

Clinical prognosis of avulsed and reimplanted permanent incisors due to accidental facial trauma in children

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Abstract: **Introduction:** Permanent tooth avulsion caused by accidental facial trauma in pediatric patients has a variable incidence of 0.5% to 3% in anterior teeth. To monitor these cases in teeth with open apex, obliteration of the pulp canal should be considered, which can be radiographically recognized during the first year after the event. **Objective:** To examine the available evidence on the clinical prognosis of permanent incisors replanted due to accidental facial trauma in children up to 12 years of age. **Methods:** The analysis was conducted following the methodological approach of PRISMA-ScR and Joanna Briggs Institute (JBI). Two researchers from the team performed an independent search in the PubMed/MEDLINE, Web of Science and LILACS databases, using combinations of health descriptors interconnected by "and/or". Studies published in English in a 10-year interval (2013 to 2023) were tabulated with the aid of the EndNote reference manager. **Results:** A total of 25 case reports and 1 case series were selected. Inflammatory resorption and replacement resorption were present in permanent teeth reimplanted after a 60-minute avulsion period and stored in water (H₂O) or in a dry environment (50%; 13 cases), in addition to ankylosis (26.93%; n=7 cases), contributing to an unfavorable clinical prognosis. A total of 9 cases were asymptomatic in a follow-up period ranging from 1 to 10 years. **Conclusion:** Resorption and ankylosis were highly prevalent in permanent incisors avulsed and reimplanted due to accidental facial trauma in children, generating an unfavorable clinical prognosis in a mean follow-up of 5 years and 5 months.

Key words: Dental Avulsion, Tooth Replantation, Prognosis, Ankylosis.

Pronóstico clínico de incisivos permanentes avulsionados y reimplantados debido a trauma facial accidental en niños

Resumen: **Introducción:** La avulsión dental permanente causada por traumatismo facial accidental en pacientes lactantes tiene una incidencia que oscila entre el 0,5% y el 3% en los dientes anteriores. Para el seguimiento de estos casos en dientes con vértice abierto, se debe considerar la obliteración del canal pulpar, el cual puede ser reconocido radiográficamente durante el primer año después del evento. **Objetivo:** Examinar la evidencia disponible sobre el pronóstico clínico de los incisivos permanentes reimplantados por traumatismo facial accidental en niños de hasta 12 años de edad. **Métodos:** El análisis se realizó siguiendo el enfoque metodológico de PRISMA-ScR y Joanna Briggs Institute (JBI). Dos investigadores del equipo realizaron una búsqueda independiente en las bases de datos PubMed/MEDLINE, Web of Science y LILACS, utilizando combinaciones de descriptores de salud interconectados a través de "y/o". Los estudios publicados en inglés durante un intervalo de 10 años (2013 a 2023) se tabularon con la ayuda del administrador de referencias de EndNote. **Resultados:** Se seleccionaron 25 reportes de casos y 1 serie de casos. La reabsorción inflamatoria y la resorción por reemplazos estuvieron presentes en los dientes permanentes reimplantados después de un período de avulsión de 60 minutos y almacenados en agua (H₂O) o en un ambiente seco (50%; 13 casos), además de anquilosis (26,93%; n=7 casos), contribuyendo a un pronóstico clínico desfavorable. Un total de 9 casos resultaron asintomáticos en un seguimiento variable entre 1 y 10 años. **Conclusión:** Se demostró que las reabsorciones y anquilosis son altamente prevalentes en los incisivos permanentes avulsionados y reimplantados por trauma facial accidental en niños, generando un pronóstico clínico desfavorable a un seguimiento medio de 5 años y 5 meses.

Palabras clave: Avulsión dental, reimplante dental, pronóstico, anquilosis.

