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Replantation After Dental Avulsion: A Scoping Review and Proposal of a Flow Chart

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ABSTRACT

Dental avulsion, the complete displacement of a tooth from its socket, is a severe dental trauma with a prevalence of 0.5% to 16% of all dental injuries. Replantation of avulsed teeth is common, yet recent studies show high failure rates and unpredictable long-term outcomes. This review examines clinical variables influencing intentional dental replantation decisions and proposes a treatment flow chart. A comprehensive literature search was conducted in PubMed-Medline, Scopus, WoS, and Cochrane databases using the keywords "tooth avulsion," "tooth replantation," and "tooth ankylosis." Inclusion criteria encompassed studies from January 2018 to February 2024. From 752 identified articles, 9 systematic reviews including 3 meta-analyses were selected for this scoping review. Immediate replantation is the gold standard for avulsed teeth, yet delayed replantation is more common in practice, impacting survival rates. Adherence to guidelines from the International Association on Dental Traumatology improves outcomes, especially in paediatric patients. Factors such as multiple caries, severe periodontal disease, advanced age, psychological conditions, immunodeficiency, and lack of cooperation are contraindications for replantation. Despite the high failure rate, replantation remains recommended in literature due to its potential advantages over prosthetic implants. This review highlights the complexities in decision-making for dental replantation, emphasising the need for a comprehensive approach considering individual clinical cases. A proposed treatment flow chart aims to support clinicians in predicting prognosis and making informed decisions. The review also underscores the link between dental trauma, poor oral health, and potential neglect in children, highlighting the importance of preventive measures and parental awareness.

INTRODUCTION

The complete displacement of a tooth from its socket, known as avulsion, is one of the most severe forms of dental trauma, with a prevalence ranging from 0.5% to 16% of all dental injuries [Fouad et al., 2020; Day et al., 2019; Andreasen et al., 2019]. This type of trauma becomes more common with increasing age [Lauridsen et al., 2012]. Replantation of an avulsed tooth is a common clinical practice; however, recent studies have reported a failure rate ranging from 55% to 96%, with poor and unpredictable long-term survival [Andreasen et al., 2019; Coste et al., 2020; Muller et al., 2020]. This raises the question of why natural teeth continue to be saved in the era of dental implants [Clark et al., 2019]. Some authors have demonstrated that following the guidelines of the International Association on Dental Traumatology improves the survival rates of replanted teeth, particularly in paediatric patients [Wang et al., 2019]. However, it is known that while guidelines provide useful recommendations for clinical decision-making, they do not guarantee a favourable prognosis [Levin et al., 2020]. Immediate replantation is considered the gold standard for the best chance of success, but unfortunately, in most clinical cases, replantation is delayed [Ulfat et al., 2021]. Some authors have analysed both the tangible and intangible costs, as well as the impact on quality of life related to oral health, in relation to replantation, particularly when the chances of success are diminished, such as in cases of delayed replantation [Das et al., 2022; Zerman, 2009]. Multiple caries, severe periodontal disease, advanced age, fragile psychological conditions, immunodeficiency, serious heart disease, and lack of cooperation from the recipient and/or parents are known contraindications to replantation [Fouad et al., 2020]. The present study examines the scientific evidence on the clinical variables influencing the therapeutic choice of intentional dental replantation. Despite its high failure rate, this procedure is still recommended in the literature today, given the presumed greater reliability of prosthetic implants [Norgaard et al., 2022; Mainkar et al., 2017]. The systematic review by Day et al. [2019] serves as the reference study for this scoping review, which particularly analyses subsequent literature to address

