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Management of the Avulsed Tooth in Emergency and Prehospital Care

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Abstract

Background: Tooth avulsion, the complete displacement of a tooth from its socket, is a serious dental emergency, predominantly affecting the maxillary anterior teeth in children and adolescents. Its management is time-critical, as the viability of the periodontal ligament (PDL) cells on the root surface and the long-term prognosis are heavily dependent on immediate and appropriate prehospital and emergency care.

Aim: This article reviews the etiology, pathophysiology, and, most importantly, the evidence-based emergency and prehospital management protocols for avulsed permanent teeth, with the goal of optimizing outcomes through timely intervention.

Methods: A comprehensive narrative review synthesizes current guidelines from dental traumatology, focusing on the critical steps from the moment of injury to definitive dental care. It examines the importance of storage media, handling techniques, replantation procedures, and adjunctive therapies.

Results: Immediate replantation at the site of injury is ideal. When not possible, storing the tooth in a physiologically compatible medium like milk or saline is essential to preserve PDL cell viability. The extraoral dry time is the single most critical prognostic factor; dry storage beyond 60 minutes drastically increases the risk of root resorption and ankylosis. Management involves gentle cleansing, possible anti-resorptive pre-treatment, careful replantation, semi-rigid splinting for approximately two weeks, and systemic antibiotics (e.g., doxycycline). Long-term success requires diligent follow-up, including pulp vitality testing and timely endodontic treatment for mature teeth.

Conclusion: Successful management of an avulsed tooth hinges on a coordinated, rapid response. Public and professional education on proper first-aid (crown handling, use of milk) is vital to improve outcomes. Adherence to established protocols for replantation, splinting, and follow-up care maximizes the potential for long-term tooth retention, preserving function and alveolar bone.

Keywords: Tooth Avulsion, Dental Trauma, Replantation, Periodontal Ligament, Storage Media, Splinting, Emergency Management.

Introduction

Dento-alveolar trauma encompasses a spectrum of injuries resulting from the application of external mechanical forces to the teeth and their supporting tissues. These insults may be confined to the dental hard tissues and periodontal ligament or may extend to involve the surrounding alveolar bone and soft tissues of the oral cavity. Clinically, such trauma ranges from minor, reversible injuries, such as simple tooth contusions or subluxations, to severe and complex lesions, including complete displacement of the tooth from its socket. This latter entity, known as tooth avulsion, represents one of the most dramatic and relatively infrequent forms of dental trauma, typically illustrated by cases involving the upper anterior teeth, such as the maxillary central incisors. Because avulsion generally requires the application of a substantial traumatic force, its occurrence frequently signals the possibility of concomitant injury to adjacent oral and maxillofacial structures. Accordingly, when an avulsed tooth is identified, the clinician must maintain a high index of

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suspicion for associated damage, including fractures of the alveolar bone, periodontal ligament disruption, and gingival lacerations or contusions.[1] A meticulous clinical and radiographic assessment is therefore indispensable to delineate the full extent of injury and to formulate an appropriate, comprehensive treatment plan. Within this context, immediate and well-coordinated management of an avulsed tooth is critical to optimizing both functional and esthetic outcomes. Replantation of the avulsed tooth into its original socket remains the treatment of choice in most cases, particularly when dealing with permanent dentition. The success of this procedure, however, is highly time-sensitive and strongly influenced by the conditions under which the tooth is handled and stored prior to reimplantation. Extra-alveolar dry time and the preservation medium are key determinants of periodontal ligament cell viability; prolonged desiccation or inappropriate storage can greatly increase the risk of inflammatory root resorption, ankylosis, and eventual tooth loss. For this reason, immediate replantation at the site of trauma, when feasible, is advocated as the ideal scenario. When immediate replantation is not possible, placement of the tooth in physiologic storage media—such as milk, saline, or specialized preservation solutions—is recommended to maintain cellular integrity until definitive care can be provided.[1]

