



Subluxation injuries of maxillary primary anterior teeth: epidemiology and prognosis of 207 traumatized teeth

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Abstract

This study investigated the epidemiology, sequelae, and prognosis of subluxation injuries to the maxillary primary anterior dentition. Data were collected from dental records at the Montreal Children's Hospital, Montreal, Canada, of patients sustaining trauma between 1982 and 1993. The study group consisted of 207 teeth in 134 patients, 81 males and 53 females. The age of the patients ranged from 0.8 years to 7.5 years, with a mean of 3.5 years. The highest incidence of trauma was in males between the ages of 3 and 4 years, and in females between 1 and 3 years. The highest incidence of trauma (66.2%) involved the primary central incisors. The most common cause of trauma (52%) was simple falls indoors. Occlusal or periapical radiographs were the radiographic view of choice unless an anterior nasal spine fracture was suspected, in which case a lateral projection was exposed. Approximately 64% of study teeth had a mobility ranging from 0.6 to 1.5 mm. Treatment varied from no treatment (80% of teeth) to extraction.

Post-traumatic evaluations were distributed into six common time intervals used by dentists for follow up. The results indicated that patient discomfort and occlusal interference were not common. Discoloration and pulpal calcification increased with time. Mobility decreased with time, with the majority of teeth returning to a normal physiologic range. External resorption may have been present, but was rare. Treatment or antibiotics were rarely needed at follow-up visits. Overall, these teeth responded positively, and there was a low morbidity associated with subluxation injuries. (Pediatr Dent 18:145-51, 1996)

Trauma to the maxillary primary anterior dentition is common in a pediatric dental setting. Traumatic injuries have been classified in various ways.^{1,2} An easy and accepted classification is to first subclassify the condition into trauma affecting the tooth, that is fracture; and trauma affecting the periodontium. The classification put forth by Ellis for tooth fractures has been modified, but is still in common use.²

Many authors^{1,3-8} subclassify trauma to the periodontium using the following terms: concussion, subluxation, luxation, and avulsion (Table 1).

Subluxation is the loosening of the tooth without displacement and has been reported with a broad range of incidence.^{6,8} Galea³ found that 80% of all injuries to the primary anterior dentition were subluxated and displaced teeth. Meadow et al.⁶ reported subluxations to occur at an incidence of 40% of all trauma. Ferguson and Ripa⁹ reported subluxations to occur in 12% of all trauma. Andreasen¹⁰ noted this type of injury to occur at a frequency of 12% in all traumatized primary teeth.

The purpose of this study was to gather epidemiological data pertaining to subluxation injuries sustained in the maxillary primary anterior dentition and to report the sequelae experienced by these teeth.

TABLE 1. DEFINITION OF TOOTH TRAUMA TO THE PERIODONTAL TISSUES

Type of Injury	Effect on Tooth
Concussion	Sensitivity without abnormal mobility
Subluxation	Mobility without displacement
Luxation	Displacement in any direction
Avulsion	Exarticulation

Methods and materials

A retrospective chart audit was done at the Montreal Children's Hospital, Montreal, Quebec, Canada, by the primary investigator (IF), to identify patients who sustained a subluxation injury to the maxillary primary anterior dentition between 1982 and 1993.

The information was collected on standardized trauma assessment forms by dental residents and staff

practicing at the hospital. The residents and dentists were instructed by one of the authors (SS) as to the diagnostic criteria and methods of evaluation prior to completing the forms. In order to verify information gathered, the primary investigator (IF) reviewed all radiographs, and ensured data collected on the forms corresponded to information entered in patient records. Each patient was seen by only one dentist at each visit. Patients whose records contained an unknown for a given category were excluded from that category in data analysis. Patients having any permanent maxillary anterior teeth present were excluded from the study. Patients who were not examined within 1 week of the trauma were excluded.

Information gathered pertaining to the child and trauma included the following: date of visit, age and sex of child, teeth involved including teeth sustaining other types of trauma, time elapsed since trauma oc-

curred, how trauma occurred, maturity level of the subluxated teeth and presence of physiologic root resorption as assessed radiographically, types of radiographs exposed, previous trauma to subluxated teeth, condition of alveolar bone, tooth mobility, treatment of subluxated teeth, and whether antibiotic coverage was administered.