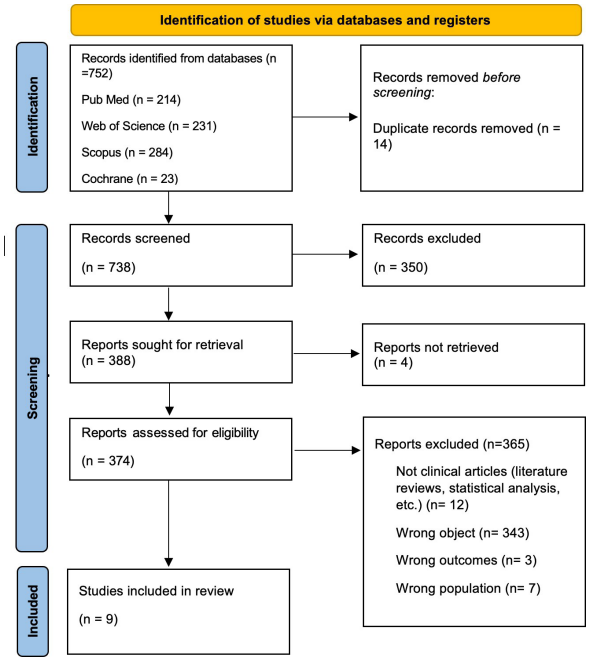

FIG.1 A PRISMA flow diagram for the search methodology employed for this systematic review.

unresolved issues that affect daily clinical practice. Each individual clinical case presents a challenge for dentists, requiring them to make precise decisions, predict outcomes, and communicate the most probable prognosis to the patient. Furthermore, this study proposes a treatment flowchart that considers various decision-making factors, supporting dentists in their clinical approach by identifying predictive prognostic indices. Finally, the study highlights the link between dental trauma and poor oral health conditions, which can be indicators of neglect in children [Bradbury-Jones et al., 2020; Zerman et al., 2024]. This is also demonstrated by the correlation between mothers' and their children's oral health and a lack of awareness about the crucial role of prevention in dental health [Ludovichetti et al., 2022; Tomasin et al., 2015].

MATERIALS AND METHODS

A comprehensive search of the English language literature was conducted using the Pubmed-Medline, Scopus, WoS and Cochrane databases. The search was based on the keywords "tooth avulsion" and/or "tooth replantation" and/or "tooth ankylosis". Inclusion criteria included all studies conducted from January 2018 to February 2024. Seven hundred fifty-two articles were identified (Fig. 1). Screening for the scoping review resulted in the inclusion of 9 systematic reviews including 3 meta-analyses (Table 1).

Variables Influencing The Prognosis Of Intentional Post-Avulsion Replantation

The systematic review by Day et al. 2019] considers four studies that propose different therapeutic choices for avulsed and replanted permanent front teeth. The quality of the scientific evidence in this systematic review on the treatment variables influencing the prognosis of replanted teeth, compared to controls, appears to be very low and leaves numerous issues unresolved. Given the clinical importance of some of these variables and the uncertainty of their effectiveness, our study sought confirmation in the most recent systematic reviews, aiming to contribute to the un-