In recent years, advances in pharmacologic adjuncts have contributed to improved outcomes in the management of avulsed teeth, particularly with respect to the prevention of root resorption. Anti-resorption therapy has emerged as an important component of modern treatment protocols, aiming to mitigate the inflammatory cascade that frequently follows traumatic avulsion and subsequent replantation. This approach typically involves the topical or systemic administration of agents such as antibiotics and corticosteroids, designed to modulate the host inflammatory response and inhibit osteoclastic activity at the root surface. In addition, stabilization of the replanted tooth is achieved through flexible splinting, which provides sufficient immobilization to facilitate periodontal and pulpal healing while preserving physiological tooth mobility. The choice of splinting technique and duration must be tailored to the specific clinical circumstances, including the presence of alveolar fractures, the maturity of the root, and the overall condition of the periodontal tissues.[1] Systemic antibiotic therapy is often prescribed to reduce the risk of infection and to further support healing, particularly in cases where the extraoral time has been prolonged or the trauma occurred in a contaminated environment. Long-term success following replantation of an avulsed tooth depends not only on optimal acute management but also on diligent follow-up and ongoing clinical surveillance. Scheduled review appointments are essential for monitoring the healing trajectory of the periodontal ligament and dental pulp and for the early detection of complications such as pulp necrosis, external or internal root resorption, and ankylosis. These evaluations must integrate both clinical examination and radiographic imaging, as radiographic changes may precede obvious clinical signs. Sensibility testing, percussion assessment, and evaluation of tooth mobility and periodontal status provide additional information regarding tooth vitality and functional integration. Endodontic treatment is frequently required, particularly in mature teeth with closed apices, to prevent or manage infection-related resorption and to enhance the long-term prognosis of the replanted tooth. Through this combination of prompt, evidence-based acute care, adjunctive pharmacologic therapy, appropriate splinting, and rigorous follow-up, it is often possible to preserve the avulsed tooth for a considerable period, thereby maintaining occlusal function, esthetics, and alveolar bone volume, and delaying or avoiding the need for prosthetic replacement.[1]

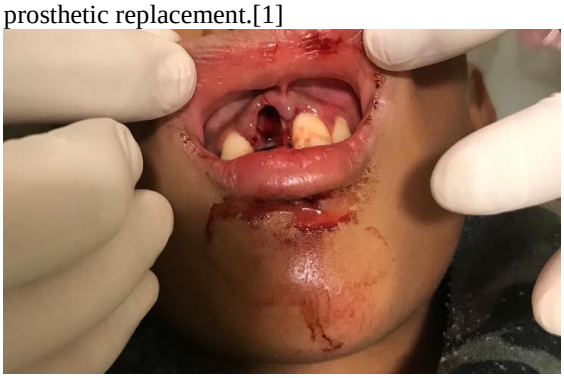

Fig. 1: Tooth Avulsion.

Etiology

Dentoalveolar trauma arises from a variety of external mechanical insults that act directly on the teeth and their supporting structures. The most frequently implicated etiologic factors include accidental falls, particularly in young children, cycling accidents, participation in full-contact or high-impact sports, road traffic collisions, and interpersonal violence or assault. These incidents typically occur in everyday environments such as the home, school, playgrounds, and organized sports facilities, reflecting the close relationship between normal childhood and adolescent activities and the risk of orofacial injury. The domestic environment, where supervision may be intermittent and children are highly active, is a common setting for falls from furniture, stairs, or play equipment, all of which can result in direct impact to the anterior maxillary region. Similarly, in school and sports contexts, collisions with other children, sports equipment, or hard surfaces can readily transmit sufficient force to damage the dentoalveolar complex. Beyond external circumstances, a number of intrinsic anatomical and occlusal characteristics significantly increase susceptibility to dentoalveolar trauma. Protrusive

maxillary incisors, often described as “protuberant” upper front teeth, are more exposed to direct impact and thus more vulnerable to injury.[2][3] An increased overjet, particularly greater than 3 mm, places the upper incisors in a more forward position relative to the lower teeth, effectively removing the protective influence of the lips and mandible and making them a frequent target of trauma.[2][3] Anterior open bite and Class II malocclusion similarly alter the spatial relationship between the upper and lower jaws, further exposing the maxillary anterior teeth. Incompetent lip seal, in which the lips do not naturally close at rest, deprives the dentition of a critical soft tissue barrier that usually helps dissipate or redirect traumatic forces. Mouth breathing, often associated with adenotonsillar hypertrophy, allergic rhinitis, or craniofacial growth patterns, can exacerbate lip incompetence and contribute to a protrusive dental appearance.[2][3] These anatomical and functional features collectively create a biomechanical context in which traumatic forces are more likely to be concentrated on the maxillary anterior teeth, particularly the central and lateral incisors. The absence of adequate soft tissue coverage and the forward positioning of the incisors reduce the capacity of facial tissues to absorb or distribute impact energy, increasing the likelihood of luxation injuries, fractures, and complete avulsion. Thus, dentoalveolar trauma reflects an interplay between environmental exposures and individual anatomical risk factors. Recognition of these predisposing features is essential not only for risk stratification and preventive counseling but also for early orthodontic or interceptive interventions that may reduce exposure of vulnerable teeth and thereby lower the overall incidence and severity of trauma.[2][3]

