

How does orofacial trauma in children affect the developing dentition? Long-term treatment and associated complications

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Abstract

Each year, millions of children are injured and live with the consequences of those injuries. Through infancy and childhood, orofacial trauma caused by falls or being struck by or against objects occurs in children. The long-term implications on the developing permanent teeth are little known, even when the oral region is the second most frequently injured body area in children under 6 years of age. During this period, the developing permanent teeth may be directly involved after trauma, causing mild to severe hypoplasia, displacement, damage to the tooth germ, or an extended range of morphofunctional disturbances. In some cases, the effects of oral and dental injuries caused by trauma appear later with the eruption of the permanent incisors when ectopic eruption, malalignments, and other developmental disturbances become visible. Therefore, long-term follow up of the patient in order to diagnose and treat associated complications becomes essential. Critical points for facing the consequences of orofacial trauma on the developing dentition are to recognize the impact of orofacial trauma in young children and the dentist's role in providing anticipatory guidance to parents and health care professionals, differentiate between mild and severe disturbances affecting the developing permanent teeth after oral injuries in early childhood, recognize the importance of follow-up controls, and recognize the importance of early referral to a pediatric dentist and orthodontist for diagnosis and treatment planning.

KEYWORDS

dental trauma, developing teeth, developmental disturbances, injuries, permanent tooth, primary tooth

1 | INTRODUCTION

The World Report on Child Injury Prevention¹ states that child injuries are a significant public health issue. Children are susceptible to injuries. However, few countries have useful data on child injury, and research is too limited. It notably lacks in low-income and middle-income countries, resulting in a significant gap in knowledge.^{2,3}

Reports from the World Health Organization¹ and the Centers for Disease Control and Prevention⁴ reveal that in children below the age of 4 years, most injuries are caused by falls. However,

information regarding the circumstances, the force of the impact related to both, the severity, and the injured parts of the body are lacking. Moreover, reports and studies are related to fatal injuries, whereas the long-term consequences of nonfatal injuries in children are scarce.²

Through infancy and childhood, children are at risk of severe facial and oral trauma. A recent study from Petti et al⁵ based on the report from the global burden of disease stresses the need for worldwide awareness of the importance of recognizing traumatic dental injuries that may cause disability according to their severity. It is well-known

that traumatic injuries to the primary dentition may affect the developing permanent teeth.⁶ An impact against the primary incisors in children below the age of 2 years may have long-term effects on the crown of the developing permanent tooth.^{6,7} In older children over 4 years of age, severe impacts to the primary teeth and surrounding bone can result in disturbances affecting the root of the developing permanent tooth.⁶ In general, unless there have been severe tooth displacements, children with injuries to the primary dentition are not diagnosed at the time of injury, and their parents are not aware of the potential sequelae to the developing dentition in the long-term. An interesting systematic review states that the type of injury and the child's age at the time of trauma are the most critical factors to determine the presence of developing disturbances.⁸ Intrusion and avulsion are the most common injuries that may disturb the developing dentition, mainly if these injuries affect the primary teeth before the age of 3.⁶ However, most severe sequelae to the developing teeth are recognized during the early mixed dentition stage when the parents seek treatment because of a lack of eruption of the permanent incisors. Because the caregivers do not always remember a traumatic episode at an early age, tooth disturbances reveal a history of trauma that may inflict mild to severe consequences on the permanent dentition. The wide range of sequelae to permanent teeth after trauma demands improving diagnosis for taking appropriate action at the time of treatment planning.⁹ The purpose of this review was to illustrate the severity of injuries to the developing dentition and to discuss treatment for mild and severe disturbances.

2 | OROFACIAL TRAUMA IN CHILDREN

According to epidemiologic studies, oral injuries were the second most frequently injured body area in children under 6 years of age (17%).¹⁰ In a large study, children between 1 and 4 years old accounted for the highest percentage of accidents in all ages (26.3%), sustaining mainly dentoalveolar injury to the primary dentition and soft tissue injuries.¹¹

The literature underestimates the high occurrence of pediatric facial trauma involving soft tissues and dentoalveolar arches. Moreover,

Significance

Long-term complications to the developing permanent incisors are often associated with white or yellow-brown discoloration and hypoplasia after intrusion and avulsion of primary teeth. However, severe disturbances to 1 or several developing permanent teeth may occur in children after orofacial trauma of high impact at an early age. Close monitoring is essential for taking timely action at the expected eruption time of permanent teeth.

the long-term outcome after severe injuries to the face, alveolar bone, and primary teeth is uncertain and unknown.^{2,3,12} There is a need to identify whether most severe injuries are caused by a lack of supervision, especially when children come from lower economic groups.⁴

3 | TRAUMATIC INJURIES TO PRIMARY TEETH, ALVEOLAR BONE, AND SOFT TISSUES

According to the study by Petti et al,⁵ the world population contains about 791 115 600 children aged 1-6 years old, and around 180 million children had sustained at least 1 traumatic injury to their primary teeth. The world prevalence of traumatic dental injuries to primary teeth is 22.7%, ranging from 14.2% in the European region to 26.5% in the region of the Americas and 27% in the Southeast Asia region.