	Type of study	Total survey	Studies recruited	Study object	Results / Reported evidence	References
1	Systematic review	266	4	To compare the effects of a range of interventions for managing traumatised permanent front teeth with avulsion injuries.	Results:None of the four studies investigated the same intervention. Therefore, it was not possible to combine the results and each study was evaluated individually. Conclusion: There is insufficient evidence to support or refute the effectiveness of different interventions for avulsed and replanted permanent front teeth. The overall quality of existing evidence was very low, therefore great caution should be exercised when generalising the results of the included trials. There is urgent need for further well-designed randomised controlled trials.	Day, P. F. et al. [2019]
2	Systematic review	999	6	Implant treatment To provide an overview on the outcome of dental implant treatment in the anterior maxilla after traumatic tooth loss, based on a systematic review of the existing evidence	Results: 96 patients with 120 implants were included. The age ranged from 18 to 59 years. The survival rates of implants and superstructures were 97% and 95%, respectively, after a mean followup of 3.5 years. Complication rates were 7% and 11% on implant and superstructure level, respectively. The maxillary central incisor was the most frequently replaced tooth (70). Conclusion: This systematic review revealed a low level of evidence on the outcome of dental implant treatment after traumatic tooth loss. Systematic reporting of treatment outcomes of tooth replacements after dental trauma is highly encouraged to further guide dentists for the benefit of these challenging patients.	Nørgaard Petersen et al.[2022]
3	Meta- analysis	1507	23	Incidence of root resorpiton to evaluate the incidence of root resorption after the replantation of avulsed teeth.	Results: A meta-analysis showed that the incidence of internal root resorption was 1.2% Regarding external root resorption, the incidence of surface root resorption was 13.3% that of inflammatory root resorption was 23.2% and that of replacement root resorption was 51.0%. The overall level of evidence identified was very low. Conclusion: The incidence of root resorption after avulsion and replantation in descending order was replacement root resorption > inflammatory root resorption > surface root resorption > internal root resorption.	Souza B. et al. [2018]
4	Systematic review	5701	15	Storage media The efficacy of different storage media used for the survival of PDL cells of avulsed teeth in the in vitro setting	Results: For storage up to 2 hours, H BSS, DMEM, milk, 1 0 % propolis, 20% propolis, and Viaspan conserved more than 80% of PDL viability. For storage at 24 hours, Viaspan showed best cell survival at 88.4 %, followed by DMEM (70.9%) and 10% propolis (68.3%). Milk and HBSS showed similar PDL survival at 24 hours (57.2% and 57.3%, respectively). Conclusion: Milk remains the most convenient, cheapest, and readily available solution in most situations while also being capable of keeping PDL cells alive. Further studies are required to evaluate the efficacy of more commonly found storage media besides milk.	Osmanovic A. Et al. [2018].
5	Systematic review & Meta-analysis	4118	33	Storage media the best available evidence for the effectiveness of any technique available to laypeople for storing an avulsed tooth compared with storage in milk or saliva	Results: There is insufficient evidence to recommend for or against temporary storage of an avulsed tooth in saliva compared with alternative solutions. The certainty of evidence was considered low to very low due to limitations in study design, indirect study populations and outcome measures, and imprecision. Conclusion: Although milk was shown to extend the periodontal ligament cell viability before replantation compared with saline or tap water, the following media have also demonstrated efficacy at preserving the cell viability: Hank's balanced salt solution, propolis, oral rehydration salts, rice water, and cling film.	De Brier et al. (2020).
6	Systematic review	2361	35	Storage media: The aim of this study was to evaluate the effect of plants on the tissue repair following tooth replantation.	Results: The evaluated plants had a potential effect on cell viability and proliferation. The articles evaluated mainly the action of plants on cells of the periodontal ligament. Propolis, coconut water and Aloe vera were the most common storage medium. Conclusion: The methodological l imitations persist, and the evaluation of the pharmacological potential of plants on dental tissues still requires more research.	Resende et al. [2020]
7	Systematic review	804	9	Systemic Antibiotics: The evidence on effectiveness and harms of the administration of systemic antibiotics at replantation of avulsed permanent teeth.	Results: The meta-analyses showed non-significant associations between the administration of systemic antibiotics on the one hand and tooth survival. Conclusion: Currently there is no high-quality evidence to support the use of systemic antibiotics at replantation of avulsed permanent teeth. Hence, their routine use cannot be recommended in medically fit patients. Well- designed RCTs should be a priority on the research agenda.	Bourgeois et al. [2022]
8	Systematic review	65	5	Emdogain vs ankylosis: The main purpose of the present systematic review was to evaluate the efficacy of enamel matrix derivative Emdogain in healing of replanted teeth in humans.	Results: The uneventful healing of replanted teeth was varied from 20% to 75%. Two controlled trials found Emdoga in treatment significantly reduced resorption of replanted teeth and improved the healing of periodontal ligament compared with controls. Two studies showed high recurrent resorption in Emdogain treated teeth. Conclusion: To conclude, the number of publications that met all inclusion criteria were limited and did not allow for drawing evidence for Emdogain being effective in supporting healing of replanted teeth.	Mohamed et al [2019].
9	Meta- analysis	472	20	Storage Media: Which medium is the optimal option for the storage of avulsed teeth to preserve the viability of periodontal ligament (PDL) cells before replantation?	Results: HBSS was superior to ORS, milk, saline, and water, ORS was superior to milk but inferior to coconut water and propolis, egg white was superior to milk but inferior to AVG and propolis, propolis was superior to AVG, milk, and saline, and coconut water and water was inferior to saline and milk, respectively. Propolis may be the optimal media for storing avulsed teeth before replantation. However, given the availability of propolis and HBSS and the hypotonic properties of saline, ORS or milk should also be preferentially selected. Conclusion: Based on limited available evidence, we conclude that propolis may be the preferred storage media for storing avulsed teeth for the purpose of preserving the viability of PDL cells before replantation when it is available to actual settings. However, given the availability of propolis and HBSS in real settings of occurring t raumatic injuries and the hypotonic properties of saline solution, ORS or milk should also be preferentially selected to store an avulsed tooth as a media.	Zhang, N.et al.[2021]