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Prognóstico clínico de incisivos permanentes avulsionados e reimplantados devido a trauma facial acidental em crianças

Resumo: **Introdução:** A avulsão dentária permanente ocasionada por trauma facial acidental em pacientes infantis possui incidência variável de 0,5% a 3% em dentes anteriores. Para acompanhamento desses casos em dentes com vértice aberto, deve-se considerar a obliteração do canal pulpar, que pode ser reconhecida radiograficamente durante o primeiro ano após o acontecimento. **Objetivo:** Examinar as evidências disponíveis sobre o prognóstico clínico de incisivos permanentes reimplantados devido a trauma facial acidental em crianças de até 12 anos de idade. **Métodos:** A análise foi conduzida seguindo a abordagem metodológica do PRISMA-ScR e Joanna Briggs Institute (JBI). Dois pesquisadores da equipe realizaram uma busca independente nas bases de dados da PubMed/MEDLINE, Web of Science e LILACS, utilizando combinações de descritores em saúde interligados através de "and/or". Foram tabulados estudos publicados na língua inglesa em um intervalo de 10 anos (2013 a 2023), com auxílio do gerenciador de referências EndNote. **Resultados:** Ao todo, 25 relatos de casos e 1 série de casos foram selecionados. Reabsorção inflamatória e reabsorção por substituições se fizeram presentes em dentes permanentes reimplantados após um período de avulsão de 60 minutos e armazenados em água (H₂O) ou ao ambiente seco (50%; 13 casos), além de anquilose (26,93%; n=7 casos) contribuindo para um prognóstico clínico desfavorável. Um total de 9 casos demonstraram-se assintomáticos em um acompanhamento variável entre 1 e 10 anos. **Conclusão:** Reabsorções e anquiloses demonstraram-se alta prevalência em incisivos permanentes avulsionados e reimplantados devido a trauma facial acidental em crianças, gerando um prognóstico clínico desfavorável em um acompanhamento médio de 5 anos e 5 meses.

Palavras-chave: Avulsão Dentária, Reimplante Dentário, Prognóstico, Anquilose.

Introduction

Dental trauma is a condition characterized by external impact that results in the rupture of periodontal ligament fibers, with some fibers adhering to the cementum of the tooth and others to the alveolar bone¹. These injuries encompass damage to the dentition and adjacent supportive structures, manifesting in various forms and showing higher incidence in school-aged children².

The classification of these injuries is based on severity levels, with concussion considered a minor trauma, while avulsion is the most extensive form, characterized by the complete displacement of the tooth from the alveolar bone³. Consequently, various combinations of damage to oral tissues can be identified, including injuries to the gingiva, pulp, dental tissues, periodontal ligament, and alveolar bone⁴.

From an epidemiological perspective, the

prevalence of dental trauma in permanent teeth ranges from 0.5% to 3%². The most frequently reported causes in the literature include falls from standing height, full-contact sports, traffic accidents, and physical assaults⁵. Trauma-induced damage can lead to the rupture of the neurovascular bundle, pulpal necrosis, and the possibility of inflammatory resorption⁶.

The prognosis of such cases is closely linked to prior treatment of the avulsed tooth, the time elapsed outside the alveolus, storage conditions, and the overall health status of the patient^{7,8}. In this regard, Coste *et al.*⁵ highlight that the survival rate of replanted teeth over a period of 5.5 years is 50%, with an additional 1% increase for immature avulsed teeth.

Although preservation methods, such as the use of milk and saliva, help maintain the viability of periodontal ligament cells for a longer period^{7,9,10}, some replanted teeth exhibit a low probability of long-

term survival, potentially being lost or requiring extraction due to complications such as resorption and ankylosis^{11,12}. Thus, complications like external inflammatory resorption or replacement resorption can occur in traumatic dental injuries when the tooth is luxated or avulsed and subsequently replanted^{13,14}.

Ankylosis of teeth following traumatic injuries occurs when osteoclasts originating from the surrounding alveolar bone are immediately followed by osteoblasts, reaching the root surface after crossing the damaged periodontal ligament and precementum¹⁵. This process results in the osseous replacement of root cementum and dentin, particularly in older children¹⁶.