4 | INJURIES TO DEVELOPING PERMANENT TEETH

Initial calcification of the crown of the permanent tooth germ starts at childbirth or during the first 6 months of life. The eruption of the maxillary primary incisors occurs at 6-10 months old, and then the primary immature root takes up to 12-14 months to reach its length

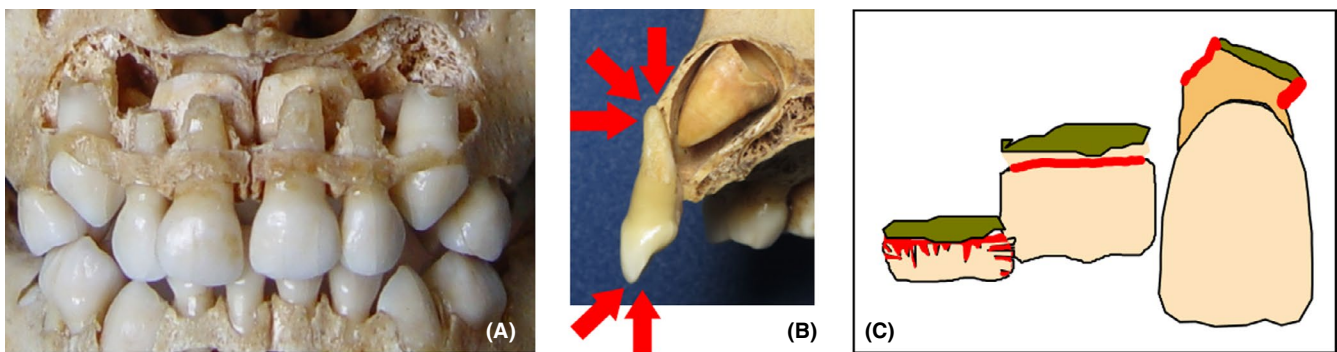


FIGURE 1 The correlation between the stage of crown formation, the force of impact, and the type of injury. A, An 18-month-old skull shows the close relationship between the apex of primary incisors and the developing permanent teeth. B, A lateral view at 4 y. C, The location of developmental disturbance is age related to the stage of tooth calcification: 1, 3, and 5 y