Post-traumatic sequelae were evaluated including: patient discomfort, occlusal interference, tooth discoloration, presence of fistula, sensitivity and sound upon percussion, mobility, response to vitality tests, presence of periapical radiolucency, condition of periodontal membrane space, presence of resorption and pulpal calcification, and rate of physiological root resorption. Also post-traumatic treatment and issuance of antibiotics were evaluated. The criteria used for these evaluations are described in Table 2 and Table 3.

Data were distributed into the following six time

intervals of examination post-trauma: 0-10, 11-30, 31-91, 92-183, 184-365, and 366-730 days. These follow-up intervals represent the standard recall periods that many dentists advocate following traumatic injuries. Patients should be seen within 10 days of trauma to ensure proper healing of any tissue laceration, as well as to ensure that no significant signs or symptoms ex-

TABLE 2. CRITERIA USED FOR PATIENT ON TRAUMA EXAMINATION RECORD

<i>Maturity Level</i>	<i>Root Resorption</i>	<i>Condition of Bone</i>
0. <1/4 root	0. N/A	0. N/A
1. 1/4 root	1. no	1. no fracture of alveolar bone
2. 1/2 root	2. yes; physiologic	2. mobile and/or Fx alveolar bone
3. 3/4 root	3. yes, pathologic	3. loss of alveolar bone
4. 4/4 open apex	4. yes; type unknown	—
5. 4/4 closed apex	—	—
9. Unknown	9. Unknown	9. Unknown

N/A = not applicable.

TABLE 3. CRITERIA USED FOR PATIENT ON FOLLOW-UP EXAMINATION RECORD

Is patient complaining of discomfort?	0. N/A 1. Yes 2. No 3. Sometimes 9. Unknown
Occlusion interference	1. Yes 2. No
Discoloration	0. N/A 1. No 2. Grey 3. Grey 4. Yellow 5. Pink 8. Uncertain 9. Unknown
Fistula	0. N/A 1. Yes 2. No 8. Uncertain 9. Unknown
Percussion Sensitivity	0. N/A 1. No 2. Moderately yes 3. Acutely yes 4. Yes but how much is not known 8. Uncertain 9. Unknown
Sound	0. N/A 1. Normal 2. Dull (ankylosis) 8. Uncertain 9. Unknown
Vitality Test	0. N/A 1. Yes 2. No 3. Maybe 9. Unknown
Resorption	0. N/A 1. Internal resorption 2. External surface resorption 3. External inflammatory resorption 4. External replacement resorption (ankylosis) 5. External cervical resorption 6. External resorption but kind not known 7. None 8. Uncertain 9. Unknown
Pulpal calcification (pathological)	0. N/A 1. None 2. Discrete (<contralateral tooth) 3. Severe 4. Total 8. Uncertain 9. Unknown
Physiologic root resorption (compared with antimere)	0. N/A 1. Normal rate 2. Delayed 3. Accelerated 8. Uncertain 9. Unknown

N/A = not applicable.

ist. Follow-up examinations should be completed within 1 month to assess tooth mobility and presence of infection. Furthermore, splints should usually be removed within the month, providing an alveolar fracture was not sustained. If an alveolar fracture was present, splinting periods as long as 6 to 8 weeks are recommended. Further evaluations should be carried out at approximately 3 months, 6 months, and at subsequent 6-month intervals. In cases where two follow-up visits fell into the same range, only data from the first visit were evaluated. Teeth were not necessarily evaluated in every follow-up period, and when evaluated, radiographs were not always exposed.

Data analysis was performed using SPSS Release 4.0™ for Macintosh™. Age and sex distributions were analyzed with *t*-test and chi-square tests, respectively.

Results

A total of 207 teeth were evaluated in 134 patients (81 male, 53 female) sustaining subluxation injuries to the maxillary primary anterior dentition. The central incisors were involved 66.2% of the time, and lateral incisors 33.3%. One case involved a canine. The age of patients ranged from 0.8 years to 7.5 years (Table 4). Table 5 describes the frequency and percentage of the number of teeth subluxated on a per patient basis. A chi-square test demonstrated that the sex ratio was significantly different, with an excess of males (chi-square = 5.85, *df* = 1, *P* = 0.016). A *t*-test indicated that the mean age of boys was significantly greater than that of girls (*t* = 3.40, *df* = 132, *P* = 0.001). The etiology of the traumatic injuries is displayed in the Figure. The most common cause of trauma was simple falls indoors.