In both cases, preserving the vitality of the periodontal ligament emerges as the key factor in preventing clinical complications and improving patient prognosis¹⁷. In this context, the present study aims to examine the available evidence on the clinical prognosis of replanted permanent incisors following accidental facial trauma in children up to 12 years of age.

Materials and Methods

Study Design and Protocol

This study is a scoping review conducted following the methodology outlined by the Joanna Briggs Institute (JBI)¹⁸. The established criteria were guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR)¹⁹. The research protocol was registered in the Open Science Framework (DOI 10.17605/OSF.IO/UJBNC).

Search Information and Search Strategy

The following research question was formulated to guide the literature search: "What is the clinical prognosis of replanted permanent incisors due to accidental facial trauma in pediatric patients up to 12 years of age?" This topic was developed using the PCC strategy (Population, Concept, and Context), as recommended by the JBI protocol, as detailed below:

- Population (P): Children who experienced dental avulsion
- Concept (C): Permanent dentition
- Context (C): Clinical prognosis

The following descriptors were subsequently used to locate primary studies, connected using health-related terminology as follows: "Tooth Injuries/Traumatisos Dentários" AND "Tooth Avulsion/Avulsão dentária" OR "Tooth Replantation/reimplante dentário" AND "Prognóstico/Prognostic" AND "Relatos de casos/Case Reports" AND "Reabsorção da Raiz/Root Resorption" OR "Reabsorção de Dente/Tooth Resorption" OR "Anquilose Dental/Tooth Ankylosis" OR "Raiz Dentária/Tooth Root" OR "Apexificação/Apexification".

All references were managed using a reference management program (EndNote, Thomson Reuters, Philadelphia, PA, USA), and duplicate reports identified during the search were removed.

Eligibility Criteria

Inclusion Criteria

Only full-text case reports and case series published within a 10-year period (January 1, 2013, to December 30, 2023) in English (United States of America), Portuguese

(Brazil), or Spanish (Spain) were included in the analysis. The selected articles had to address dental avulsion, exploring possible management and treatment alternatives—both immediate and delayed—with a minimum clinical follow-up of one year. The choice of study type and the 10-year period was justified based on data provided by the International Association of Dental Traumatology (IADT)¹¹, which recommends considering pulp canal obliteration in teeth with open apices, a phenomenon that can be radiographically identified within the first year post-trauma.

Additionally, the studies selected for tabulation had to highlight clinical aspects such as the causal factor, tooth type (permanent numbering), time between avulsion and replantation, storage material used, recommended professional conduct, presence or absence of internal/external resorption or ankylosis, and clinical prognosis. Moreover, clinical aspects related to the alveolar condition and imaging examinations for follow-up had to be presented to analyze the favorable or unfavorable outcomes of the reported cases.

Exclusion Criteria

The following types of research were excluded: narrative or integrative literature reviews, master's or doctoral theses/dissertations, editorial notes, pilot studies, duplicate studies, studies unavailable in full text, abstracts only, conference proceedings, data prior to 2013, epidemiological studies, case-control or cross-sectional studies, opinion articles, and studies not written in the Latin (Roman) alphabet.

Additionally, studies discussing dental trauma without avulsion—such as

concussion, subluxation, lateral luxation, intrusion, or the use of stem cells—were excluded from this review. Case reports without final follow-up information, those lacking imaging examinations, and those without details on the post-trauma physical state of alveolar bone and ligament were also excluded. Studies on avulsed primary teeth, with follow-up shorter than one year, and those without a specified prognosis by the authors were not considered in the final sample.

Information Sources

To identify relevant studies, an electronic search was conducted in PubMed/MEDLINE, Web of Science, and the Latin American and Caribbean Health Sciences Literature (LILACS) databases. The search was carried out between June 11, 2023, and June 16, 2023. Figure 1 quantifies the total number of initially retrieved studies in each database, highlighting the screening phases, eligibility assessment, and the final number of studies included in this review (n=26).

