae

Only 51.4% (114/222) of the sample was followed for post-traumatic sequelae. The average length of followup after injury was 4.3 years. About 55% (63/114) of the injuries demonstrated no sequelae, 26.3% (30/114) became necrotic, 10.5% (12/114) demonstrated calcific degeneration, and 7.9% (9/114) became ankylosed. The prevalence of various type of sequelae was not significantly associated with the type of luxation injury ($P = 0.12$).

Treatment rendered (no treatment versus repositioning) was significantly associated with the sequelae of all the luxation injuries as a group ($P = 0.03$), lateral luxations only ($P = 0.01$), and intrusions ($P = 0.02$).

Table 3 shows the types of sequelae for lateral luxation and intrusion and treatment rendered. There was no significant relationship between treatment rendered for extrusions and post-trauma sequelae.

Fig 1 illustrates survival to sequelae of the teeth from time of injury. Five groups were formed for age at time of injury; 0 to 2 years old, > 2 to 3 years old, > 3 to 4 years old, > 4 to 5 years old, and > 5 years old. There was a significant difference in the rate of survival among the five groups ($P < 0.01$). The group with the least sequelae over time was the > 5 group followed by the 0–2 age group. The worst survival rate was noted in the 2–3 age group.

Evaluation of the permanent successors was possible for 55.0% (169/307) of the luxated primary incisors. The succedaneous teeth demonstrated hypoplastic defects in 7.7% (13/169) of the cases. Intrusions resulted in hypoplasia of the successor in 17.4% (4/23) of the cases, compared with 7.1% (7/99) of the lateral luxations and 5.7% (2/35) of the avulsions, however

these differences were not significant ($P = 0.23$). There was no significant association between the type of treatment rendered and secondary successor hypoplasia for both lateral luxations ($P = 0.13$) and intrusions ($P = 0.38$). Nor was there any significant relationship between the type of luxation injury and secondary successor hypoplasia ($P = 0.23$). Similarly, there was no significant relationship between necrosis and hypoplasia of the succedaneous tooth ($P = 0.80$).

Discussion

Sample characteristics

This study examined a wide range of variables and their possible association with the prognosis of trau-

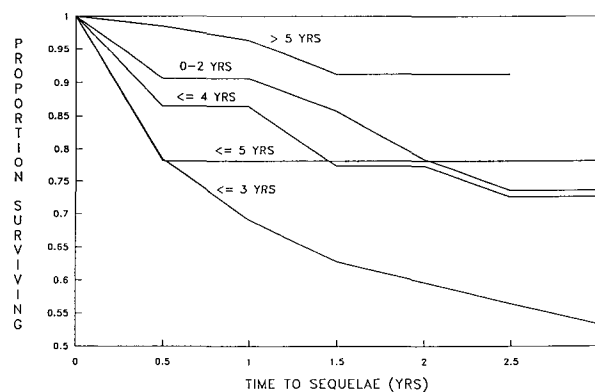


Fig 1. Sequelae-free sequelae analysis as a function of age.

matically luxated primary anterior teeth. The vast majority of teeth sustaining luxation injuries in this study were central incisors. Similarly, the vast majority of luxated primary teeth were in the maxilla (91.2%). These findings are similar to those of Kapala and Frankl² who reported that 94% of their luxation injuries to the primary dentition involved maxillary teeth. Since the maxillary teeth, especially the central incisors, are the most prominent in the dentition, they are more susceptible to traumatic events.

Age

The mean age of the children sustaining luxation injuries to the primary anterior teeth was 3.8 years. This is slightly younger than the findings of Ferguson and Ripa⁹ and Garcia-Godoy⁷ who reported that the most prevalent age range for this type of injury was 4–5 years. Certainly, after age 3 children become more independent and more physically active, and thus become more likely to sustain injuries to their dentitions. An analysis of the mean ages of the children who sustained different types of luxation injuries indicated that older children were more likely to sustain avulsions, extrusions, and lateral luxations, whereas younger children were more likely to sustain intrusions. This may in part be due to the length of root at the time of injury. Older children have incisors with less root structure due to resorption by the permanent successors, thus making them more easily dislodged. The direction of force may also play an important role. The activities of young children usually consist of running and unsupervised forms of play, while older children more often participate in organized activities where thrown objects (balls, Frisbees, etc.) or flailing implements (hockey sticks, bats, rackets, etc.) are involved. Falling on the ground or an object delivers an upward reciprocal force, whereas airborne objects are more likely to deliver lateral forces.