Epidemiology

The epidemiologic profile of dentoalveolar trauma indicates a distinct age and sex predilection, as well as characteristic patterns of injury distribution. The peak incidence of dental trauma is observed in children between 7 and 11 years of age, a period marked by increased physical activity, participation in sports, and relative risk-taking behavior, coupled with incomplete neuromuscular coordination.[2][3] In this age group, boys are affected approximately twice as often as girls, yielding a male-to-female ratio of about 2:1.[2][3] This discrepancy is commonly attributed to higher levels of engagement in vigorous play and contact sports among boys, although changing social patterns may influence this difference over time. With respect to dentition type, permanent teeth are injured more frequently than primary teeth, with epidemiologic data suggesting that approximately 60% of traumatic injuries involve permanent dentition, compared to 40% affecting the primary dentition.[2][3] This is particularly relevant in the mixed dentition phase, when newly erupted permanent incisors are prominent, less mineralized, and more susceptible to trauma. In one study evaluating 800 children aged 11 to 13 years, slightly more than half reported a history of trauma involving the permanent anterior teeth, and notably, nearly 10% did not recall a specific traumatic incident, highlighting that some injuries may go unnoticed or be perceived as minor at the time of occurrence. Another investigation of 1298 trauma patients treated in an emergency department found that 24% had dental injuries, and among these, roughly two-thirds were tooth avulsions, underscoring the frequency with which avulsion forms part of the injury spectrum in acute trauma settings.

In terms of causative events, falls represent the single most common mechanism of dental trauma, followed by cycling accidents, full-contact or collision sports, and assaults.[4][5] Epidemiologic studies in athletic populations have further delineated the risk associated with sports participation. Bemelmans reported that at least 32% of athletes engaged in full-contact sports have sustained some form of injury to their dentition, indicating that a substantial proportion of sports-related orofacial injuries involve the teeth.[4][5] High-risk sports for dental trauma include ice hockey, American football, lacrosse, rugby, martial arts, and various forms of skating, all of which involve rapid movements, physical contact, and potential falls on hard surfaces. Interestingly, while helmets and face shields have proven highly effective in preventing head injuries and facial fractures, they have not consistently reduced the incidence of dental trauma, likely because they do not fully protect the anterior dentition. By contrast, the routine use of appropriately fitted mouthguards has been clearly associated with a reduction in dental injuries across multiple sports.[4][5] In younger children, particularly those below school age, dentoalveolar trauma warrants careful scrutiny for possible non-accidental injury. Trauma in this group may occur in contexts not typically associated with high-impact play, and patterns of injury may be inconsistent with the reported mechanism. Consequently, dental trauma in very young children should raise a reasonable suspicion of physical abuse, prompting a thorough, multidisciplinary assessment.[4][5] Overall, the epidemiology of dentoalveolar trauma reflects a complex interaction between age-related behavior, environmental exposure, and preventive measures, emphasizing the importance of targeted education and protective strategies in high-risk populations.

Pathophysiology

The pathophysiology of tooth avulsion and related dentoalveolar injuries is fundamentally rooted in the structure and biomechanics of the periodontal ligament (PDL) and its interface with the alveolar bone and root surface. The PDL is a specialized

