Pattern of Root Resorption in Luxation Injuries in
Permanent Incisors Presented to Restorative Unit, Institute of Oral Health, Maharagama – Sri Lanka

Andarawewa KRBSK, Goonathilake A and Denagama HAU
Institute of Oral Health, Sri Lanka

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Abstract
The aim of this descriptive study was to evaluate the association between root resorption and each type of luxation injury, the effect of timely treatment, age of the patient at presentation and maturity of maxillary anterior teeth presented with luxation injuries.

A cross sectional descriptive study was carried out on 132 patients aged 6 to 50 years old with luxation injuries occurred to 213 teeth and were followed up for 24 months. Data were collected on the age, sex, the tooth/teeth involved, type of trauma, date of occurrence of trauma and date of presentation for treatment. Radiographically teeth were assessed for the presence/absence of resorption and type of resorption (External inflammatory, external replacement and Internal inflammatory) at review appointments. Data analysis was done using the SPSS version- 24 and non-parametric tests were used assess associations. Amongst all types of luxation injuries, most frequently presented type was subluxation (40.8%) injuries followed by concussion (25.4%), Intrusive and palatal luxation (15.5% each) and extrusive luxation (2.8%) respectively.

Further, 51 of 213 teeth (23.9%) showed root resorption after luxation injury. The most frequently observed resorption was external inflammatory resorption in 44 teeth (20.7%) followed by external replacement resorption in 6 teeth (2.8%) and internal inflammatory resorption in 1 tooth (0.5%). Out of 43 late presenters 77% (34) showed root resorption, while only 10% (17) of immediate presenters showed resorption of root. The results indicated that there is a statistically significant difference in occurrence of root resorption and the late presentation for treatment (X²=91.63, df=3, p=0.000), as well as with the type of injury (X²=35.9, df=12, p=0.000). Furthermore, there was a statistically significant difference between the age of the patient and the type of luxation injury (X²=54.29, df=12, p=0.000).

Introduction
Trauma to the oral region occurs frequently and comprises 5% of all injuries for which people seek treatment. Amongst all facial injuries, dental injuries are the most common, of which crown fractures and luxations occur most frequently. Luxation dental injuries are the injuries to dental supporting tissues (periodontium) and they are five in type comprising concussion, subluxation, lateral luxation, extrusion and intrusion [1]. Root resorption is a complication of maximum concern occurred following luxation injuries to the teeth [2].

In the tooth structure dentine is lined internally by the odontoblastic layer and predentine and externally from the periodontium by the cementoblastic layer and preemento-mentum. These two layers act as a barrier for resorption by preventing odontoclasts (similar to os-teoclasts) from adhering to unmineralized matrix. Major mediators of osteoclast binding are arginine-glycine-aspartate (RGD) peptides that are bound to calcium salt crystals on mineralized surfaces [3]. Since these peptides are not present on organic preemento-mentum and predentine, even in the presence of inflammation, an intact root is resistant to resorption [4].

Corresponding author: Andarawewa KRBSK, Institute of Oral Health, Sri Lanka, E-mail: emanthiand@yahoo.com

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However, when tooth sustains a luxation injury, attachment damage of varying degrees will occur. In addition necrosis of the pulp might result, thereby making the pulp susceptible to infection [2] and thus root resorption due to both of these reasons.

The root resorption process may be self-limiting and go undetected clinically; however, once initiated and with the initial injury and stimulus sustained, destruction of hard dental tissue will continue, and tooth tissue loss may occur.

There are many classifications and terms for different types of root resorption. The classification system proposed by Andreasen is widely acknowledged [5,6]. In this classification resorption is broadly classified into internal, external and combined lesions. External and internal resorptions further classified in to surface, inflammatory, and replacement resorptions where surface resorption is transient [5,7]. When the injury is localized (e.g., after concussion or subluxation), mechanical damage to the cementum occurs, which results in a local inflammatory response and a localized area of root resorption. If no further inflammatory stimulus is present, periodontal healing and root surface repair will occur within 14 days [8].

However, in a minority of cases, small radiolucencies can be seen on the root surface if the radiograph is taken at a specific angle. It is important not to misinterpret these cases as progressive in nature. Failure to isolate an inflammatory stimulus (e.g., a necrotic infected pulp space) is a clue that no treatment should be performed. A “wait and see” approach should be executed in this type of cases.

Treatment for luxation injuries are of a great significant since incorrect and inadequate treatment may lead to greater risk of complications like root resorption, pulpal obliteration, pulp necrosis, and interruption in root formation in immature teeth [9].