TAB. 1 Systematic reviews and meta-analyses included in the study.

derstanding of the hierarchy of therapeutic choices for managing replanted teeth to improve their prognosis. The variables influencing the prognosis of intentional post-avulsive replantation are essentially of two types: factors that do not depend on therapeutic choices and factors that do depend on therapeutic choices (Table 2). The factors that do not depend on therapeutic choices include: the extra-oral time before replantation, damage to the periodontal ligament and cementum due to trauma, the storage medium for preserving the avulsed tooth, and whether the avulsed tooth has an open or closed apex. When evaluating the prognosis of replantation after an avulsion, the time spent outside the socket, known as extra-oral time, is a crucial factor as it significantly affects pulpal and periodontal tissue damage. According to Andreasen et al. [2002], replantation is considered delayed if it occurs beyond the first 24 hours after trauma, subacute if within the first 24 hours, and acute if within the first 2 hours. However, a favourable prognosis is not guaranteed in any of these cases. The current "gold standard" is intentional replantation within minutes of trauma, preferably within 30 minutes, as recent studies have shown that this offers the best prospects for success [Plotino et al., 2020; 2021; 2022]. Within the first 2 hours, the prognosis remains acceptable but with a lower chance of success. After this period, replantation becomes much riskier, with a reduced possibility of pulp revascularisation and an increased risk of root resorption [Souza et al., 2018] (Table 1). Although some studies report positive results even with delayed treatments, with follow-up periods of up to 4 years [Ulfat et al., 2021; Ionta et al., 2018], in general, when the extra-oral time exceeds 30 minutes, the prognosis is always uncertain by definition (Table 3). Damage to the periodontal ligament and cementum caused by the trauma itself represents another critical factor that can lead to complications in the follow-up of replanted teeth. Complications such as ankylosis, external cervical resorption, and inflammatory root resorption are commonly described in recent studies [Hasanuddin et al., 2018; Patel et al., 2018; Albertsson et al., 2021; Chen et al., 2021]. Ankylosis, a condition where the tooth fuses with the surrounding bone, may be the only way for a late replanted tooth with a compromised periodontal ligament to survive for an extended period after replantation. However, ankylosed teeth lose normal mobility and do not have a functioning periodontal ligament. Ankylosis is not considered a benefit but rather a complication, as it can negatively impact the success of dental replantation. When a tooth becomes ankylosed, it loses its ability to adapt to changes in occlusion and bone growth, leading to root resorption and eventual tooth loss. The use of Emdogain, a product containing enamel matrix derivatives, has been studied for its potential to promote periodontal regeneration and prevent ankylosis in replanted teeth. However, clinical studies by Schjøtt and Andreasen in 2005 and a review by Mohamed et al. in 2019 suggest that Emdogain may not be effective in preventing progressive root resorption after the replantation of avulsed teeth (Table 1). The storage medium used to preserve an avulsed tooth prior to intentional replantation is another crucial aspect for maintaining the viability of periodontal ligament (PDL) cells and thus affects the prognosis of replantation. The systematic review conducted by Osmanovic et al. in 2018 supports the effectiveness of milk as a storage medium for avulsed teeth. A more recent systematic review by De Brier et al. in 2020 (Table 1) indicates that other mediums, such as Hank's balanced salt solution, propolis, oral rehydration salts, and rice water, may be equally effective alternatives to milk for preserving the viability of periodontal ligament (PDL) cells.