The significant difference in the ages of the children in each of the treatment groups may also be explained by the amount of root structure present. Our data indicate that extractions were more likely to be performed on luxated teeth of older children. Older children have primary anterior teeth with less root structure since they are closer to exfoliation. Therefore, the need to save young primary teeth for cosmetic and space maintenance purposes often outweighs rendering complex treatment and possible post-traumatic sequelae.

Gender

Our results suggest that the children sustaining luxation injuries to their primary teeth were almost twice as likely to be male than female (1.7/1), which is similar to the 1.8/1 male/female ratio reported by Garcia-Godoy.⁷ There was no statistical association between either the type of luxation injury or the etiology and the child's gender.

Etiology

The most common cause of lateral luxations in this study were falls (70.9%), which is similar to the 79.8% reported by Garcia-Godoy.⁷ The etiology of an accident was associated with the type of injury sustained. Bike accidents were more likely to cause extrusions and avulsions, while sports-related accidents were more likely to cause lateral luxations. This may be explained by greater supervision and protective gear worn in organized sports for children, making them less susceptible to more severe tooth injury. The high velocity that can be attained on a bike also increases the amount of force that can be delivered to the dentition.

Types of injuries

In our study, most of the luxation injuries were lateral luxations (57.0%), followed by avulsions (19.2%), intrusions (15.3%), and extrusions (8.5%). Garcia-Godoy's⁷ study involving 64 luxated primary teeth revealed a lower percentage of lateral luxations (34%) and extrusions (3%), and a higher percentage of intrusions (34%), and avulsions (29%). Since our sample was almost five times larger than theirs, our findings may be more representative of the types of luxations injuries occurring in the pediatric population.

The only associated injury (intraoral soft tissue trauma, extraoral soft tissue trauma, crown fracture, or bony fracture) statistically significantly related to a particular type of luxation injury was root fracture, which occurred exclusively with lateral luxations. This may be due to the distribution and direction of force placed on the laterally luxated tooth at the time of injury. Avulsions, intrusions, and extrusions may be the result of forces delivered along the long axis of the root involving the periodontal ligament, thus resulting in damage to the ligament or the surrounding bone rather than the tooth structure itself. In contrast, the forces resulting in lateral luxation are dissipated within the root structure around the center of rotation, predisposing the tooth to root fracture. All of the luxation injuries in this study were associated with intraoral soft tissue injury, which by definition must involve the surrounding tissues.

Occlusion

Thirty-two point two percent of the patients sustaining luxation injuries to their primary anterior teeth had a distal step (Class II-type) molar occlusion, which is similar to the 35% prevalence of this molar occlusion reported by Kelly, et al.¹⁴ in the United States Public Health Service study. Thus, there does not appear to be any increased risk in sustaining a luxation injury of the primary anterior dentition in children with Class II-type malocclusions. Children sustaining intrusions had a statistically significantly larger overjet than those who sustained avulsions. This may be due to the sus-

ceptibility of incisors with a large overjet having incisal edges more vulnerable to a direct apical force parallel to the tooth's long axis.

Sequelae

In reviewing the survival analysis (Fig 1), it is apparent that the two age groups with the best sequelae-free survival during the first year post injury are children ≤ 2 years old and > 5 years old. This may be due to the status of the root development of the incisors at the time of injury. The majority of teeth included in the study were maxillary anterior teeth. The approximate time of root closure for these teeth is 2 years, while root resorption begins approximately at age 5. In either case, the apices are open with a larger neurovascular bundle entering the apex. The lowest survival was noted in the 2-3 year old group where apices were more mature. As has been previously reported in many studies of the prognosis of permanent incisors after trauma, teeth with immature apices generally have better prognoses.¹⁵⁻¹⁶

An interesting finding in this study was that 56.8% of the luxated primary anterior teeth had no sequelae. There was no statistically significant association between the type of injury and the various sequelae. There was, however, a significant association between treatment rendered at the time of the injury and the sequelae for lateral luxations. Repositioning of lateral luxation was associated with an increased risk of developing pulpal necrosis. The repositioning of a lateral luxation in which the periodontal ligament may already be traumatized and edematous, may increase the pressure already existing on nutritive vessels to the tooth, and thus, increase the chance of ischemia and necrosis. It must be noted however, that the severity of the lateral luxations may confound this finding. Severely luxated teeth usually require repositioning, thus making this subgroup of lateral luxations more likely to develop necrosis by virtue of the severity of the injury rather than as the result of repositioning itself. In contrast, intruded teeth that were repositioned were less likely to become necrotic. Repositioning an intruded tooth moves the tooth outward, relieving apical compression, lessening the likelihood of ischemia, and allowing for possible reanastomosis.