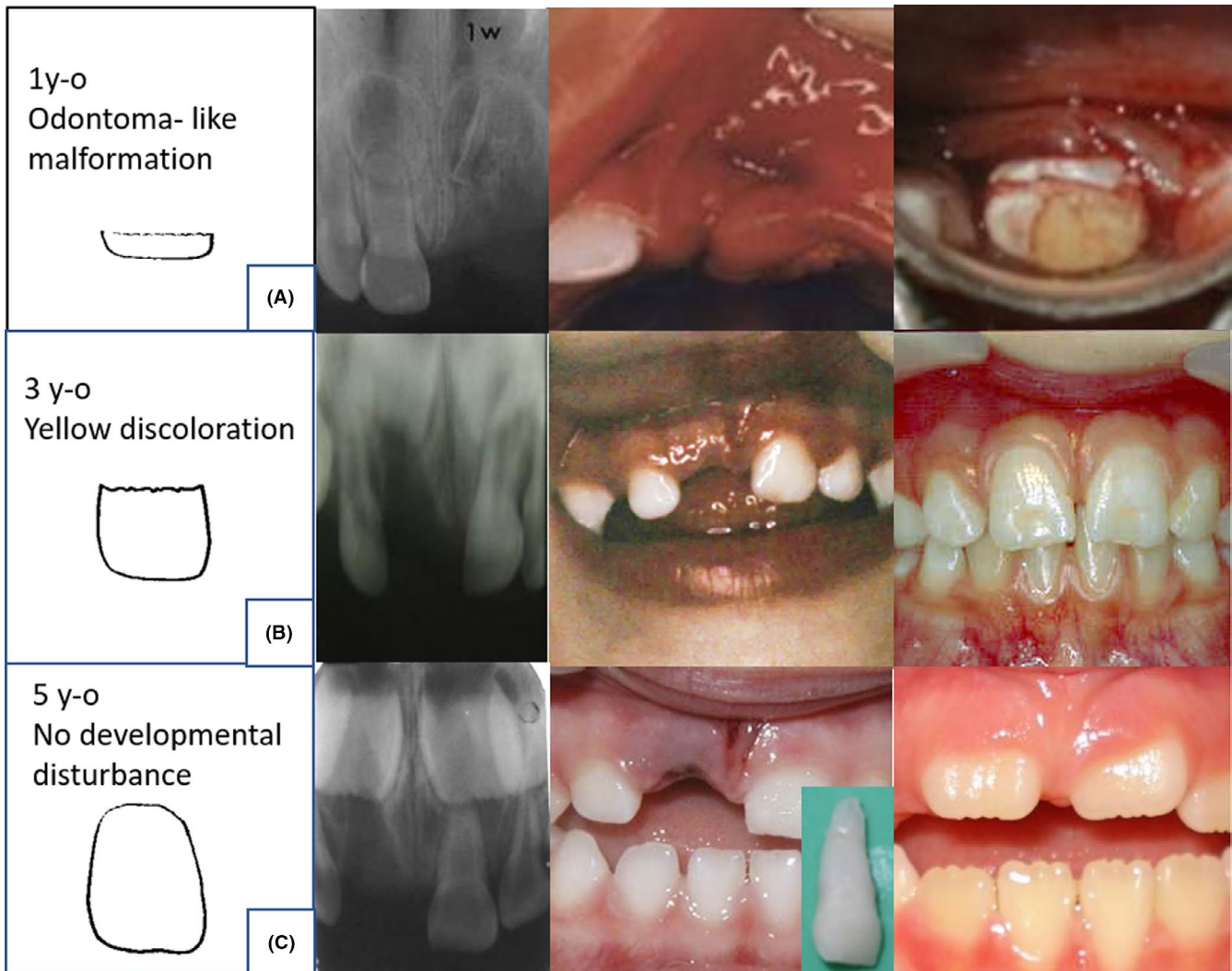


FIGURE 2 Long-term sequelae after avulsion of primary incisors and age at the time of injury. A, Severe injury to the developing permanent incisor. Avulsion of the primary maxillary left central incisor in a 10-month-old boy. The radiograph shows the permanent maxillary left central incisor displaced and initial calcification of the crown. An odontomalike malformation developed, which means a loss of the permanent tooth. B, Avulsion of the primary maxillary right central incisor at the age of 3 y. The child swallowed the avulsed tooth. While the mother was changing diapers the day after, she found the tooth in the excretion. A yellow discoloration is seen in the permanent maxillary central incisors (a mild disturbance to the developing teeth). C, Avulsion of the primary maxillary right central incisor at the age of 5 y. No sequelae have affected the crown of the permanent maxillary right central incisor

with apical closure. Complete formation of primary central incisors will be expected in a child aged 18-24 months old.¹³ After trauma to the oral region, potential damage to the developing teeth is age related because of the proximity between the roots of the primary incisors and the permanent tooth germs during the first 5 years of life.

The stage of crown formation, the force of impact, and the type of injury will all influence the kind of developmental disturbance. There are more probabilities for developing hypoplasia of the crown after an impact over the mouth below the age of 2 years (Figure 1A-C).

It has been widely documented that intrusion and avulsion in the primary dentition pose a risk for developmental disturbances to the permanent successors after trauma.^{8,9} However, there are few case reports addressing comprehensive long-term treatments for the most severe disturbances in growing children.¹⁴⁻¹⁶ Through

clinical cases, this report will illustrate some of the sequelae after oral trauma according to Andreasen's classification.^{6,9}

5 | LONG-TERM FOLLOW-UP

Avulsion of primary teeth is a severe injury with several implications for the child and the parents. Besides the stressful situation at the time of injury, replantation of a primary tooth is not indicated to avoid inflicting further trauma to the child.¹⁷ Also, potential damage to the developing incisors may occur. Once a radiograph confirms displacement of the tooth out of the alveolar socket or the avulsed tooth is found, long-term complications may range from mild to severe according to the damage to the tooth germ and dental treatment needs (Figure 2A-C).