Treatment strategies for root resorption include preventing it by recognizing the causes of the root surface injury and avoiding them; minimizing initial inflammation and thus the resorative consequences by manipulating the inflammatory response; and reversing resorption by eliminating the inflammatory stimulator [10-12].

This study was aimed to evaluate the frequency of development of root resorption in cases of dental trauma involving supporting tissue, considering factors such as the type of injury, the patient’s age, tooth’s maturity and the period between dental injury and initial examination.

Materials and Methods

Approval for this descriptive study was granted by the ethical review committee of Faculty of Medicine, University of Colombo, Sri Lanka. Administrative clearance to carry out the study was obtained from relevant authorities at IOH Maharagama.

Patients aged between 6 to 50 years who were presented to Restorative Unit, Institute of Oral Health Maharagama, Sri Lanka from year 2015 – 2017 with luxation injuries to maxillary anterior teeth were included in this study according to systematic sampling technique and followed up until the end of 2019. Patients with traumatic injuries involving root fractures, alveolar bone fractures, who have undergone orthodontic treatment, bleeding for same teeth, endodontic treatment and teeth with previous history of crown fractures were excluded from this study.

An information sheet explaining the study was provided to the patient/parent prior to enroll in the study and written informed consent/assent was obtained from the patients/primary care givers. Confidentiality of all the information was ensured.

Data were collected by interviewer administered questionnaire, detailed clinical history with objective clinical examination and photographic and radiological investigations. Collection of data was focused on the information about the following factors: gender; patient age at the time of injury; the teeth that had been injured; the type of dental injury; whether the tooth/teeth are matured or not; and the period between dental injury and initial examination. Digital x-rays [13] were used to assess the teeth at periodic intervals according to the International Association of Dental Traumatology (IADT) guidelines [10]. The radiographs were analyzed by two qualified authors including the supervising consultant in restorative dentistry under optimal conditions, using an x-ray illuminator and a magnifying glass which is large enough to allow binocular observation. The following aspects were examined in radiographs, presence of total or partial absence of the lamina dura; presence of increased periodontal ligament space; presence of pathologic root resorption, including external inflammatory root resorption, internal inflammatory root resorption and external replacement resorption.

Treatment was carried out according to the guidelines of the IADT. Patients were reviewed in 2 weeks, 1 month, 2 months, 6 months, 1 year, and 1½ year intervals.

Data were analyzed statistically using SPSS (Version-24) to identify any relationship of root resorption with other variables: patient’s age, type of luxation injury, maturity of teeth and time duration between trauma and treatment. Cross-tabulations with chi-squared was performed to examine the relationships between the evaluated parameters [Figure 1].

![Figure 1](image-url)

**Figure 1**: Radiographs and photographs of some patients presented to the clinic. A: Intruded UL2; B: Extruded UL1; C: UL1 with IIR and UL1 with EIR; D: Radiograph of the same patient with ERR on UL1/UR1 and intrude UL2.
Results

The study population consisted of 213 teeth of 132 patients with luxation injuries to maxillary anterior teeth. The age of the patients at the time of presentation varied between 6 and 50 years. According to the data, majority of the population was males (63.4%) which is compatible with the results of previous studies of this type. Out of 213 teeth most frequently luxated tooth was maxillary central incisor which counts for 183 (85.9%) followed by 27 (12.7%) maxillary lateral incisors and 3 (1.4%) canines respectively. Further, there were 156 (73.2%) closed apex teeth and 57 (26.8%) open apex teeth. The most frequently presented type of luxation injury was subluxation (40.8%) injuries followed by concussion (25.4%), intrusive and palatal luxation (15.5%) and extrusive luxation (2.8%) respectively [Figure 2].

![Figure 2: Proportion of the type of luxation injuries among the injured teeth.](image)

Considering the consequence of resorption taking place after luxation injuries, 162 of 213 teeth (76.1%) didn’t show any type of resorption and most frequently observed resorption was external inflammatory resorption in 44 teeth (20.7%) followed by external replacement resorption in 6 teeth (2.8%) and internal inflammatory resorption in 1 tooth (0.5%) [Figure 3].