connective tissue that anchors the cementum covering the tooth root to the surrounding alveolar bone, providing both mechanical support and a shock-absorbing function during mastication and minor trauma. When a significant external impact is applied to a tooth, the magnitude and direction of the force may exceed the tensile strength of the periodontal fibers. This results in partial tearing or complete rupture of the PDL and can permit luxation or total displacement of the tooth from its socket. In the case of avulsion, the tooth is completely extruded from the alveolus, leaving an empty socket and exposing the root surface and attached PDL to the external environment.[6][2][3] The initial injury frequently entails not only disruption of the PDL but also damage to the neurovascular bundle entering the tooth through the apical foramen. This trauma can interrupt the blood supply to the dental pulp, predisposing to ischemia and subsequent pulp necrosis. Clinically and epidemiologically, the maxillary central incisors are most commonly affected by avulsive injuries, followed by the maxillary lateral incisors, reflecting their anterior position and relative exposure to direct impact.[6][2][3] Avulsion often involves more than one tooth, particularly when the traumatic force is broad-based or when the impact occurs in high-velocity accidents such as sports collisions or road traffic incidents. The viability of the PDL cells on the root surface is a critical determinant of long-term prognosis. Once a tooth is avulsed and exposed to air, PDL fibers begin to desiccate rapidly. Even brief periods of extraoral dry time can lead to substantial cellular damage. If the tooth is not promptly replanted or stored in an appropriate medium, the PDL cells may undergo irreversible necrosis. When a tooth with compromised PDL viability is replanted, the healing response may be dominated by inflammatory and replacement resorption rather than regeneration of a functional ligament. Inflammatory root resorption arises when damaged root surfaces are colonized by osteoclasts and associated inflammatory cells, leading to progressive loss of root structure. Replacement resorption, or ankylosis, occurs when the root surface fuses directly to the alveolar bone, eliminating the PDL space and leading to gradual resorption of the root and its substitution by bone.[6][2][3] Over time, ongoing resorptive processes can severely compromise root integrity, culminating in crown-root fractures and eventual loss of the tooth. In growing patients, ankylosed teeth may become infraoccluded as the surrounding alveolar bone continues to develop, further complicating occlusal relationships and esthetics. Thus, the sequence of biomechanical disruption, vascular and neural compromise, and cellular desiccation in the PDL underpins the complex cascade that follows avulsive dental trauma. Understanding these mechanisms underscores the importance of immediate and appropriate emergency management, including minimizing extraoral dry time, using suitable storage media, and applying evidence-based replantation and follow-up strategies aimed at preserving PDL viability and mitigating root resorption.[6][2][3]

Histopathology

From a histopathological perspective, tooth avulsion is characterized primarily by structural disruption of the periodontal ligament and localized injury to the cementum and alveolar bone. When a tooth is forcibly displaced from its socket, the PDL fibers that span the space between the cementum and alveolar bone are torn. This mechanical rupture separates the root from its bony housing, but importantly, many periodontal ligament cells remain adherent to the root surface, particularly if the tooth is handled appropriately and extraoral dry time is minimized.[7] These residual PDL cells, including fibroblasts, progenitor cells, and remnants of epithelial rests, retain the potential to contribute to reattachment and regeneration, provided that they remain viable and are not subjected to prolonged desiccation or mechanical damage. Microscopically, small and localized areas of cemental damage are often noted on the root surface of avulsed teeth. These defects typically result from the root scraping against the alveolar socket during the traumatic displacement, producing irregularities, microfractures, or superficial loss of cementum.[7] In some instances, fragments of alveolar bone and cementum may be detached and embedded in the surrounding soft tissue, and small hemorrhages within the ligament space are common. If the tooth is rapidly replanted under favorable conditions, early healing may involve reorganization of the PDL, reattachment of collagen fibers, and reparative cementum deposition over damaged areas, restoring continuity between the root and alveolar bone. The presence of viable PDL cells on the root surface is crucial for this regenerative response. However, when PDL injury is extensive or when extraoral conditions are unfavorable, the histopathological picture may evolve toward resorptive processes. Areas of denuded dentin or severely damaged cementum can become focal points for osteoclastic activity, leading to external root resorption. Initially, this may manifest as small, localized resorptive lacunae, but if the inflammatory stimulus persists, the lesions can enlarge and coalesce, jeopardizing the structural integrity of the root. In cases where the PDL fails to regenerate and the root surface comes into direct contact with alveolar bone, ankylosis may develop, characterized histologically by fusion of bone to the root and loss of the normal PDL space.[7] Over time, this replacement resorption results in gradual substitution of the root structure with bone. Thus, the histopathological features of avulsed and replanted teeth reflect a balance between injury and repair. The extent of PDL tearing, the degree of cemental damage, and the viability of residual PDL cells on the

root surface largely determine whether healing proceeds via regeneration of a functional ligament or via resorptive and ankylotic pathways that ultimately lead to tooth loss. Careful attention to the biological principles underlying these microscopic changes informs clinical strategies aimed at preserving PDL vitality and optimizing long-term outcomes after traumatic avulsion.[7]