FIGURE 3 Yellow-brown discoloration and circular hypoplasia in an immature tooth. A, Radiographic examination shows a circular radiolucency around the crown in the permanent maxillary left central incisor with incomplete root formation. B, A clinical view shows part of the gingiva covering the partially erupted crown. C, After gingiva remodeling, a round cavity full of debris was found in the middle third of the crown. A yellow-brown discoloration and circular hypoplasia were diagnosed. D, The radiograph at the time of treatment. A round radiolucency in the middle third of the crown resembles a cavity preparation. E–H, The pulp was not exposed. Calcium hydroxide was placed as a pulp cap, and this was covered with glass ionomer cement. The tooth discoloration was removed with a diamond finishing bur, and a direct composite restoration was placed using composite masking. I, The 14-month follow-up shows continued root development and root canal narrowing. J and K, A new trauma occurred 2 y after the first radiograph was taken. There was complete root formation with a closed apex. A new composite restoration was placed

6 | MILD DISTURBANCES TO DEVELOPING TEETH

From Andreasen's classification, the white or yellow-brown discoloration of enamel and hypoplasia are the most frequent complications affecting the permanent incisors after luxation injuries to the primary teeth.^{18,19} Hypoplasia because of trauma is an external defect with or without discoloration found in the middle of the crown. The

location is related to the age of the child at the time of injury, which usually occurs before the age of 3 when calcification of the crown of the permanent incisor has already commenced (Nolla's stage of tooth calcification 3 [1/3 of the crown completed]).

The circular enamel hypoplasia is a typical finding associated with intrusion or avulsion of primary teeth. Usually, there is a narrow horizontal groove that encircles the crown cervical to the discolored areas.^{6,7}

TABLE 1 Case series from the last 12 y of developmental disturbances affecting permanent teeth after traumatic injuries to the primary dentition

Year	Author(s)	Type of injury	Age (y)	Developmental disturbances	Development disturbances/ teeth with follow-up (%)	Significance
2006	Sennhenn-Kirchner et al ²⁸	All	1-7	Hypoplasia crown and/or root deformation Eruption disturbances	20/81 (24.6)	SS not reported
2009	Altun et al ²⁷	Intrusion	1-2	Hypoplasia crown and/or root deformation Eruption disturbances	74/138 (53.6)	NS correlation between age of intrusion and frequency of subsequent DD
2009	do Espiritu Santo Jacomo et al ²⁵	All	0-10	Discoloration of enamel and/or enamel hypoplasia (46.08%) Eruption disturbances (17.97%)	89/174 (51.1)	NS correlation between the type of traumatic injury and frequency of subsequent DD
2009	da Silva Assuncao et al ²⁶	All	1-5	W or Y-B discoloration of enamel (78.0%) Hypoplasia (86.0%)	126/623 (20.2)	SS associations: between enamel defects in successors and the child's age at the time of injury (P = .000325) Between enamel defects in successors and intrusion and avulsion (P = .0001)
2010	Scerri et al ²⁴	All	1-5	W or Y-B discoloration of enamel W or Y-B discoloration of enamel w/circular hypoplasia	32/67 (47.8)	SS not reported Control group with no traumatic injuries
2011	de Amorim et al ²³	All	4-7	Discoloration and hypoplasia (74.1%) Eruption disturbances (25.9%)	54/241 (22.4)	NS association between the sequelae to primary teeth and injuries in permanent teeth
2015	Skaare et al ²²	Luxation injuries	1-8	Demarcated opacity (12%) Hypoplasia (5.3%) Combined (2.7%)	66/300 (22%)	SS associations between enamel defects in successors and the child's age at the time of injury and the severity of the injury (P < .05)
2018	Tewari et al ²⁰	CRF Extrusion Intrusion Avulsion	1-5	YW discoloration (38%) Hypoplasia (24%)	218/596 (36.6%)	SS associations of age and type of TDI and frequency of subsequent DD (P < .001)
2018	Lenzi et al ²¹	All	1-8	Discoloration (11.2%) Enamel hypoplasia (9.8%)	62/214 (29%)	Trauma group presents a higher risk than the control group (OR = 5.388) Control group from the same patient

Abbreviations: CRF, crown root fracture; DD, developmental disturbances; NS, not significant; OR, odds ratio; SS, statistically significant; TDI, traumatic dental injuries; W, white; Y-B, yellow-brown.

Both types of trauma-related hypoplasia compromise esthetics and should be diagnosed in a timely fashion in order to prevent further complications, such as caries. However, discolorations and hypoplasia can be considered mild disturbances. These teeth can be restored with minimal intervention using composite resins. Figure 3A-K describes the misdiagnosis and treatment delay for severe hypoplasia of a maxillary left central incisor with incomplete root formation in a 7-year-old boy. The disturbance was not diagnosed as a trauma-related complication when the child sought treatment for the first time. In this case, an extensive horizontal yellow-brown discoloration was located in the middle third of the crown. Radiographically, a horizontal radiolucency was observed. It is important to consider that in immature teeth pulp preservation will allow continuing root formation. Immediate restoration of the crown is indicated when hypoplasia is associated with a loss of hard tissue. There is a risk of caries because of biofilm and accumulation of debris, which are difficult to remove by tooth brushing (Figure 3B,C).