![Figure 3: Proportion of different types of Resorption observed.](image)

Table 1 shows the association between type of luxation injury and frequency of resorption reported. Out of the 54 patients who have undergone luxation injury, only one patient reported with internal inflammatory resorption (1.85%). This patient presented for treatment more than 12 months after the initial trauma. Intrusive luxation is the most severe luxation injury except for avulsion which shows the highest percentage of resorption (42.42%). There is a statistically significant relationship between the type of luxation injury and the type of resorption (X² = 35.9, df = 12, p = 0.000).

| Type of Luxation Injury | EIR | ERR | IIR | Total | Percentage |
|------------------------|-----|-----|-----|-------|------------|
| Concussion             | 0   | 0   | 1   | 54    | 1.85%      |
| Subluxation            | 19  | 3   | 0   | 87    | 25.88%     |
| Intrusive luxation      | 14  | 0   | 0   | 33    | 42.42%     |
| Extrusive luxation      | 2   | 0   | 0   | 6     | 33.33%     |
| Palatal luxation        | 9   | 3   | 0   | 33    | 36.36%     |
| Total                  | 44  | 6   | 1   | 213   | 100.00%    |

Table 1: Distribution of the Type of Resorption Injury related to the Diagnosis of Luxation (N = 213).

There were 43 (20.2%) late presenters on this study population and 77% of them showed root resorption, while only 10% of immediate presenters reported resorption of root [Table 2]. The results indicated that there is a statistically significant difference in occurrence of root resorption and the late presentation for treatment (X² = 91.63, df = 3, p = 0.000).

| Time of presentation to the hospital for treatment | No resorption or type of resorption | Total | Percentage of resorption |
|---------------------------------------------------|-----------------------------------|-------|--------------------------|
| Immediate presentation                             | No resorption | EIR | ERR | IIR | 170 | 10% |
| Late presentation                                  | No resorption | EIR | ERR | IIR | 43  | 77% |
| Count                                             | No resorption | EIR | ERR | IIR | 213 | 100.00% |

Table 2: The Association between the Presence of Root Resorption related to the Time of Presentation to the Health Facility (N=213).

Table 3 shows the association between the age and resorption of root. The study population was categorized in to 5 age groups. Age groups of <11 and 11-20 years were included 54 patients each which is the highest number included in to one age group and the least number of 29 was included in the age group of 41-50. This indicates that the young age groups more prone to get the traumatic injuries. There is a statistically significant correlation between age and the root resorption. (X² = 54.29, df = 12, P = 0.000). Only one patient each reported with resorption in the age groups of <11 and 41-50 years. These are the age groups which reported the least number of late presentations [Table 4]. The highest number of resorptions were reported in the age group of 11-20 years (50%) followed by 21-30 years (39.58%) and 31-40 years (11.11%).

| Time of presentation to the hospital for treatment | No resorption or type of resorption | Total | Percentage of resorption |
|---------------------------------------------------|-----------------------------------|-------|--------------------------|
| Immediate presentation                             | No resorption | EIR | ERR | IIR | 170 | 10% |
| Late presentation                                  | No resorption | EIR | ERR | IIR | 43  | 77% |
| Count                                             | No resorption | EIR | ERR | IIR | 213 | 100.00% |

Table 3: The Association between the age and resorption of root. The study population was categorized in to 5 age groups. Age groups of <11 and 11-20 years were included 54 patients each which is the highest number included in to one age group and the least number of 29 was included in the age group of 41-50. This indicates that the young age groups more prone to get the traumatic injuries. There is a statistically significant correlation between age and the root resorption. (X² = 54.29, df = 12, P = 0.000). Only one patient each reported with resorption in the age groups of <11 and 41-50 years. These are the age groups which reported the least number of late presentations [Table 4]. The highest number of resorptions were reported in the age group of 11-20 years (50%) followed by 21-30 years (39.58%) and 31-40 years (11.11%).
Table 3: Proportions of the Types of Tooth Resorption related to the Age Category of the Patient (N=213).

| Age at presentation | Type of resorption | Total | Percentage of resorption |
|---------------------|--------------------|-------|--------------------------|
|                     | EIR | ERR | IIR |                   |
| <11 years           | 1   | 0   | 0   | 54  | 1.85% |
| 11-20 years         | 24  | 3   | 0   | 54  | 50.00%
| 21-30 years         | 15  | 3   | 1   | 48  | 39.58%|
| 31-40 years         | 3   | 0   | 2   | 27  | 11.11%|
| 41-50 years         | 1   | 0   | 0   | 30  | 3.33% |
| Total               | 44  | 6   | 1   | 213 |              |

Table 4: The association between time of presentation to the hospital and the age at presentation (N=213).

Considering the maturity of teeth, 156 closed apex teeth and 57 open apex teeth were included in the study. Out of 156 closed apex teeth 44 showed resorption of root which counts as 28.21%. On the other hand, out of 57 open apex teeth only seven showed root resorption which is 12.28% as a percentage. Therefore, according to this study, there is no statistically significant difference (P>0.005) in the maturity of teeth and the presence of tooth resorption [Table 5].

Table 5: Distribution of the Status of Tooth Resorption related to the Maturity of the Tooth (N=213).