Patients often sustained other types of trauma to the dentition, including avulsion, luxation, concussion, and fractured teeth. Table 6 presents the frequency

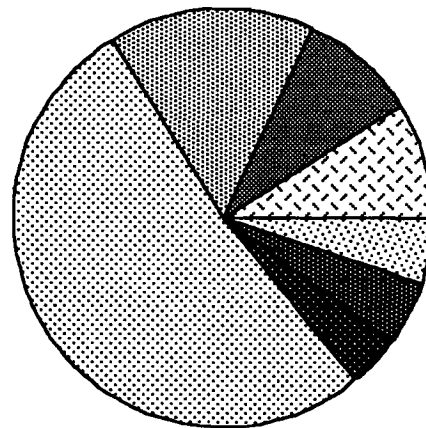


Figure. Etiology of trauma.

TABLE 5. PER PATIENT NUMBERS OF TEETH SUSTAINING SUBLUXATION

Number of Teeth per Child	Number (%) of Children
1	78 (58.2)
2	42 (31.3)
3	11 (8.2)
4	3 (2.2)
Total	134 (100.0)

distribution of patients sustaining such injuries in conjunction with subluxation injuries.

Twenty patients (14.9%) were seen within 1 hr after trauma, 53% within 3 hr, 70.1% within 12 hr, and 78.4% within 24 hr. The remaining 21.6% of patients were seen between 24 hr and 7 days after injury.

Of 183 cases, one-quarter of root formation was completed in 16.9% of subluxated teeth, one-half the root formation was completed in 11.5%, and three-quarters in 8.2%. Complete root formation with an open apex was seen in 9.8% of the teeth, while 53.6% of teeth had complete root formation with a closed apex.

TABLE 4. NUMBER (PERCENTAGE) OF PATIENTS SUSTAINING SUBLUXATION BY AGE AND SEX

Age (years)	Male	Female	Total
0-1	3 (2.2)	2 (1.5)	5 (3.7)
1-2	12 (9.0)	16 (11.9)	28 (21.1)
2-3	12 (9.0)	16 (11.9)	28 (21.1)
3-4	16 (11.9)	6 (4.5)	22 (16.5)
4-5	14 (10.4)	7 (5.2)	21 (15.8)
5-6	11 (8.2)	5 (3.7)	16 (12.0)
6-7	10 (7.5)	1 (0.7)	11 (7.5)
7-8	3 (2.2)	0 (0.0)	3 (2.3)
Total	81 (60.4)	53 (39.6)	134 (100.0)

TABLE 6. INCIDENCE OF OTHER TRAUMA ASSOCIATED WITH SUBLUXATION INJURIES

Type of Injury	Number (%) of Children
None	49 (36.6)
Luxation only	51 (38.1)
Avulsion only	21 (15.7)
Luxation and avulsion	4 (3.0)
Concussion only	4 (3.0)
Isolated fracture only	3 (2.2)
Avulsion and concussion	1 (0.7)
Luxation and fracture	1 (0.7)
Total	134 (100.0)

Root resorption was evaluated in 192 cases and was not present in 54.7% of subluxated teeth. Physiologic root resorption was present in 38.0% of study teeth and 6.8% of teeth demonstrated pathologic root resorption at initial assessment. One tooth demonstrated resorption, yet it could not be determined if it was physiologic or pathologic.

Occlusal or periapical radiographs were exposed in 89.6% of the 134 cases and a lateral view was used in 25.4%. No panoramic radiographs were exposed.

Previous trauma to each study tooth was assessed clinically, radiographically, and through a history with the supervisory adult. Most (95.7%) of the teeth had no previous trauma, whereas 4.3% of teeth demonstrated some type of previous trauma.