Study Selection

The examiners were previously trained to apply the study selection criteria in two distinct phases. In Phase 1, titles and abstracts of all articles retrieved from the databases were screened to select those for full-text reading. In Phase 2, the full texts of the articles chosen in Phase 1 were read in detail to assess their eligibility according to the pre-established inclusion and exclusion criteria.

Both phases were conducted independently by two authors (N.C.M and P.A.G.S). In Phase 2, an additional manual search of the references from the selected studies after full-text reading was performed by the

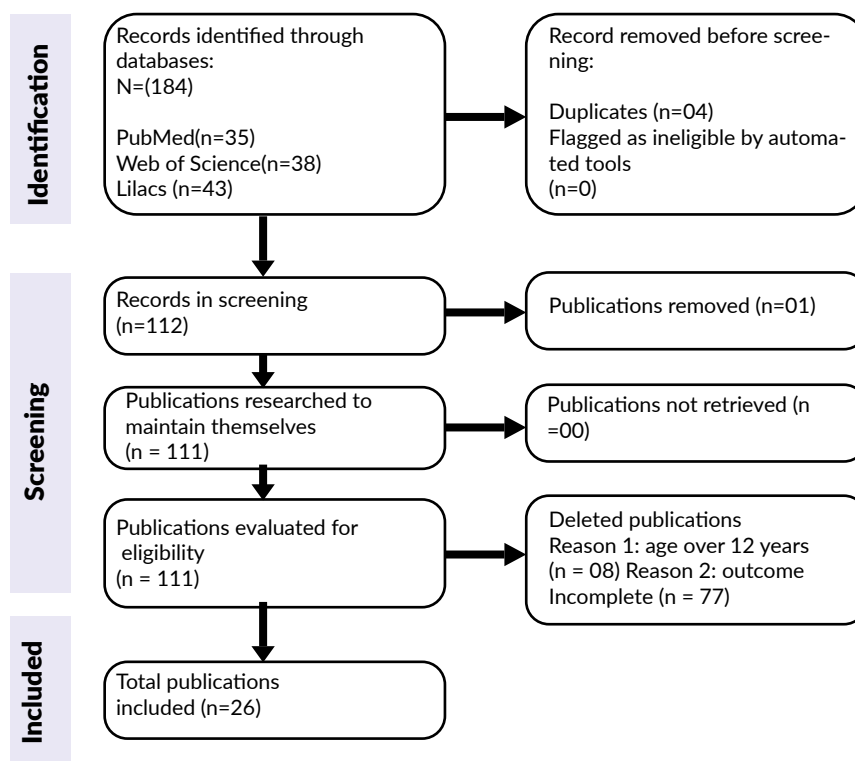


Figure 1. Flow diagram, adapted from PRISMA21, illustrating the sequence of study selection and its inclusion in this review

Source: Survey data, 2023.

researchers to identify potential articles that may have been inadvertently omitted during the database searches.

In both phases, any disagreements between the two researchers were resolved by a third author (Z.S.S). In cases of disagreement, the article in question was discussed among the two authors and the third researcher until a consensus was reached.

Results

Study Characterization

The selected studies underwent a detailed analysis, focusing on the clinical and radiographic characteristics

of avulsed teeth. These characteristics were subsequently categorized according to prognosis, distinguishing between favorable and unfavorable approaches recommended by dental surgeons.

Tables 1 and 2 provide a comprehensive overview of the relevant aspects for discussing prevalence results. They include information such as author, year of publication, affected patient characteristics (age and tooth type), recommended storage medium, time interval between avulsion and reimplantation, preservation method, type of immobilization as treatment, interventions advocated by professionals, presence or absence of inflammatory or replacement resorption, ankylosis, and finally, study outcomes based on a minimum follow-up of one year.

Case reports were classified as having a favorable prognosis for reimplantation when they exhibited at least one of the following characteristics after one year: 1) continuous root formation; 2) completion

of apexogenesis in immature permanent teeth; 3) absence of pain on percussion and palpation at the end of follow-up; 4) absence of pathological periodontal pockets; and/or 5) normal percussion tone

Table 1. Tabulation of data extracted from the literature regarding the conducts recommended in the studies, highlighting favorable outcomes.