Discussion

This present study acquired the detailed information about the development of root resorption in cases of trauma to supporting tissues of the maxillary anterior teeth. Some basic observations in the present study are in accordance with the data in the literature such as males (63.4%) are involved in accidental injuries more often than females (36.6%), the maxillary central incisors (85.9%) are most susceptible to get traumatic injuries [1,14].

The results revealed that, the frequency of root resorption in luxated teeth is 23.9% which is closely related with the study done by Majorana et al. [2]. The results revealed that 86.2% of the pathological resorption was represented by EIR and was present more frequently in cases of intrusive luxation. These results are consistent with previous finding of the studies [15-18] performed across the world.

Most of the studies conducted previously, included only severe luxation injuries such as avulsion, intrusive luxation, lateral luxation and palatal luxations into their studies in contrast to the present study where minor luxation injuries such as concussion and subluxation injuries also taken in to consideration. However, in present study, teeth with avulsion were excluded. Author’s opinion in this regard is, it is worth including minor types of luxation injuries, as in this study teeth with concussion and subluxation injuries also presented with root resorption. The single tooth which exhibited internal inflammatory resorption as a consequence of concussion injury was due to late presentation of >12 months. This exhibits the importance of timely presentation to the treatment.

The frequency of external inflammatory root resorption (EIR) observed in cases of intrusive, extrusive and palatal luxation contradicts the findings of Adriana et al. [19]. They observed EIR in 92.8% of intrusion, 80.2% of lateral luxation and 77.7% of extrusive luxation teeth. In the present study these findings were far more less than the above values (42.42% for intrusion, 36.36% for extrusive luxation and 33.33% for palatal luxation) which are consistent with the study of Hecova et al. [18], who found that it occurred in 33.3% of intruded teeth and 14.5% of laterally luteded teeth.

Previous studies have reported that internal inflammatory resorption rarely occurs in the most severe cases of luxation [19-21], and this was also found in the present study where the only internal inflammatory resorption was found in a tooth with concussion (Late presentation) which is a minor luxation injury. This can be explained by, the odontoclasts get the nutrients from the vital pulp to progress the internal inflammatory resorption, and one of the most common sequelae in severe trauma is pulp necrosis [18,22,23].

Another significant factor related to the development of root resorption is patient’s age [16,22]. Root resorption is more frequent in patients with immature teeth (Open apex), and its incidence also increases in proportion to the time elapsed between the date of trauma and initial examination [19]. The latter parameter was significantly related to the root resorption in the present study, where the highest percentage of root resorption presented in the age group of 21-30 years consists of highest percentage of late presentation for the treatment. This finding is consistent with the previous study carried out by Adriana et al. [19]. However, in the present study, there was no statistically significant association between maturity of teeth and the occurrence of root resorption.

The present study examined the importance of early diagnosis of root resorption in relation to the time of presentation to the hospital for treatment following a luxation injury. There was a significant relationship between the root resorption and the time of presentation for treatment in this study, (X2 =91.63, df= 3, p=0.000) where some other recently conducted studies showed the results compatible with this finding [15,19].

Early diagnosis of luxation injuries improve the prognosis and provides a lifeline for the tooth. Therefore, it should
be emphasized that, timely presentation to the treatment following a luxation injury is immensely important in preventing the root resorption and better prognosis of luxated teeth.

The present study analyzed the frequency of RR in maxillary anterior teeth following luxation injuries related to the age of the patient at presentation for treatment, type of luxation injury, time of presentation for the treatment following the luxation injury and amount of maturity of teeth at the time of presentation. Only the last variable didn’t show statistically significant difference in relation to the RR while all the other parameters showed the same.

Therefore, it can be concluded that frequency of root resorption after luxation injuries depends on the type of luxation injury sustained and the time of presentation to the treatment. Even though there is a statistically significant correlation in presentation of RR and the age of the patient, this can be explained in terms of sampling, as the least number of resorptions were observed in the groups with the least number of late presenters. Further, it is worth to carry out further research on maturity of teeth related to RR as in this study sample is small and cannot display the expected results.

Since the previous studies [19] as well as the present study revealed that, the type of luxation injury plays a major role in deciding the type and the frequency of RR that occurs, it can be the major factor that governs the RR. Apart from that, RR in minor luxation injuries such as concussion and subluxation injuries can be prevented if patients presented to the hospital without a delay. On the other hand root resorption cannot be prevented in severe luxation injuries such as intrusion, palatal luxation and extrusion injuries even the patient presented to the hospital without a delay. Thus, regular reviews are necessary for an early detection of complications.

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