Hypoplastic defects were noted on 7.7% of succedaneous teeth following luxation of their primary counterparts. This is lower than the 13-57% prevalence reported in other studies.^{8, 10-13} Hypoplastic defects of the succedaneous teeth occurred with 17.4% (4/23) of the intrusions, 7.1% (7/99) of the lateral luxations, 5.7% (2/35) of the avulsions, and none (0/12) of the extrusions. Although the higher prevalence rate for intrusions was not statistically significant, similar high rates (20%) have been previously reported.⁸ This finding is expected since intrusions are more likely to cause contact between the primary tooth's root and

the developing tooth germ during trauma when compared to avulsions, extrusions, and lateral luxations.

Conclusions

1. The majority of luxation injuries to primary anterior teeth occurred to males (1.7/1), were maxillary central incisors, and were the result of falls.
2. Lateral luxations were the most common type of luxation injury (57.0%), followed in prevalence by avulsions (19.2%), intrusions (15.3%), and extrusions (8.5%).
3. Children who sustained intrusive luxation injuries to primary anterior teeth were significantly younger and had larger overjets when compared to other types of luxation injuries.
4. Root fractures were more often associated with lateral luxation than other types of injuries.
5. no post-trauma sequelae were noted in 56.8% of the luxated primary anterior teeth, while 25.4% became necrotic, 10.2% demonstrated calcific degeneration and 7.6% became ankylosed.
6. There was no relationship between the type of luxation injury and the prevalence of different types of sequelae.
7. The development of post-trauma sequelae was related to the type of treatment rendered, i.e., repositioning a lateral luxation was associated with increased prevalence of necrosis, while repositioning an intrusion was associated with decreased prevalence of necrosis.
8. Children ≤ 2 years old and > 5 years old have the best sequelae-free survival rate and consequently, the least sequelae during the first year post-trauma.
9. Hypoplastic defects were noted on 7.7% of the successors of luxated primary anterior teeth and there was no association between the type of injury and the prevalence of hypoplasia.

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Frequent family moves may mean failed school grades and behavioral problems

Frequent family moves increase the risk a child will fail a grade in school, according to an article in a recent *Journal of the American Medical Association*.

"After adjusting for other covariates, frequent family relocation was associated with an increased risk of children failing a grade in school and four or more frequently occurring behavioral problems," writes David Wood, MD, MPH, from the Division of Primary Care, Cedars-Sinai Medical Center, Los Angeles, with colleagues.

The authors analyzed data on 9,915 6- to 17-year-old children collected in 1988 for the National Health Interview Survey. Responses were from adult family members, usually parents. Respondents were asked to report whether the child had a delay in growth or development, had a learning disability, had ever repeated a grade, or had four or more frequently occurring behavior problems listed on the Achenbach Behavior Check List (specific behavior problems were not listed in the study). Children were divided into two groups — never/infrequent relocation and frequent relocation.

"The measures of both child dysfunction and family relocation were independently associated with multiple sociodemographic characteristics such as poverty, race, and family structure," they write.

They say white children were less likely to have repeated a grade or have four or more behavioral problems, but more likely to have developmental or growth delays; and that children from two-parent families were "significantly less likely to have repeated a grade or have four or more behavioral problems than children from single-parent/grandparent families."

Controlling for confounding covariates, they found that "children who moved frequently were 77% more likely to have four or more behavioral problems and were 35% more likely to have failed a grade, but no more likely to have had delays in growth or development or a learning disorder."

"There is a growing movement of school-based family resource centers that provide health, mental health, and social services to families with children who are at risk for school failure or have severe behavioral problems. Perhaps if this movement grows and family resource centers become the norm, more children will receive the services needed to successfully mitigate the untoward effects of multiple family moves," they write.