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PREVALENCE OF HYPOPLASTIC DEFECTS AND THEIR ASSOCIATION WITH LUXATION INJURIES IN PRIMARY ANTERIOR TEETH AMONG PEDIATRIC PATIENTS: A RETROSPECTIVE STUD

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ABSTRACT

This study aims to evaluate the relationship between luxation injuries in primary anterior teeth and hypoplastic defects in permanent successors in pediatric patients attending a dental clinic in Saudi Arabia over a period of 4 years (January 2020 – December 2023). The study included 222 children (97 males, 125 females) aged 0–6 years with 623 injured primary anterior teeth, selected based on strict inclusion criteria, such as no systemic diseases or medications affecting dental health and regular follow-up visits. Data were collected from patient records and radiographic evaluations, focusing on injury types (subluxation, intrusion, extrusion, lateral luxation, avulsion) in primary teeth and developmental disturbances in permanent successors like enamel hypoplasia, crown dilaceration, and root malformation. Hypoplasia was the most common defect, observed in 52.64% of cases, followed by aplasia (32.78%), crown dilaceration (28.25%), and root malformation (19.11%). Linear enamel defects (34.15%) and enamel discoloration (27.13%) were prevalent among hypoplastic cases. The study found a significant age-related pattern to primary teeth injuries, where children under 2 years showed higher rates of structural defects like crown dilaceration, while hypoplasia was more frequent in older age groups (2–6 years). However, no statistically significant association was found between specific luxation injury types and hypoplastic defects (p=0.289). Early intervention of primary tooth trauma is critical because of the long-term developmental consequences in permanent teeth as these findings illustrate the importance of maintaining vigilant monitoring, early intervention, and targeted preventive strategies in younger children.

KEYWORDS: Extrusions; Intrusions; Tooth Luxation; Hypoplasia.

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INTRODUCTION

Traumatic dental injuries (TDIs) can make up as much as 17% of all injuries sustained by children between the ages of 0 and 6 (Lembacher et al. 2022). These injuries, which are frequently brought on by sports, falls, or accidents, present a serious public health concern because they may interfere with the formation of permanent teeth. TDIs to primary teeth can lead to various developmental defects in their permanent successors, including enamel hypoplasia, crown dilaceration, and root malformation (Caeiro-Villasenín et al., 2022; Gibbison & Crozier, 2022). Among these, enamel hypoplasia, characterized by thinning, pitting, or loss of enamel, is the most frequently observed sequela, with prevalence rates ranging from 4.5% to 68.8% across studies (Caeiro-Villasenín et al., 2022). Luxation injuries, which include subluxation, extrusion, avulsion, concussion, lateral luxation, and intrusion, are particularly common in primary teeth, accounting for 21% to 81% of all TDIs due to the resilient nature of young children's alveolar bone (Diab & ElBadrawy, 2000; Spinas et al., 2020; Spinas et al., 2021).

There is a large void in the research despite the high occurrence of TDIs and the possibility of long-term consequences. While previous studies have explored the general consequences of TDIs on permanent teeth, none have specifically examined the prognosis of a large sample of luxation injuries to primary anterior teeth and their association with hypoplastic defects in permanent successors (Patnana et al., 2021; Lenzi et al., 2019). This gap is critical because hypoplastic defects can lead to aesthetic concerns, increased caries susceptibility, and challenges in both primary and permanent dentitions (Masri et al., 2021; Casaña-Ruiz et al., 2023). The close anatomical proximity between the apices of primary teeth and the developing permanent tooth buds heightens the risk of such complications, particularly in young children aged 2 to 3 years, who are prone to injuries due to immature motor coordination (Lauridsen et al., 2017; Costa et al., 2023).

Enamel hypoplasia results from defective enamel matrix formation, leading to quantitative issues like thinning or pitting, while hypomineralisation, a qualitative defect, causes changes in enamel colour and translucency (Olczak-Kowalczyk et al., 2023). These defects, whether localized due to trauma or generalized due to systemic factors, give significant challenges in pediatric dentistry, necessitating both conservative and invasive treatment approaches depending on severity (Meyer-Lueckel & Paris, 2008; de Camargo & Natera, 2020). The purpose of this study is to fill the gap by identifying the relation between different kinds of luxation injuries in primary teeth in children and hypoplastic abnormalities in the jaw. By analyzing a large sample, this study provides insights into the prevalence of hypoplastic defects following different luxation injuries, such as intrusion, which is often associated with the highest incidence of sequelae (Caeiro-Villasenín et al., 2022). This study also explores the influence of age at the time of injury, as younger children are known to be at higher risk for severe permanent tooth disturbances (Bardellini et al., 2017; Gibbison & Crozier, 2022). Furthermore, this study will discuss the clinical implications for pediatric dental care, emphasizing the importance of early intervention, monitoring, and structured educational programs to mitigate the consequences of TDIs. this study seeks to contribute to the field of pediatric dentistry and maxillofacial research, supporting the development of effective preventive and treatment strategies to enhance the quality of life for young patients (Richardson et al., 2016; Rao et al., 2013; Chacko et al., 2014).