An analysis of several case series studies from the last 12 years is listed in Table 1. This provides interesting information related to the association between traumatic injuries to the primary dentition and their effects on the developing dentition. However, all articles are related to diagnosis.²⁰⁻²⁸

In all of these studies, enamel discoloration, hypoplasia, or both were the most prevalent sequelae in the permanent incisors. These results should be analyzed with caution because only 2 studies in Table 1 report a control group, but they differ in their selection. In 1 study, the control group included teeth from the same patient,²¹ whereas in the other controls were from other individuals.²⁴

Studies on the treatment and long-term follow-up for different injuries to developing teeth are scarce in the literature. In a bibliometric analysis of 15 years of articles published in *Dental Traumatology*, Kramer et al²⁹ reported that the effects of traumatic dental injuries in primary teeth on their permanent successors were addressed in 20.4% of the articles (31/152).

The critical points to address mild disturbances are the following:

1. Accurate diagnosis after intrusion and avulsion of primary teeth.
2. Referral to a pediatric dentist.
3. Clinical and radiographic follow-up once a year.
4. If a permanent incisor is affected by enamel hypoplasia, early composite restoration as soon as the hypoplasia becomes visible (or immediately after tooth eruption).

7 | SEVERE DISTURBANCES TO DEVELOPING TEETH

The impact of a blow over the mouth at an early age may cause severe disturbances to the developing permanent teeth such as crown dilaceration, root dilaceration, and eruption disturbances, which are the most cited in case series studies from the last 12 years (Table 1). Even when these disturbances are not frequent, all of them pose a challenge to the clinician at the time of diagnosis and treatment planning. They are always the result of a high impact over the mouth in a child who is younger than 5 years of age with a history of severe intrusion, avulsion, alveolar process fracture, or a combination of these (Figure 4A-L and 5). Most studies reveal that intrusion and avulsion of primary incisors in children below the age of 2 years present the most significant hazard to the developing permanent teeth. However, other variables rather than the type of injury affecting the primary teeth can influence the damage sustained by the permanent tooth germs. These factors relate to the history of trauma and the age of the child at the time of injury, the force of the impact, and the presence of a fracture of the alveolar process. Sometimes, a hit of high impact may cause severe damage to the developing teeth without affecting the primary incisors (Figure 5A). It is essential to keep in mind that all anterior teeth will absorb a blow over the mouth, even if only 1 or 2 primary incisors are severely displaced. Therefore, clinical and radiographic follow-up is required when expecting severe disturbances after oral trauma of a high impact.

The key points to address severe injury disturbances are as follows:

1. Early diagnosis of impacted dilacerated incisors.
2. A multidisciplinary approach.
3. Surgical exposure followed by orthodontic traction in the early mixed dentition.
4. Conservative treatment whenever possible.

8 | THE RATIONALE FOR MULTIDISCIPLINARY TREATMENT

Severe disturbances to the developing teeth comprise a wide range of tooth germ malformations that may affect the crown and the root. Depending on the magnitude of the impact and the age at the

FIGURE 4 Complete arrest of root formation and impaction of a permanent mandibular central incisor after fracture of the alveolar process. The 11-year follow-up. An alveolar process fracture of the mandible in a boy 2 y 6 mo old. The primary mandibular central incisors were avulsed because of a fall on the stairs. A, The radiograph shows the initial stages of crown formation of the permanent mandibular incisors (Nolla 3). B, The displaced vestibular position of the alveolar segment is disclosed in the lateral radiograph. C, Occlusal interference caused by a crossbite and a movable section are clinical findings before the intervention. The alveolar fracture extended from the primary mandibular right central incisor to the mandibular left canine. D, The fractured segment was repositioned and splinted under general anesthesia 2 wks after trauma. E, The splint was removed 1 mo later. F, The clinical appearance 9 mo after injury. G and H, At the 3-year follow-up control, the radiograph discloses a developmental disturbance and impaction of the permanent mandibular right central incisor. I and J, The eruption of the mandibular left central incisor occurred at the age of 6 y old, whereas the right central incisor did not erupt. Arrest of root formation was diagnosed, and the right central incisor was extracted. K and L, Clinical examination at 11 y 4 mo follow-up control. Spontaneous alignment of the mandibular incisors occurred. The left central incisor shows a white discoloration of enamel



time of trauma, the developing permanent tooth can be displaced and remain impacted. Diagnosis and treatment planning must be performed by expert teamwork with not only the skills to manage

complicated cases but also, most importantly, a strong biological-based approach for planning conservative treatment in growing children. The initial team should include an orthodontist, an oral