TABLE 7. TREATMENT OF SUBLUXATED TEETH

<i>Treatment</i>	<i>Number (%) of Teeth</i>	
None	166	(80.2)
Extract	19	(9.2)
Splint	16	(7.7)
Relieve occlusion	2	(1.0)
Relieve and splint	4	(1.9)
Total	207	(100.0)

TABLE 8. NUMBER OF TEETH EXAMINED DURING EACH FOLLOW-UP RANGE THAT EXHIBITED SIGNS AND SYMPTOMS FOLLOWING SUBLUXATION

<i>Follow-up Category</i>	<i>Follow-up Range (Days Post-Trauma)</i>					
	0-10	11-30	31-91	92-183	184-365	366-730
Total (N)	20	42	38	19	22	22
Patient discomfort	1/20	2/42	0/38	3/19	2/22	2/20
Occlusal interference	0/20	0/42	0/38	0/19	0/22	0/20
Discoloration	4/16	12/38	9/33	4/17	4/13	11/16
Fistula	0/19	0/40	0/38	1/19	0/21	0/20
Percussion						
Sensitivity	2/9	0/24	1/18	1/10	0/10	0/8
Sound	1/9	0/22	0/16	0/9	0/6	0/6
Mobility						
Ankylosis	0/15	0/33	0/35	1/17	0/11	0/11
Normal	2/15	16/33	28/35	14/17	8/11	6/11
Increased	13/15	17/33	7/35	2/17	3/11	5/11
Periapical radiolucency	3/14	0/20	0/25	2/11	2/18	3/18
Periodontal ligament space						
Decreased	0/14	2/19	0/22	1/11	0/17	1/16
Normal	9/14	15/19	19/22	9/11	16/17	15/16
Increased	5/14	2/19	3/22	1/11	1/17	0/16
Internal/external resorption	1/14	0/19	5/25	1/11	6/14	7/16
Pulp calcification	0/14	4/20	3/25	0/10	6/13	11/15
Abnormal physiologic resorption	1/11	0/6	1/11	0/6	0/9	0/11
Received treatment	3/20	10/42	4/37	4/19	0/22	2/22
Antibiotics prescribed	3/14	1/24	0/26	0/13	0/12	0/14

Crown fractures were noted on 5.8% of the study teeth, two cases of Ellis Class I and seven cases of Ellis Class II fractures. Root fractures were identified in 5.8% of study teeth.

One hundred and twenty-nine patients were assessed for an alveolar bony fracture. We found that 91.5% of patients sustained no bony fractures. Fracture was noted in 7.8% of cases, and a segment of alveolar bone was lost in one patient.

An assessment of tooth mobility in 192 teeth measured in the labial-palatal dimension demonstrated that 64.1% had mobility ranging from 0.6 to 1.5 mm, 23.4% from 1.6 to 2.5 mm, 9.9% from 2.6 to 3.5 mm, and 2.6% presented with a mobility greater than 3.6 mm.

Dental treatment varied from no treatment (80.2%) to extraction (9.2%) (Table 7), with 41.8% of patients receiving antibiotics at the time of examination.

Table 8 presents the number of teeth exhibiting signs and symptoms in each follow-up interval. The sample size varied within each category and range. Data related to vitality testing will not be reported because of the small number of teeth actually tested.

Patient discomfort was not a common complaint at follow-up examinations. No teeth demonstrated any signs of occlusal interference in any follow-up time interval. Observations of discoloration, however, tended to increase over time. There appeared to be some improvement in the amount of mobility, and a return of the periodontal ligament space to a normal width over time. Periapical radiolucencies were not common, while pulpal calcification increased with time.

Discussion

The significance of our study is that, as previously mentioned, trauma to the maxillary primary anterior dentition is very common. With increased knowledge of possible sequelae to traumatized teeth, dentists can better understand how to treat these teeth and how to deal with potential complications. It is only through clinical and radiographic evaluations that these findings can be ascertained.

This retrospective study examined many factors regarding trauma to the primary maxillary anterior dentition. The Montreal Children's Hospital serves a racially heterogeneous group of children of predominantly urban, lower and

middle socioeconomic circumstances. We found that central incisors were involved 66.2% of the time, which coincides with Zadik's¹¹ findings. Galea³ and Ferguson and Ripa⁹ found the central incisors to be traumatized 71 and 74% of the time, respectively. Galea³ found trauma to the lateral incisors one-third as often, whereas, in our study group, the central incisors were affected twice as often as the lateral incisors.