Research Question: What is the association between hypoplastic defects in the maxillary jaw and luxation injuries in primary anterior teeth in the pediatric population?

MATERIALS AND METHODS

A retrospective study was conducted to examine primary anterior teeth that sustained luxation injuries at a pediatric dental clinic in Saudi Arabia. Clinical data of Saudi and non-Saudi children were collected during the period January 2020 to December 2023. The process began by first searching for all records of children with luxation injuries, followed by an investigation into the possible post-traumatic sequelae. This included details about the type of dental injuries, treatment approaches, and post-traumatic sequelae. Data were gathered from the records of patient history and radiographic evaluations performed by expert dental professionals to diagnose developmental disturbances in permanent successor teeth.

Sample size calculation was done in accordance with calculations of power analysis with G*Power version 3.1.9.7. (Heinrich Heine University HHU). Developmental disturbances of permanent successor teeth after luxation injuries of primary anterior teeth represented the main outcome variable. Assuming a medium effect size (0.50) with a power of 80% and an alpha level of 5% was used for sample size estimation. According to these parameters, the minimum sample size was estimated to be 220 children. However, after implementing the inclusion and exclusion criteria, 222 children were included in the study.

The inclusion criteria of the study were as; children from birth until 6 years at the time of injury, anterior primary tooth injuries in the maxillary jaw, and no history of systemic disease or use of medication that may influence dental or bone health, such as systemic corticosteroids, immunosuppressant's, or other medications known to affect tooth development or healing. Only the children having records of regular follow-up visits (at least three scheduled post-injury visits over one year) were included in the final analysis. Out of 350 children (1490 injured teeth) treated for anterior primary tooth injuries at Taibah University Hospital, 222 children (97 males, 125 females) with 623 injured primary anterior teeth met the inclusion criteria and were included in the study. 128 children with incomplete medical records, lack of minimum follow-up periods, injuries in non-maxillary teeth, pre-existing developmental disturbances, and no post-trauma radiographs were excluded from the study.

All parents of children gave informed consent based on the recommendations of the Declaration of Helsinki. Ethical approval for the research was granted by the Kingdom of Saudi Arabia Ministry of Education Taibah University College of Dentistry Research Ethics Committee TUCD-REC with approval number TUCDREC/15092020/SBAHAMAM.

A standardized data collection form was utilized to gather information about the type of injury; treatment approaches; and post-traumatic sequelae. The recording of post-traumatic sequelae includes hypoplasia; crown dilacerations; and root malformation among secondary successors. Apart from this; data related to gender; date of birth; accident etiology; molar classification; overjet at the time of injury; and overbite among the affected children were also collected. All the clinical diagnosis results present in the medical records of pediatric patients were obtained. Moreover; radiographs of traumatized teeth were reviewed by expert dental professionals. The questionable diagnosis was removed from the study because not all sustained injuries need a post-trauma radiograph. The categorization of luxation injuries was performed as follows;

- Intrusions – apical displacement into the socket
- Extrusions – incisal displacement out of the socket
- Lateral luxation – displacement in distal; palatal; mesial; or labial direction
- Avulsion – tooth displace entirely from the socket

The data was entered in Microsoft Excel and then coded. Further; the data was entered and analyzed using Statistical Package of Social Sciences (SPSS) version 22. Initially, frequency distribution was

estimated. Secondly, the Kruskal Wallis test was applied to analyze the ranked data and compare the ranked values within each category. The use of the test allows for the assessment of differences between groups (e.g., injury types) in terms of their relative ranks, even when the underlying data is categorical. The significance level was set at $p<0.05$.