Further research is needed to evaluate the effectiveness and safety of plant-based preservatives, such as aloe, propolis, and coconut water, for avulsed teeth [Resende et al., 2020]. The presence of an open or closed apex in avulsed permanent teeth affects pulp healing and the prognosis following replantation. Andreasen et al. [1995] studied 400 replanted avulsed permanent incisors and demonstrated that teeth with an open apex have a better prognosis than those with a closed apex. When the tooth root is not yet fully formed, revascularisation and root development are better promoted after replantation. Factors that depend on therapeutic choices include the timing of pulp extirpation in avulsed and replanted teeth, which can significantly influence outcomes and complications during follow-up. A study conducted by Hinckfuss and Messer in 2009 examined the results of extra-oral and intra-oral pulp extirpation at different time points, comparing 12-month outcomes such as periodontal healing, tooth survival, root resorption, and coronal discoloration. The study found that extra-oral pulp extirpation on day 0 was more effective compared to intra-oral pulp extirpation on day 7. The study by Giannetti et al. [2019] also reported better results for extra-oral endodontic treatment, which may seem unexpected considering that this approach further prolongs the time the tooth is out of its socket. According to current clinical guidelines from the International Association of Dental Traumatology [Fouad et al., 2020], pulp extirpation should be performed intra-orally within 10–14 days of replantation. This approach strikes a balance between addressing potential pulpal complications and allowing for possible revascularisation of the tooth, while also ensuring the best chances of periodontal tissue healing. Complications anticipated during follow-up for pulp damage include discoloration, inflammatory internal resorption, and obliteration of the pulp canal [Day et al., 2011; Day et al., 2012; Abd-Elmeguid et al., 2015; Al Khayyal et al., 2021]. These complications can significantly impact the long-term prognosis of the replanted tooth and the overall treatment outcome. The type and duration of splinting play a crucial role in the stabilisation and protection of teeth after replantation, creating favourable conditions for the regeneration of supporting tissues [von Arx et al., 2001]. A recent review by Sobczak-Zagalska and Emerich [2020] examined the effectiveness of different types of splinting and the optimal time for their removal, providing an updated perspective on splinting strategies in dental replantation. Additionally, a study by Moon et al. in 2022 compared elastic and rigid splinting, inves-

Factors that do not depend on therapeutic choices:
the extra-oral time before replantation
damage to the periodontal ligament and cementum due to trauma
the storage medium of preservation of the avulsed tooth
the open or closed apex of the avulsed tooth
Factors that depend on therapeutic choices
the extirpation of the extra-oral or intra-oral pulp
the type and duration of the splinting
systemic antibiotics
hyperbaric oxygen
intra-canal medications such as Ledermix compared to Ultracal and calcium hydroxide
treatment of pre-replantation avulsed tooth: Thymosin alfa 1e, emdogain
the decoronation
To which are added the independent factors: the condition of the avulsed tooth and surrounding tissues, the patient's oral health and compliance

TAB. 2 Variables influencing the prognosis of intentional post-avulsive replantation.