Author/year	Sample	Tooth	Storage	Des. radicular	Time	Immobilization	Intervention	Reabsorption	Accompaniment	Denouement
Moradian <i>et al.</i> ²²	But, 12 to	ISP 11	Milk	Complete	12 h	Semi/2 weeks	Pulpectomy	-	3 years	Asymptomatic
Munavalli <i>et al.</i> ²³	Female, 12 to	ISP 11	Alveolus	Complete	10 m	Semi/2 w/	Redeploy only	-	2 years	Asymptomatic
Harris <i>et al.</i> ¹⁷	But, 12 to	ISP (11)	Wrapped in Newspaper	Complete	2 days	Semi/ 14 dias	Pulpectomy	-	24 months	Asymptomatic
Majd <i>et al.</i> ⁷	Fem, 7 to	IIP (41)	Milk	Incomplete	90 m	Semi/NE	Apicification (MTA)	-	20 months	Continuous formation of roots
Souza <i>et al.</i> ²⁴	But, 12	ICP 11,21	Oral cavity	Complete	1 hr e 30 m	Semi/ 10 dias	Pulpectomy	-	3 a	Asymptomatic
Nagata <i>et al.</i> ²⁵	But, 8 to	ISP (21)	Saline	Incomplete	30 m	Semi / 1 month	Pulp revascularization with MTA	External	16 months	Apical closure
Savas <i>et al.</i> ²⁶	Case 1: Mas, 8a	ISP (21)	Piece of paper (dry)	Incomplete	27 hrs	Semi/ 4 sem	Apisification	Replacement	18 months	Ankylosis
	Case 2: But, 10 to	ICP (11)	Dry	Complete	7 am	Semi/ 4 sem	Pulpectomy	Replacement	12 months	Ankylosis
Days; Nunes; camila ²⁷	F,6	ISP (21)	Water	Incomplete	2 hrs	e Semi/4 s	Capping	-	5 a	Impairment of root formation
Lucisano <i>et al.</i> ²⁸	But, 8 to	ISP (11)	13 dry 4 h milk	Incomplete	5 p.m.	Semi/ 4 sem	Pulpectomy	-	1 year and 6 months	Apical closure
Rahbar <i>et al.</i> ¹³	Fem, 8.5 a	ICP (21)	Dry	Incomplete	30 hours	Semi/ 8 sem	Revascularization with MTA	-	1 year	Asymptomatic
Bendoraitinene <i>et al.</i> ²⁹	NE, 10 to	ISP (11)	Dry	Incomplete	1 hour	Rigid / 2 weeks	Pulpectomy	External	7 years	Asymptomatic
Kolli <i>et al.</i> ³⁰	Fem, 8 to	ISP (21)	Saline	Incomplete	4 days	Semi/ 2 sem	Pulpectomy	Replacement	18 months	Ankylosis
Lee; Banks; axe ⁹	Fem, 8 to	ISP (11)	Milk	Incomplete	4 p.m.	Semi/2 w/w	Apicification (MTA)	-	4 A	Small Apical Ankylosis (Substitution)
Ulfat; javed; haq ³¹	NE, 12 to	ISP (12)	Tissue Paper	Complete	10 p.m.	Semi/4 w/	Pulpectomy	-	4 A	Ankylosis (substitution)
Kirzioglu; güngör; erdoğan ³²	But, 9	ISP (12)	Milk and olive oil	Incomplete	10 h	Rigid/ 4 as	Indirect capping and subsequent pulpectomy	-	16 years	Apexogenesis Completed
Handle-iron ³³	NE, 7 a	ISP (11)	Water	Incomplete	10 m	Semi/ 14 dias	Pulp revascularization with MTA	-	3 years	Continuous root formation
Özlek; and; acol ¹⁶	Fem, 9 to	IIC (31)	Milk	Complete	2 hours	Semi/NE	Pulpectomy	External	36 months	Asymptomatic
Park; son ¹⁴	Women, 5 to	IIP (41)	Milk	Incomplete	1 hour	Semi/NE	Apisification	Apical narrowing	12 months	Asymptomatic
Abulhamael <i>et al.</i> ¹⁵	Female, 7 to	ICP (11)	Dry	Incomplete	2 hours	Semi/NE	Revascularization and apicification	External	4 years	Asymptomatic
Kotsano ¹⁰	But, 9.5 to	ISP (NE)	Milk	Incomplete	60 m	Semi/NE	Apisification	External	10 years	Asymptomatic