RESULTS

This Study includes 56.3% females and 43.7% males, as illustrated in Figure 1. Figure 2 illustrates the age distribution of patients at the time of injury. Most of the participants were under the age of 2 years (54.22%), followed by 28.82% of participants who were between the ages of 2 to 4 years, and 16.66% of participants were between the ages of 4-6 years.

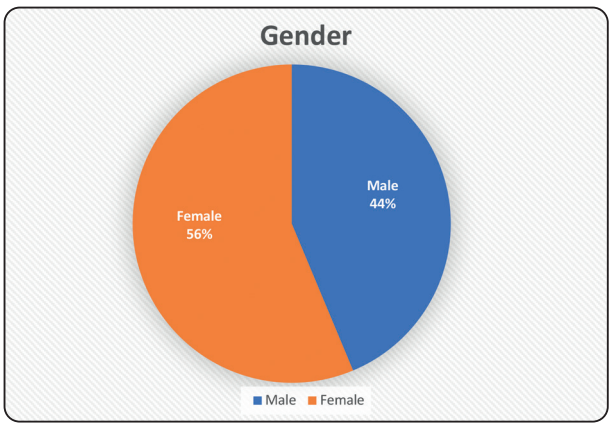

Fig. (1). Gender Distribution

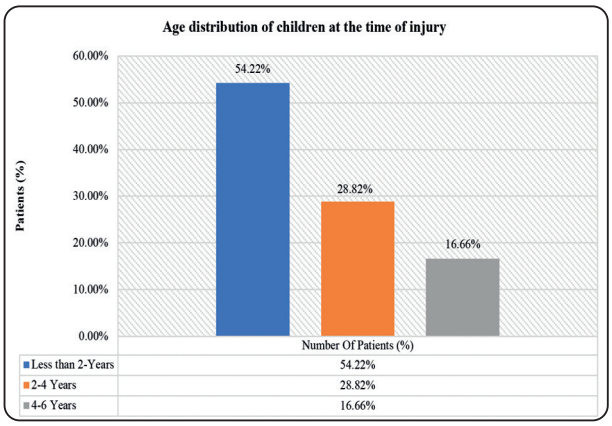

Fig. (2). Age distribution of children at the time of injury.

Figure 3 presents the frequency distribution of injuries in the maxillary arch, revealing that the majority of injuries 86.6%, affected the central incisors, with the remaining 13.4% affecting the lateral incisors. Figure 4 illustrates the percentage distribution of various trauma types in primary dentition. Subluxation was the most common type, occurring in 32.43% of cases, followed by intrusive luxation at 29.27%, avulsion at 19.81%, and lateral luxation at 14.41%. Extrusive luxation was noted in only 2.25% of cases.

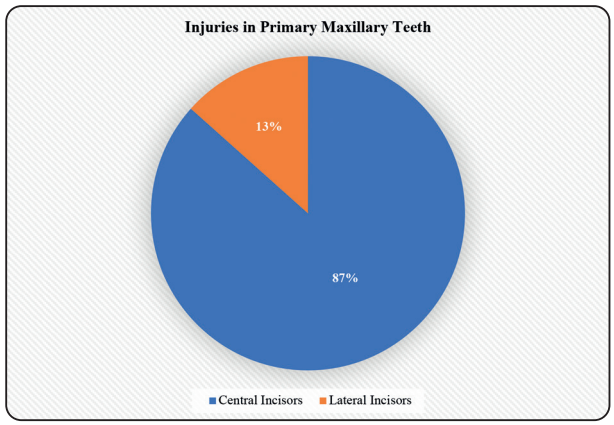

Fig. (3). Frequency Distribution of Injuries in Primary Maxillary Teeth

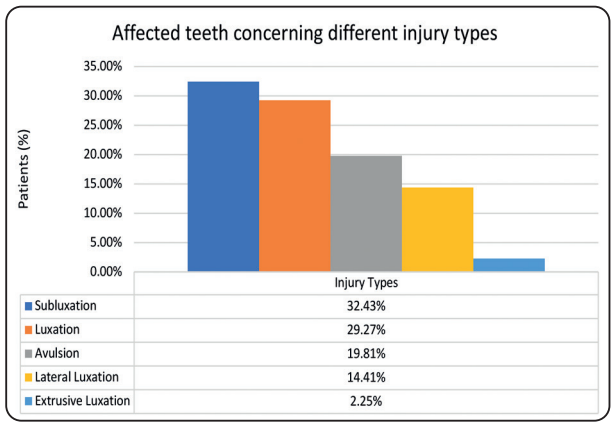

Fig. (4). Affected teeth concerning different injury types

The general dental disturbances affecting permanent successors in the study population are displayed in Table 1. The most frequently observed disturbance was hypoplasia, found in 328 cases (52.64%),