The mean age of study patients sustaining subluxations was 3.5 years (males 3.9 and females 2.9 years). Other studies,^{3, 4, 12} looking at total traumatic injuries found differing age ranges. Andreasen and Ravn¹³ found that the highest number of injuries occurred at 2 to 4 years in males and in girls between 2 and 3 years of age. Garcia-Godoy et al.⁴ found that males between 1 and 2 and females between 1 and 2 and between 3 and 4 showed the most trauma cases. Ferguson and Ripa⁹ found that both males and females showed the highest number of cases between the ages of 4 to 5 years. The difference may be that this study examined only subluxation injuries, while other studies examined trauma in general.

The ratio of affected males to females sustaining subluxations was approximately 1.5:1, significantly different from 1:1. This ratio was slightly lower than that found by Soporowski et al.¹⁴ (1.7:1) in their study of primary luxation injuries. It was also less than the 1.8:1 ratio of found by Garcia-Godoy et al.,⁴ who studied all types of injuries.

The etiology of traumatic injuries in our study group consisted mainly of simple falls indoors (52%), followed by falls outside (15.7%), and falls on stairs at (9%). Bicycle injuries (5.2%), sports injuries (4.4%), and blows while playing (5.2%) showed a relatively low incidence. These figures were consistent with other studies.^{4, 6} The high incidence of traumatic falls is consistent with the developing motor coordination of the age of the study population.

Subluxations are often not the only tooth injury sustained during a particular accident. In our study population, 19.4% of patients sustained tooth avulsions, 41.8% sustained luxations, 3.7% sustained concussions, and 2.9% sustained isolated fractures to anterior teeth. Of the whole study population, 58.2% patients sustained an avulsion and/or luxation along with subluxations. Tooth fracture also can occur with subluxation, however, this was relatively uncommon. Crown fractures and root fractures were each noted to occur at an incidence of 5.8%. All cases of crown fracture showed minor severity, not being greater than an Ellis Class II fracture. The infrequency of fractures associated with subluxated teeth is probably due to the relative plasticity of bone in young children, which sustains the brunt of the impact.³

The most common radiograph exposed was the occlusal or periapical view (89.6%), which allows the dentist to assess tooth or root fractures, tooth displacement, or widening of the periodontal ligament space. The lat-

eral view also can be used to assess the condition of the permanent tooth bud, as well as the displacement or fracture of the traumatized tooth. A lateral radiographic view was exposed in 25.4% of patients — more commonly when there was an associated tooth avulsion or luxation, or suspected anterior nasal spine fracture. Panoramic radiographs were not used for any study patients possibly because the diagnostic value of a panoramic radiograph in assessing anterior tooth trauma is minimal and young children often can not remain still for the procedure.

The treatment of subluxated teeth varies. In this study, 80.2% of teeth required no dental treatment. Splinting of teeth, with or without relief of occlusion, was performed in 9.6% of cases and extractions were performed on 9.2% of the teeth. Many of the study teeth (64.1%) had minor mobility ranging from 0.6 to 1.5 mm, which did not warrant the time and patient management necessary for placing a splint. Even teeth with a slightly greater mobility of 1.6 to 2.5 mm may not have warranted such treatment. A certain number of these teeth (38.0%) had already begun physiologic root resorption, which may have influenced the decision to extract. The treatment choice may also have been influenced by the trauma sustained by neighboring teeth or the occurrence of a root fracture to the study teeth. For instance, if a splint was placed to immobilize a luxated tooth, the dentist included the subluxated tooth in the splint.

Antibiotics are administered in cases where a potential for systemic infection is considered possible; in this study antibiotics were administered in 41.8% of patients. Since 58.2% of the study population had an associated avulsion and/or luxation injury to the neighboring teeth, this figure is not unnecessarily high. With an associated avulsion or luxation, there is an increased likelihood that the gingival integument was lacerated and hence an increased risk of systemic infection. There were no written guidelines to determine whether antibiotics should be prescribed, and the decision was left solely to the practitioner upon clinical evaluation of the patient.