Legends: M = minutes; Fem = Female; Mas = Male; IIP = Permanent mandibular incisor; permanent upper incisor; A = Years; H = Hours; NE = Unspecified; Gingival tissue; Permanent upper canine = CSP
Source: Survey data, 2023.

Table 2. Tabulation of data extracted from the literature regarding the conducts recommended in the studies, highlighting favorable outcomes.

Author/year	Sample	Tooth	Storage	Des. radicular	Time	Immobilization	Intervention	Reabsorption	Accompaniment	Denouement
Sardana; goal; Gauba ²⁴	Female, 12 to	ISP (11)	Milk	Complete	3 p.m.	Semi/1 month	Pulpectomy	External	3rd to	Ankylosis
Diniz-rebouças et al. ⁸	Female, 8	21	Milk	Incomplete	1 h	NE	Pulpectomy	Replacement	3rd to	Ankylosis / decoration
Ines; Nabih ³⁵	But, 9 to	ISP 11	Milk	Incomplete	24 hours	Rigid/ 4 as	Pulpectomy	Replacement	1 year	Tooth Extrac-tion
Walia; chand-wani ³⁶	Fem, 8 to	ISP (11)	Water	Incomplete	2 h	Semi/14 days	Apisification	Replacement	10 to	Ankylosis and decoronation
Luo et al. ³⁷	But, 8 to	ISP 11, 22	Drought	Incomplete	1 h	Semi/ 14 dias	Pulpotomy Apisification	External	15 months	Periapical absorption
Kaur et al. ²	Female, 9 to	IIP (32)	TG	Complete	20 m	Semi/2 w/w	Pulpectomy	External and internal	3 years and 8 months	Revulsed

Legends: M = minutes; Fem = Female; Mas = Male; IIP = Permanent mandibular incisor; permanent upper incisor; A = Years; H = Hours; NE = Unspecified; Gingival tissue; Permanent upper canine = CSP
Source: Survey data, 2023.

or absence of post-treatment mobility (see Table 1).

Clinical cases with an unfavorable prognosis were categorized when they exhibited at least one of the following characteristics after one year: 6) reavulsion of the dental element; 7) treatment completion with tooth extraction; 8) presence of internal and/or external resorption; 9) tooth discoloration; 10) extensive replacement ankylosis; 11) abnormal percussion tone or presence of post-treatment mobility; and 12) necrosis (see Table 2).

Prevalent Qualitative Data in the Studies

The data tabulation highlights that inflammatory or replacement resorption is frequently observed in reimplanted teeth after 60 minutes^{8,16,15,24, 26,29,30,35,36}. Anterior teeth, especially the upper central incisors (teeth 11 and 12), are particularly prone to avulsion, especially among school-aged children, with an average age of 9 years.

Extraoral drying time emerged as an influential factor in the treatment outcomes of avulsed permanent teeth and can be categorized by the IADT into

two time frames: less than or greater than 60 minutes. In this review, the rate of favorable prognosis increased when teeth were reimplanted within 60 minutes^{10,14,23,25,29,33}, although three analyzed cases presented an extraoral time exceeding two hours yet still yielded favorable patient outcomes, remaining asymptomatic^{13,15,24}.

Immediate reimplantation of the avulsed tooth was found to be the most effective treatment, significantly reducing the risk of late complications such as ankylosis or resorption^{23,25,33}. However, it is crucial to note that treatment choice is intrinsically linked to root maturity (open or closed apex) and the condition of periodontal ligament (PDL) cells¹¹.