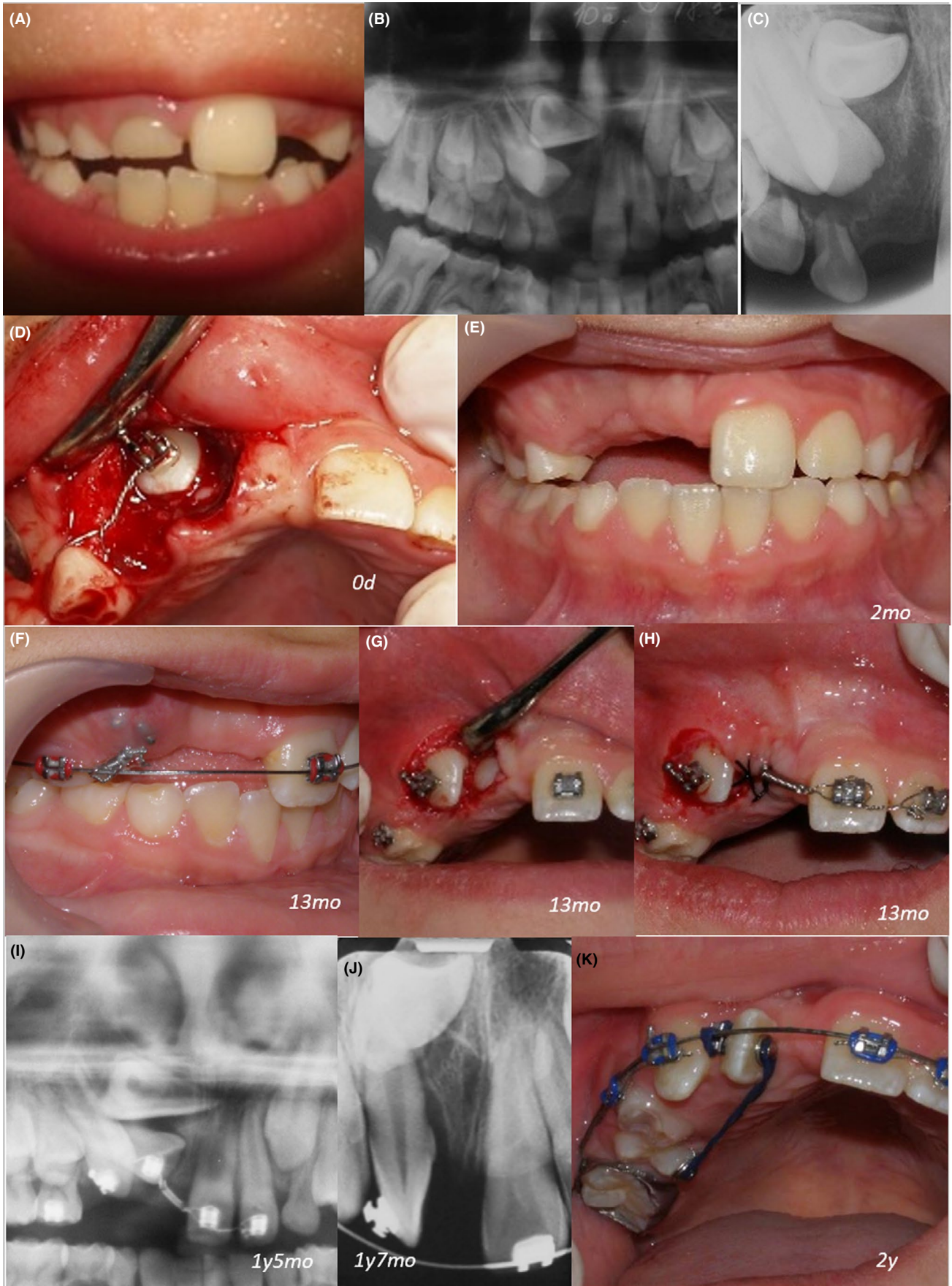


FIGURE 5 Continued

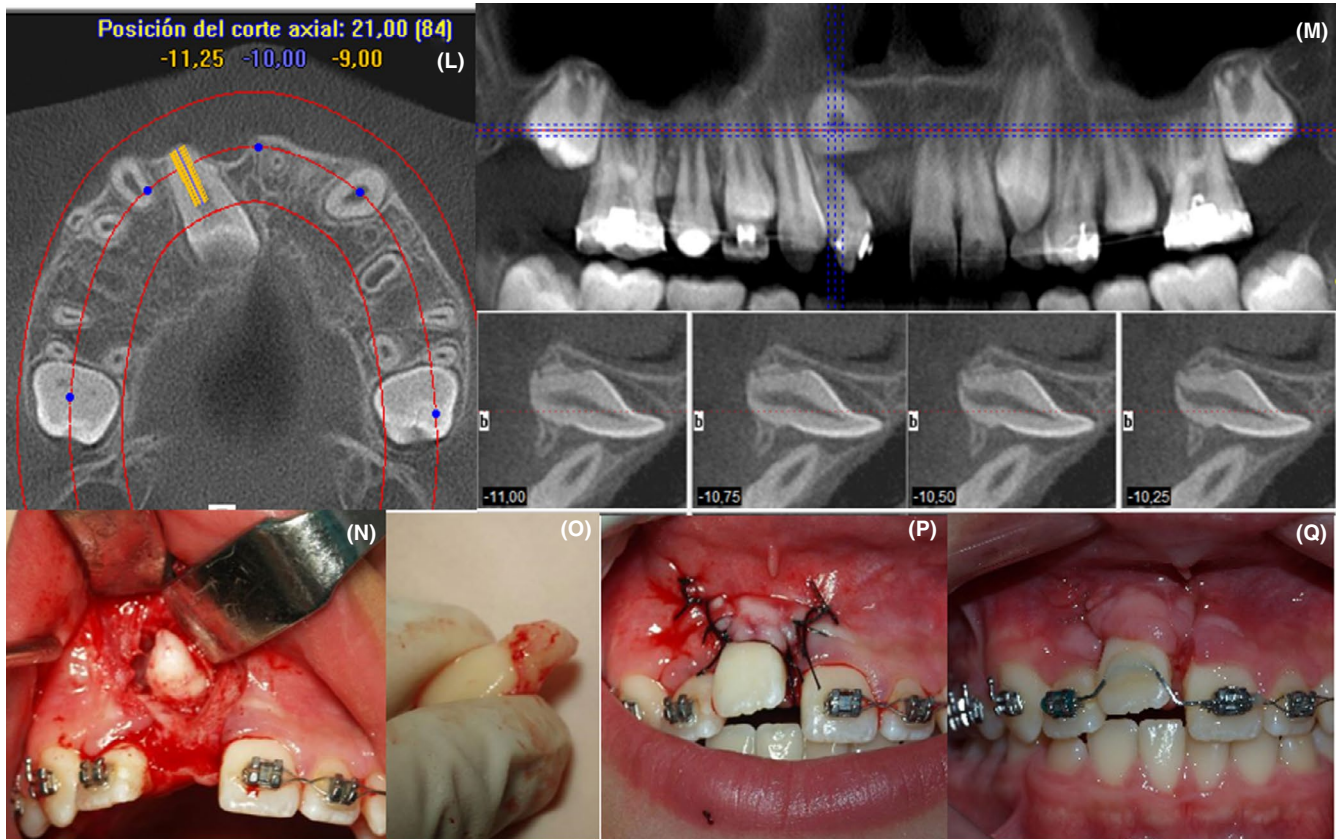


FIGURE 5 Conservative treatment of multiple injuries to the developing teeth including eruption disturbances, impacted teeth, tooth germ displacement, and partial arrest of root formation. Eight years 3 mo of follow-up. Clinical appearance of a 9-year-old boy who fell and hit his front teeth against a fence when he was 4 y old. A, At that time, the primary teeth were not affected. The maxillary right central incisor was retained. B and C, The panoramic and periapical radiographs showed the impacted and rotated position of the maxillary right central and lateral incisors. D, At the age of 10 y, a bracket was bonded to the maxillary right canine using a close fenestration approach. E, Clinical appearance after 2 mo. F–H, A second closed fenestration was performed to bond a bracket to the maxillary right lateral incisor at 13 mo. I and J, The panoramic and periapical radiographs are showing teeth movement. K, The alignment process of the maxillary right canine and lateral incisor. L and M, Two years 9 mo of follow-up. The cone-beam computed tomographic scan disclosed the palatal position of the maxillary right central incisor. N–P, The tooth was extracted and replanted in its new position by autotransplantation. Notice the short length of the root. Q, Two weeks after autotransplantation. Clinical and radiographic follow-up after autotransplantation. R and S, Ten months. T and U, Fourteen months. V and W, The patient 14 y old at the end of orthodontic treatment. There is a small abscess in the permanent maxillary right central incisor. X and Y, Five years. There is a slight infraocclusion. Endodontic treatment was performed

surgeon, and a pediatric dentist, all of them with expertise in the treatment of trauma patients. Most disturbances will be disclosed at the time of eruption of the permanent incisors during the early mixed dentition. A pediatric dentist may be able to follow the patient up to the age of 18 years. During this period, several interventions may be required, and the dentist who is in charge of following the patient should also be responsible for coordinating treatment planning with the different specialists.