tigating their efficacy in cases of delayed replantation. The study suggests that rigid splints are more effective in instances of delayed replantation, where the extra-oral period is prolonged and greater stability is crucial to prevent unwanted movements during the critical healing phase, similar to the management of root fractures, including those of deciduous teeth [Spinas et al., 2022]. On the other hand, elastic splints are preferred for their flexibility and gentle support in immediate replantation, aiming to optimise healing chances and long-term survival. Digital dental models can aid in defining clinical choices [Zotti et al., 2022]. The use of systemic antibiotics in cases of dental trauma, especially post-replantation, has been a topic of debate in the literature. A study by Hinckfuss and Messer in 2009 did not provide significant evidence to support the routine use of systemic antibiotics in such scenarios. However, despite the lack of conclusive evidence, current guidelines recommend prescribing systemic antibiotic therapy as a precautionary measure. A systematic review by Bourgeois et al. in 2022 concluded that while systemic antibiotic administration is considered prudent, it may not be necessary in all cases. The decision to prescribe systemic antibiotics ultimately lies with the clinician, who should carefully assess the individual case, taking into account various factors such as the patient's overall health, the extent of the injury, the presence of concomitant infections, the risk of complications, and antibiotic resistance (Table 1). Hyperbaric oxygen therapy has been investigated for its potential benefits in managing dental trauma, including avulsed teeth. This therapy involves breathing pure oxygen in a hyperbaric chamber, aiming to increase oxygen concentration in injured tissue and promote healing. However, there is currently no specific evidence regarding the efficacy of hyperbaric oxygen therapy [Day et al., 2019] on periodontal healing, tooth survival, and pulp healing at 12 months. Further well-designed randomised controlled trials are necessary to evaluate their effectiveness. A study conducted by Day et al. in 2012 compared the intra-canal use of Ledermix and Ultracal on days 0-10 and 7-10, respectively. According to this study, the use of Ledermix was associated with more significant grey-brown discoloration of replanted teeth, while Ultracal resulted in more yellow discoloration. Dyschromia is an important consideration in dental trauma cases as it can impact aesthetics and patient satisfaction post-replantation. However, further research and clinical studies may be required to confirm and validate these findings and explore additional factors influencing the choice between Ledermix and Ultracal in dental trauma management. The use of calcium hydroxide as an intra-canal dressing in cases of inflammatory root resorption and post- traumatic ankylosis has also been recently studied by Zare et al. in 2019. This study indicated that there is currently insufficient evidence from clinical trials to draw definitive conclusions about its effectiveness. The recent review conducted by Krastl et al. in 2022 aims to update the endodontic management of traumatic injuries to permanent teeth and identify relevant research areas to improve diagnosis and treatment of traumatised teeth. It emphasises the importance of new diagnostic methods to detect root resorption early and proposes timely endodontic interventions through the use of intracanal anti-resorption dressings in cases of post-traumatic pulp necrosis and inflammatory root resorption. Thymosin alpha 1, a synthetic version of a peptide naturally present in the thymus gland, has been studied for its potential therapeutic effects, including its ability to modulate immune responses and promote tissue repair. However, the study conducted by Loo et al. in 2008 shows very low-quality evidence to support the benefits of soaking the avulsed tooth in thymosin alpha 1 prior to replantation, particularly concerning periodontal healing and tooth survival. Similarly, the study by Day et al. in 2019 compares the use of thymosin alpha 1 with saline treatment. This study indicates some evidence of benefit from thymosin alpha 1 regarding periodontal healing and tooth survival. However, it is important to note that this study carries a high risk of bias. Overall, there is insufficient evidence to confirm or refute the effectiveness of different therapies for avulsed and replanted permanent front teeth. The quality of existing evidence has been rated as very low, emphasising the need for caution in extrapolating the findings of these studies. Further, well-designed randomised controlled trials are urgently needed. Decoronation, a surgical procedure employed when replantation of an avulsed tooth results unfavorably in root resorption, ankylosis, or severe root fractures, involves the removal of the dental crown while retaining the root within the alveolus. This preserves the surrounding bone tissue for potential future prosthetic or implant solutions and aids in maintaining the volume and shape of the alveolar bone. The decision to perform decoronation should be an integral component of a comprehensive and well-informed treatment plan, taking into account the patient's overall oral health, anticipated future treatment needs, and expectations [Ionta et al., 2018; Zhang et al., 2021].