All authors included in this review emphasized the importance of minimizing drying time to ensure the survival of PDL cells. After 30 minutes of extra-alveolar drying, most periodontal ligament cells no longer remain viable^{2,35-37}. Additionally, stabilizing the tooth for a period of two weeks with a passive flexible splint, such as a wire up to 0.016" or 0.4 mm, fixed to the avulsed tooth and adjacent teeth, was

recommended in the analyzed studies. This approach favored reimplantation success and minimized complications during the healing process³³.

Pulp revascularization, aiming for greater root development, was the primary goal of reimplanting immature teeth in children³⁸. The literature underscores the need to balance the risk of infection-related external root resorption (inflammatory) with the possibility of revascularization. If spontaneous revascularization does not occur, interventions such as apexification^{7,9,10,14,26}, revitalization/revascularization^{13,15,25,33}, or endodontic treatment^{8,16,17,22,24,26,28-31}, should be initiated upon identifying pulp necrosis and infection.

In immature teeth with open apices, there is potential for spontaneous healing, resulting in the formation of a new vascularized ligament^{7,9,10,13-15,25-29,32,33}. This process allows for continued root development and maturation³⁹. Therefore, endodontic treatment should not be initiated unless there is clear evidence of pulp necrosis and infection within the root canal system during follow-up¹⁰.

The reimplantation of avulsed incisors after a prolonged delay, particularly exceeding 60 minutes, exhibited a compromised prognosis^{24,35,36}. During avulsion, damage to the periodontal ligament is typically more severe, often resulting in replacement resorption. This type of resorption leads to the fusion of the tooth root with the adjacent alveolar bone³⁹.

Thus, the progression and rate of replacement resorption are influenced by various factors, including age, basal metabolic rate, extra-alveolar time, root

surface treatment before reimplantation, amount of remaining root dentin, trauma severity, and the extent of periodontal ligament necrosis⁴⁰. Even after a prolonged extra-alveolar period, dental reimplantation plays a crucial role in restoring aesthetics and improving the self-esteem of an adolescent in mid-growth phase¹³. Despite the delay, reimplantation helps preserve the dimensions of the vestibular and palatal alveolar bone, which is essential for future implant-supported prosthetic placement¹¹.

The included studies highlighted a significantly higher risk of reimplantation failure in cases of prolonged dry storage outside the mouth, delayed pulp extirpation (beyond 20 days), immature teeth, patients younger than 11 years, and the need for prolonged calcium hydroxide therapy⁵. The reported incidence of root resorption in these cases predominantly manifested as replacement resorption and ankylosis (51%), followed by inflammatory resorption (23.2%) and internal root resorption (1.2%)⁴. Evidence suggests that inflammatory and internal resorption mechanisms originate in inflamed pulp tissue, while damage and hypoxia of periodontal ligament cells are associated with external root resorption in traumatic teeth⁶.

Discussion

From an epidemiological perspective, dental avulsion is the most common condition among males, particularly between the ages of 7 and 9 years². The findings from the tabulated studies support this statement, as a higher prevalence was observed in males, with a variable mean age ranging from 7 to 12 years^{10,17,22,24-26,28,32,35,37}.

According to Mesquita *et al.*¹², this injury has a higher prevalence in the maxillary central incisors, followed by the maxillary lateral incisors and the mandibular central and lateral incisors. In this analysis, the most affected teeth were the maxillary central incisors, numbered 11 and 12. In such cases, besides reimplantation, the recommended treatment included pulpectomy or apexification followed by splinting^{8,16,17,22,24,26,28-31}.

The literature extensively covers measures related to the dental avulsion process, indicating that inflammatory resorption (both internal and external) and replacement resorption have a high prevalence in permanent teeth reimplanted after 60 minutes and stored improperly, particularly in dry conditions. Ankylosis has been identified as a contributing factor to an unfavorable prognosis in some of the considered studies^{8,24,36}. In this context, the extraoral storage time and medium emerged as critical factors for the survival of periodontal ligament cells, which, in turn, influenced the long-term prognosis of the reimplanted tooth²²⁻³³.