9 | DISCUSSION

Early diagnosis and close monitoring are essential after severe oral trauma in young children, especially after intrusion, avulsion, or fracture of the alveolar process. Since the earliest studies, injuries to developing teeth such as crown discoloration and hypoplasia have

received much attention and concern. Both disturbances occur quite frequently after intrusion and avulsion in children less than 2 years old. These should be considered mild disturbances because treatment for enamel hypoplasia consists of a timely restoration of the crown with composite resins.

The most significant hazard to the developing permanent successor occurs when it is directly involved in the trauma, causing crown or root dilaceration, or displacement of the tooth germ, resulting in impacted teeth and eruption disturbances. It is much more complicated to treat eruption disturbances and malalignments than improving the appearance of a crown with enamel hypoplasia.

Based on Andreasen's classification, the injuries to developing teeth are grouped according to the type of injury affecting the primary dentition, severity grade, and treatment needs (Figure 6). Recognizing mild and severe disturbances, which can be expected



FIGURE 5 Continued

after luxation injuries such as avulsion or intrusion of primary teeth as well as after fracture of the alveolar process, will help clinicians in treatment planning. Mild disturbances need timely treatment to recover esthetics in case of crown hypoplasia. Severe disturbances require a multidisciplinary team of skilled specialists who adhere to

biological principles supporting conservative treatment in growing individuals.

Severe disturbances are difficult to diagnose, especially when there are several teeth affected. Cone-beam computed tomographic imaging is useful to locate displaced teeth.

Andreasen's classification of injuries to developing teeth	Treatment needs by severity grade	
	Type of injury to the primary dentition	Severity grade
White or yellow-brown discoloration of enamel	Avulsion Intrusion	Mild disturbances
White or yellow-brown discoloration of enamel with circular enamel hypoplasia		
Crown dilaceration	Avulsion Intrusion and/or fracture of the alveolar process	Severe disturbances
Odontomalike malformation		
Root duplication		
Vestibular root angulation		
Lateral root angulation or dilaceration		
Partial or complete arrest of root formation		
Sequestration of permanent tooth germs		
Eruption disturbances		

FIGURE 6 Injuries to developing teeth related to its severity and type of injury to the primary dentition

TABLE 2 How does orofacial trauma in children affect the developing dentition? Long-term treatment and associated complications

Considerations for treatment	Challenges to professionals
1. Age at the time of trauma	1. Commitment to perform systematic follow-up
2. Impact force	2. Competence in growth and development
3. Crown/root formation	3. Competence in coping with the child/parents
4. Time elapsed to seek treatment	4. Skills in specialty coordination
5. The expertise of a child-oriented team	

These 2 categories of injuries to developing teeth may provide a starting point for clinicians to become aware of the complexity of diagnosis, treatment planning, and long-term follow-up. This proposal will encourage dedicated clinicians to relate diagnosis, treatment planning, and long-term follow-up to be reported in the future as clinical cases.

10 | CONCLUSIONS

Injuries to the developing permanent dentition may occur at any time in children after trauma to the oral region, and they may affect the crown and/or root, causing tooth impactions and resulting in eruption disturbances. The damage to hidden tooth germs will be proportional to the severity from a blow to the mouth, ranging from mild to severe disturbances. These injuries may be unnoticed until the time of eruption of the permanent teeth.

Children with a history of oral trauma should be followed by a pediatric dentist once a year for early diagnosis of hypoplasia or circular hypoplasia in immature teeth. Timely esthetic restoration is mandatory to avoid caries. Minimal intervention and pulp preservation are essential to complete root development in immature teeth.

Case reports describing conservative long-term treatment for multiple developing disturbances are considered necessary. It is essential to inform health care professionals and dentists working at

emergency departments about the risks of oral trauma in children as well as professionals from nursery schools.

The treatment for severe disturbances of developing permanent teeth demands several competencies from a committed child-oriented team willing to recover esthetics by a biological-based approach. Excellent communication, empathy, and support improve patient adherence during long-term treatment in growing children (Table 2).

ACKNOWLEDGMENTS

The authors thank their team—the residents, faculty members, and staff members from the Postgraduate Clinic of Pediatric Dentistry and Adolescents, Faculty of Dentistry, Universidad de Valparaíso, Valparaíso, Chile. They also thank Dr Ramon Naranjo, oral & maxillo-facial radiologist, Drs Rosa J. Yáñez and Francisca Couve, orthodontists, and Dr Maximo Hernandez, oral surgeon, for their assistance with the orthodontic and surgical treatments, respectively.

CONFLICT OF INTEREST

The authors confirm that they have no conflict of interest.

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How to cite this article: Flores MT, Onetto JE. How does orofacial trauma in children affect the developing dentition? Long-term treatment and associated complications. *Dent Traumatol.* 2019;35:312–323. <https://doi.org/10.1111/edt.12496>