followed by aplasia in 207 cases (32.78%). Additionally, there were 176 cases (28.25%) of crown dilacerations, and 119 cases (19.11%) of root malformations. A more detailed classification of hypoplastic and discoloration defects among the 328 cases of hypoplasia is presented in Table 2. The most common defects were linear enamel defects, encountered in 112 cases (34.15%). Enamel discoloration was observed in 89 cases (27.13%), and pits and grooves were noted in 96 cases (29.27%). In 31 cases (9.45%), a combination of enamel defects and discoloration was present.

TABLE (1). Distribution of Dental Disturbances and Types of Hypoplastic and Enamel Discoloration Defects (n = 623)

General Disturbances	**n (%)**
Hypoplasia	328 (52.64%)
Crown dilacerations	176 (28.25%)
Root malformation	119 (19.11%)

TABLE (2). Types of Hypoplastic and Discoloration Defects

Types of Hypoplastic and Discoloration Defects *(within the 328 hypoplasia cases)*	n (%)
Linear enamel defects	112 (34.15%)
Pits and grooves	96 (29.27%)
Enamel discoloration only	89 (27.13%)
Combined enamel defects and discoloration	31 (9.45%)

Figure 5 displays the distribution of the dental developmental defects affecting permanent successors (hypoplasia, crown dilacerations, root malformations) across three age groups (< 2 years, 2–5 years, and 4–6 years) that sustained injury to primary teeth. Overall, the most frequent defect was hypoplasia and there was a strong association with injury between ages 2 to 6 years. A total of n = 186 cases were recorded in the 2-4 years age group, 107 cases were observed in the 4–6 years group, and the less than 2 years group recorded n = 25. In contrast, most cases of crown dilacerations (n = 153) involved trauma occurring in the youngest age group (less than 2 years old). There was a sharp decline in frequency in the 2–4 years (n = 17) and 4–6 years (n = 1) age groups. Additionally, 101 patients exhibited root malformations, all of whom were under 2 years of age, these malformations were not observed in the older age groups. Our results imply a predominant age-dependent pattern of developmental defect following traumatic injury, where earlier injuries are more likely to leave subjects with structural deformities like crown dilacerations and root malformations versus later injuries in which enamel hypoplasia is more frequent.

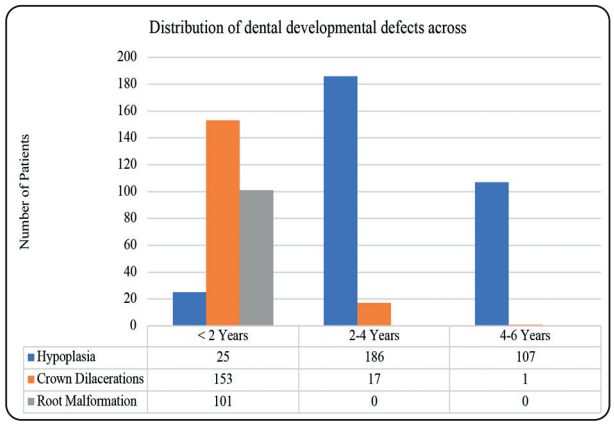

Fig. (5). Distribution of dental developmental defects across

In Table 3, the association of different types of dental injuries in primary teeth with the occurrence of hypoplastic disturbances in their successors is presented using mean rank values which are based on the Kruskal-Wallis H test. Regarding association with the type of injury, although mean ranks varied, the overall association was not statistically significant (p = 0.289). Reductions in hypoplastic disturbances correlated most strongly with subluxation (mean rank = 32.40) and hypoplasia (mean rank = 30.33) while being less strongly correlated to intrusive luxation (mean rank = 37.01) and lateral luxation (mean rank

= 35.55). On the other hand, avulsion (19.97) and extrusive luxation (15.76) ranked lowest, indicating a weaker association. Although the two types of injury are different in these attributes, the lack of statistical significance suggests that injury type alone does not form a strong or consistent effect on the development of hypoplastic disturbances among the studied sample.