Another purpose of this retrospective study was also to present prognostic information regarding maxillary anterior primary teeth that sustained subluxation injuries. As a retrospective study, the information gathered is second hand from patient records, and because the events already occurred, it is impossible to control for past problems. As such, variability may exist because information was gathered by various residents and dentists. This led to a certain amount of interexaminer variability. To control for this variability, standardized forms were used. Furthermore, certain diagnostic information is subjective and may also present inter- and intraexaminer differences. However, as mentioned previously, residents and dentists were instructed by one author (S.S.) as to diagnostic criteria and methods of evaluation prior to completing the forms.

It should be acknowledged that the number of teeth studied in certain categories of follow-up periods was somewhat low. There are two main reasons for low patient return. First, when no further observable problems are noted by the parents or expressed by the child, many parents fail to return for follow-up examinations. Second, because many patients are referred to the Children's Hospital for after-hour emergencies, they may return to their private dentist for future care. Importantly, this low patient return may be an indication of the low morbidity associated with subluxation injuries. Even so, significant clinical information and trends can still be observed from the data collected.

Discoloration has been reported as frequently following primary tooth trauma.¹⁵ The results of our study suggested an increase in the amount of tooth discoloration over time. Many other studies have examined the discoloration of teeth.¹⁵⁻¹⁹ Discoloration can range from yellow or pink to grey or black.¹⁶ The yellowish hue is thought to be due to partial pulp canal obliteration. The pink hue may be due to blood pigments entering the dentinal tubules at the time of trauma. The grey or black discoloration of a tooth is generally thought to be due to pulpal death.¹⁵⁻¹⁷ There are differing opinions as to the treatment of discolored teeth. Several authors suggest that grey and/or black teeth are a source of infection and should be extracted.¹⁵⁻¹⁸ Other authors have found that 44 of 58 grey teeth eventually turned yellow, indicating pulp canal obliteration.¹⁸ However, discoloration of the primary teeth has also been shown to be associated with various irreversible pulp changes.¹⁵ Periapical osteitis was found in 82% of grey teeth within 1 month of trauma.^{2,17} Because of these differing opinions, tooth discoloration should be used as an adjunct in diagnosis, but not as the sole criterion in determining the need for extraction. Indeed, Sonis reported that 72% of discolored primary teeth failed to develop any radiographic and/or clinical evidence of pathology.¹⁹

Pulpal calcification has been described as a pathologic process in which a tooth lays down tertiary dentin in order to attempt to heal the damage caused by an insult. It has been termed by some as nature's way of dealing with trauma.^{16,20,21} Our study demonstrated that as time progressed, the incidence and severity of pulpal calcification increased. This result was similar to that reported previously. Ravn⁷ reported that of 62 loosened teeth, 25 (40.3%) demonstrated obliteration of the pulp. Jacobsen and Sagnes¹⁸ also reported pulpal calcification, but concluded that the prognosis following pulp obliteration was favorable and that normal root resorption usually occurred.

Whereas internal and external resorption and pulp calcification occurred as a way for the body to cope with the healing process, it is interesting to note that physiologic root resorption generally occurred at a normal rate.

While this study investigated the sequelae and prognosis of subluxation injuries to primary teeth, it did not

investigate the effects of this trauma on the succedaneous tooth. Other investigators, however, have reported their impressions. Von Arx²² reported that 19% of subluxated teeth resulted in some form of developmental disturbance of permanent successors. Ravn⁷ further reported that loosened primary teeth rarely had any effect on the permanent successor, and in the few cases when it did, the injury was not serious.

Conclusions

1. The highest incidence of trauma occurred in males between 3 and 4 and females between 1 and 3 years of age. It most commonly affected the central incisors and was typically the result of falls.
2. More than half the patients were seen within 3 hr of trauma.
3. The majority of teeth had a mobility ranging between 1.6 and 2.5 mm following trauma, but they could have a mobility up to and greater than 3.6 mm.
4. Treatment included relief of occlusion, splinting, and extraction, but most teeth received no treatment.
5. Tooth discoloration tended to increase with time.
6. Mobility improved in time, with the majority of teeth returning to a normal physiological range.
7. Pulpal calcification increased in incidence and severity with time.
8. Low patient return was noted on follow up, indicating the low morbidity of subluxation injuries.

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