Treatment approaches may vary depending on whether the dental element has fully developed or remains incomplete. Nonetheless, reimplantation, even under unfavorable conditions, allowed for adequate alveolar preservation, particularly in pediatric patients undergoing facial development. This approach facilitated better long-term intervention alternatives, such as fixed prostheses, implants, or crowns, minimizing the aesthetic impact of tooth loss, as highlighted in studies by Moradian *et al.*²² and Munavalli *et al.*²³.

When the apex remains open, a prevalent approach is pulpectomy, followed by the application of intracanal medications that promote complete apex closure^{8,16,17,22,24,26,28-31}. Previous studies, such as those by Kotsanos *et al.*¹⁰ and Nagata *et al.*²⁵, suggest that the use of intracanal medication for a variable period—ranging from two weeks to six months—during endodontic treatment of avulsed teeth can positively impact treatment outcomes. Various medications have been recommended, including calcium hydroxide, corticosteroid- and antibiotic-based endodontic medication (Ledermix paste), and a combination of calcium hydroxide and iodoform⁷.

Studies by Nagata *et al.*²⁵ and Lucisano *et al.*²⁸ have demonstrated that applying calcium hydroxide and iodoform paste (Metapex) in the treatment of avulsed permanent teeth promotes continuous apical growth and successful apexification. According to these authors, calcium hydroxide is recommended as an intracanal medication for up to one month, followed by root canal obturation. In such cases, calcium hydroxide provided a favorable clinical response, contributing to tissue stimulation and canal closure, as evidenced by the included data.

Additionally, if a corticosteroid or a corticosteroid/antibiotic combination is chosen as an intracanal anti-inflammatory and anti-resorptive medication, it should be applied immediately or shortly after reimplantation and left in situ for at least six weeks^{15,37}. The application of these medications should be carefully performed within the root canal system, avoiding placement in the tooth crown^{25,33}.

Mineral trioxide aggregate (MTA) has emerged as the most commonly used material for teeth with incomplete apices, promoting root development. However, adverse aesthetic events, such as tooth discoloration, have been observed^{9, 33}.

Regarding storage media, milk has been shown to provide the most favorable clinical prognosis in most reports^{7-10,14,16,22,24,28,32,35}, although its effectiveness is influenced by factors such as avulsion duration. Some studies have performed reimplantation under unfavorable conditions, leading to unsatisfactory outcomes in most cases^{24,35}. Nevertheless, this approach has enabled the implementation of long-term alternatives due to the maintenance of proper occlusion and alveolar preservation^{9,13,15-17,22,26,28,30-32}.

Finally, semi-rigid splinting for a period of two weeks was the most prevalent professional approach, although in more severe cases, the Erich arch bar was also used^{2,8-10,14-16,22-37}. Therefore, a standardized approach to managing avulsed teeth due to facial trauma is evident, aligning with the AITD guidelines regarding timing, storage medium, antibiotic use, and splinting.

Final Considerations

Permanent incisors that are reimplanted following accidental facial trauma exhibit a favorable clinical prognosis when properly stored and reimplanted within 60 minutes. The occurrence of inflammatory resorption, replacement resorption, and ankylosis was significantly more prevalent in teeth reimplanted after 60 minutes or stored inadequately, identifying them as key determinants of an unfavorable prognosis.

However, conducting this review revealed challenges, particularly the extensive literature on the subject, which necessitates rigorous selection and substantial intellectual effort. These challenges highlight the need for a critical approach when analyzing the data. Nevertheless, the insights gained from this review have the potential to enhance clinical decision-making among dental surgeons, especially in the context of pediatric dental emergencies. This, in turn, facilitates the development of more effective therapeutic approaches for the initial management of dentoalveolar trauma, grounded in updated literature and prevalence-based guidelines.

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