Disadvantages And Advantages Of Replanting

The necessary involvement of the patient and guardian in the decision-making process can pose a challenge. Replantation involves surgery and necessitates interdisciplinary management, leading to multiple appointments and high direct costs. Additionally, there are significant indirect costs for the child and family, such as lost school and work hours, and travel time to and from the clinic. On average, 7.2 hours are dedicated in the first year for visits, excluding time for x-rays, interdisciplinary evaluation visits, denture fabrications, and orthodontic treatment, as indicated by Glendor in 2001. The cost-effectiveness ratio compared to single-tooth implants, as studied by Mainkar in 2017, is unfavourable. Obliteration of the pulp canal after replantation of avulsed immature teeth is highly frequent, occurring in up to 67.1% of cases, and often develops rapidly during the first year, as demonstrated by Abd-Elmeguid in 2016. Replantation can present complications, such as the management of ankylosis in children and adolescents, as discussed by Ionta in 2018. Despite these challenges, replantation offers several advantages. It allows for immediate restoration of the appearance and function of the affected tooth, addressing the absence of a front tooth which has long been considered an undesirable feature, as mentioned by the Royal College of Surgeons in 1997. Studies by Vlok in 2011 suggest that replantation can enhance self-esteem and improve overall social interaction among peers, as well as positively influence perceptions in photographs after dental trauma. Moreover, replantation can mitigate the negative impact on quality of life that trauma may cause and that may persist beyond a year, as discussed by Berger in 2009. In summary, replantation presents various benefits, including the immediate restoration of appearance and function, potential positive impacts on self-esteem and social interaction, and the potential to improve overall quality of life, especially in young individuals, following dental trauma.

Follow Chart And Predictive Prognostic Indices

The proposal of a flow diagram that identifies some prognostic indices to calculate the probability of success of a post-avulsion replantation, could provide a clearer picture to the clinician regarding the prognostic risk in individual cases of post-avulsion replantation. However, it is important to consider that the prognosis of a replantation depends on multiple interconnected factors and which can vary considerably from case to case. The prognostic indices of the proposed flow diagram are: the extra oral time (less

	Extra oral time		Extra oral time		Extra oral time	
	< 30 seconds		Within 2 hours		> 2 hours	
	Score		Score		Score	
Suitable storage medium	0	Replantation	1	Replantation	2	Replantation
Normal occlusion	0	Replantation	1	Replantation	2	Replantation
Normal adjacent teeth	0	Replantation	1	Replantation	2	Replantation
Good compliance	0	Replantation	1	Replantation	2	Replantation
	ALARM 0		ALARM from 1 to 4		ALARM from 2 to > 5	
Stored dry	1	Replantation after treatment	3	Replantation after treatment	5	Replantation after treatment
Malocclusion	1		2		3	
Compromised adjacent teeth	1		2		3	
Poor Compliance	5	Replantation ??	5	Replantation ??	5	Replantation ??
	ALARM from 1 to > 5		ALARM from 3 to > 5		ALARM from 3 to > 5	
LEGEND Alarm 0: green zone: regular follow-up and prognosis Alarm 1 to 4: orange zone: intensified follow-ups and doubtful prognosis Alarm => 5: red zone: personalised follow-ups and very uncertain prognosis						

TAB. 3 Flowchart and predictive prognostic indices.