TABLE (3). Association between injury type and Hypoplastic Disturbances

Injury Type	Mean Rank	p-value*
Subluxation	32.40	
Intrusive luxation	37.01	
Lateral luxation	35.55	**0.289**
Extrusive luxation	15.76	
Avulsion	19.97	

DISCUSSION

In the current study, the most commonly observed developmental defect in the permanent successors of injured primary teeth was enamel hypoplasia, affecting 52.64% of cases. This was followed by crown dilaceration (28.25%) and root malformation (19.11%). These findings emphasize that trauma to primary teeth is the major cause of enamel defects. Most of the sequelae occurred in the early traumatized cases, particularly in children in the 1-4 year age group, indicating that this age group is more susceptible to tooth germ formation. This overlaps with the biological susceptibility of permanent teeth at the stage of histodifferentiation. However, there was no statistically significant correlation between the type of injury and the presence of enamel hypoplasia ($p = 0.289$). This raises the possibility that the formation of enamel defects is not closely determined by the type of traumatic injury (e.g., concussion, subluxation, luxation, avulsion) but rather by the age at the time of the injury. In many ways, our results align with previous literature findings. According to a systematic review conducted by Caeiro-Villasenin et al. (2022), enamel hypoplasia is the most commonly reported outcome of primary tooth trauma, with a reported prevalence range of 4.5% to 68.8%. Their review showed that 68% of the affected permanent teeth had hypoplastic defects, which is higher than our rate of 52.64%. They also highlighted that enamel problems are more common than pulp damage, which supports our findings.

Crown dilaceration and root malformations occurred less frequently in earlier studies compared to our results. Caeiro-Villasenin et al. (2022) reported 17% and 10% crown dilaceration and root malformation, respectively, whereas our study showed 28.3% and 19.1%, respectively. Enamel hypoplasia is the most common result of dental issues. Bardellini et al. (2017) found similar results in their study of Italian children. These studies indicate that enamel defects and dilacerations are the most common complications following dental trauma. Approximately 25% of the cases examined exhibited enamel hypoplasia. These instances were also associated with additional issues, such as white spots and complications related to tooth eruption. Gibbison and Crozier (2022) and Von Arx (1993) highlighted that the heightened risk of irreversible damage to permanent teeth results from trauma at an earlier age. Notably, Von Arx (1993) emphasized the significant occurrence of developmental disturbances in very young children following intrusive injuries, primarily due to the proximity of primary teeth to the developing permanent successors.

Previous studies indicate that enamel hypoplasia is particularly vulnerable to injury during intrusive and extrusive events (Von Arx, 1993; Bardellini et al., 2017; Gibbison and Crozier, 2022). However, our study found no significant relation between injury type and hypoplastic defects. The discrepancies in findings may stem from differences in study groups, participant numbers, or injury categorization.

For example, Yilmaz et al. (2021) reported that only 14.8% of traumatized teeth exhibited enamel hypoplasia, significantly lower than our results, while Bardellini et al. (2017) found anomalies in 14.5% of analyzed teeth. These differences may result from variations in injury severity, follow-up times, or diagnostic criteria. the retrospective design is limited by potential selection bias and the absence of a control group without dental trauma, hindering causal conclusions regarding trauma's effect on developmental defects. Additionally, the findings in this study were limited to maxillary anterior teeth, which may not accurately reflect the entire range of trauma results in other types of teeth. The absence of a statistically significant correlation between the type of injury and enamel hypoplasia could be attributed to a small sample size or a wide range of diversity in the injury patterns. Additionally, the one-year follow-up duration may not have been adequate for determining all the long-term impacts on permanent successors, as some developmental issues can be detected later in life. Further studies on treatment effectiveness and optimal timing can guide clinical practice. Advanced imaging, like cone-beam computed tomography, enhances diagnostic accuracy for subtle defects.

CONCLUSION

Enamel hypoplasia is the most common developmental defect identified in pediatric patients who sustained injuries to primary anterior teeth, followed by crown dilaceration and root malformation. An age-related pattern was observed: structural defects occurred more often in the younger age groups, and hypoplasia was more prevalent in older age groups. This suggests the need for the early detection and continuous monitoring of primary tooth trauma so that long-term adverse effects on its successors can be prevented. Developmental defects are highly prevalent and targeted preventive strategies are important, especially in younger children who are more vulnerable during developmental stages.

DECLARATIONS

1. **Data Availability:** Data supporting this study is available from the corresponding author upon request.
2. **Conflict of Interest:** No competing interests to declare.
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