than 30 minutes, less than 2 hours or greater than 2 hours), the storage medium (appropriate or dry), the patient's compliance (good or poor), the occlusion (normal or pathological) and the state of the adjacent teeth (normal or compromised). By assigning an arbitrary score from 1 to 5 to each index, based on the extra-oral time, three alarm zones are configured, which correspond to the overall level of risk associated with that replantation. Green zone, zero alarm, in which the sum of the various indices is zero and equals regular follow-ups and a presumably favourable prognosis. Orange zone, alarm from 1 to 4, in which the sum of the indices varies between 1 and 4 and is equivalent to cases in which the replantation requires additional treatments and the follow-up must be intensified and the prognosis is doubtful. Red zone, with an alarm greater than or equal to 5, in which the sum of the indices is greater than or equal to 5 and is equivalent to cases in which the replantation requires additional treatments and the follow-up must be personalised and the prognosis is very uncertain. When compliance is poor, replantation may not be indicated. This diagram can be used as a decision support tool for the clinician, allowing them to more immediately evaluate the probability of success and consequently inform the patient and caregiver in an adequate and facilitated way, without the risk of creating false expectations and illusions of a favourable prognosis. However, it is important to underline that regardless of the predictive prognostic indices, the decision to perform a replantation should be based on the dentist's clinical experience, the patient's informed consent and an in-depth analysis of each case that considers all the other clinical variables that influence the prognosis of intentional post-avulsive replantation (Table 2). Furthermore, predictive prognostic indices should be subject to continuous updates and improvements based on new scientific evidence and clinical practice. This proposal is expressed in Table 3.

DISCUSSION

The success of replantation appears to hinge largely on the preservation of periodontal ligament (PDL) cells, which are pivotal for the revascularisation and healing of the PDL itself. Delayed replantation leads to the deterioration of PDL cells, diminishing the likelihood of establishing a healthy attachment between the tooth and surrounding bone. Delayed replantation of an avulsed tooth, compounded by inadequate storage, is associated with the poorest prognosis. Studies conducted by Andreasen et al. in 1995 had already acknowledged the complications for pulp and periodontal tissue resulting from the delayed replantation of avulsed teeth, yet the recommendation remained for replantation regardless of storage conditions. Lauridsen with Andreasen et al. in 2020 reassessed long-term clinical studies from 1995, emphasising the link between the duration of dry storage and significantly diminished chances of long-term survival. Timely replantation alone maximises the prospects of periodontal ligament healing and long-term success, irrespective of the preservation medium or stage of root development [Albertsson et al. 2021]. Nonetheless, treatment decisions, such as the timing and method of pulp extirpation and the type of splinting, can also exert considerable influence on the ultimate outcome. A study by Wang et al. in 2019 underscores the importance of meticulously evaluating and regulating occlusal forces on the replanted tooth to minimise potential trauma to the periodontal ligament and foster optimal healing. This reduces the risk of complications such as ankylosis or root resorption, thereby enhancing the long-term prognosis of the replanted tooth. Treatment decisions need to be tailored, taking into account the severity of the trauma, the condition of the avulsed tooth and surrounding tissues, as well as the patient's oral health and compliance.

CONCLUSIONS

In conclusion, timely replantation stands as a pivotal factor in optimising prognosis and ensuring long-term success. Nevertheless, the decision between replantation and alternative treatment options should be predicated upon a comprehensive evaluation of each individual case, aimed at securing the best possible outcome for the patient. Future research endeavors should prioritise the development of diagnostic methodologies for assessing pulp perfusion and identifying early indications of root resorption. Additionally, there should be a focus on enhancing materials used to address both vital and post-traumatic necrotic pulp, particularly through the refinement of intra-canal anti-resorptive dressings. Advancements in these areas hold promise for enhancing treatment protocols and prognosis, particularly in cases involving delayed replantation and suboptimal preservation of avulsed teeth. The systematic review conducted by Nørgaard Petersen and colleagues in 2022 underscored the importance of systematically documenting the biological, technical, and aesthetic outcomes of dental implant treatment subsequent to tooth avulsion. Such comprehensive reporting facilitates an understanding of prognostic factors and enables evidence-based treatment decisions, ultimately fostering improved patient care by aligning patient expectations with realistic outcomes. Lastly, it's essential to underscore the link between dental trauma and poor oral health conditions, which can serve as indicators of neglect in children. This association is further supported by the correlation observed between a mother's oral health and that of her children, highlighting a lack of awareness regarding the critical role of prevention in dental health.

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