History and Physical

A detailed history is essential in the assessment of suspected tooth avulsion and provides critical information for both diagnosis and management planning. The clinician should begin by establishing a clear account of the traumatic event, including the mechanism, direction, and magnitude of the force involved, as these factors may suggest the likelihood of concomitant injuries to the soft tissues, alveolar bone, or adjacent teeth. A specific history of the tooth being completely displaced from its socket will raise strong suspicion of avulsion. The time elapsed since the avulsion occurred is a key determinant of prognosis, as extraoral dry time has a direct impact on the viability of periodontal ligament cells and the risk of subsequent root resorption or ankylosis. Equally important is documentation of how the tooth has been handled and stored prior to presentation, including whether it was kept dry, wrapped in tissue, placed in water, milk, saline, or a specialized storage medium, or replanted temporarily at the site of injury. The dental history should clarify whether the affected tooth is part of the primary or permanent dentition. This distinction is crucial because management strategies differ significantly: primary teeth are generally not replanted due to the risk of damage to the developing permanent successor, whereas immediate replantation is the preferred approach for most avulsed permanent teeth. By approximately 14 years of age, the transition from primary to permanent dentition is typically complete, but clinicians should still confirm tooth type rather than relying solely on age. Physical examination must be systematic and thorough. Inspection of the tooth socket should focus on identifying and gently removing blood clots, debris, or tooth fragments that could interfere with replantation. The surrounding oral and perioral structures must be evaluated for additional injuries, including mucosal and skin lacerations, gingival contusions, and possible alveolar or jaw fractures, which may require separate management or alter the approach to replantation. If the avulsed tooth is not readily located at the scene or in the oral cavity, the possibility of aspiration into the airway, ingestion into the gastrointestinal tract, or intrusive luxation rather than avulsion must be considered. In such scenarios, further imaging and medical evaluation may be warranted to exclude potentially serious complications. A comprehensive extraoral examination should also be performed to assess for facial swelling, asymmetry, and signs of more extensive maxillofacial trauma, thereby ensuring that tooth avulsion is not evaluated in isolation but within the broader context of traumatic injury [6][7].

Fig. 2: Deep Laceration of lower lip.

Evaluation

The diagnostic evaluation of tooth avulsion and associated dentoalveolar trauma relies heavily on appropriate imaging to complement clinical findings and to accurately characterize the extent of injury. Conventional radiographic techniques, including periapical and occlusal intraoral radiographs, are typically the first-line imaging modalities. These views allow detailed visualization of the affected socket, adjacent teeth, and surrounding alveolar bone, enabling the clinician to identify root or crown fractures, alveolar fractures, residual root fragments, or foreign bodies within the socket that could impede replantation or healing. Multiple angulated intraoral radiographs can be particularly useful when differentiating between avulsion and intrusive luxation, as intruded teeth may be displaced into the alveolar bone and not immediately apparent on clinical inspection. Extraoral radiographs, such as panoramic radiography, provide a broader overview of the maxillofacial skeleton and are valuable when there is suspicion of more extensive trauma, including mandibular or midfacial fractures. Panoramic imaging can also assist in locating displaced teeth or fragments that may have been driven into adjacent anatomical spaces. In more complex or high-impact injuries, computed tomography (CT), including cone-beam CT in dental settings, offers superior three-dimensional visualization of the alveolar process, tooth position, and surrounding hard tissues. CT is particularly useful for confirming or excluding intrusion of a missing tooth into the alveolar bone, maxillary sinus, or other anatomical spaces, as well as for identifying subtle fractures that may not be evident on conventional radiographs. In cases where the avulsed tooth cannot be accounted for clinically, imaging of the chest and abdomen may be indicated to rule out aspiration into the respiratory tract or ingestion into the gastrointestinal system, especially in uncooperative children or unconscious trauma

patients. Radiographic evaluation also supports medico-legal documentation and serves as a baseline for future comparison during follow-up, particularly for monitoring root resorption, periapical pathology, or alveolar bone remodeling after replantation. Thus, judicious use of extraoral and intraoral radiographs, supplemented when necessary by CT imaging, is central to the comprehensive evaluation of dental, alveolar, and associated injuries in the context of tooth avulsion [5][6][7].

Treatment / Management

Replantation of the avulsed tooth is widely recognized as the preferred therapeutic approach in cases of dental avulsion, although it is not always feasible in every clinical scenario.[8] The quality of the outcome depends heavily on the timeliness and organization of the initial response; optimal management during the first 30 minutes following avulsion is particularly critical for long-term tooth survival. Early intervention is directed primarily toward preserving pulp vitality where possible or, when that is unlikely, maintaining the tooth as a functional ankylosed unit within its alveolar socket. This strategy aims to minimize disturbance to the normal development and contour of the alveolar bone, which is of central importance for future prosthetic rehabilitation, including the placement of dental implants once growth is complete.[9] Consequently, the immediate and early phases of care must be carefully planned and executed, with attention to both biological and mechanical principles that influence healing. Before replantation is attempted, attention must be given to the extraoral handling and storage of the avulsed tooth. Storage in an isotonic medium, such as milk, physiologic saline, or even the patient's own saliva, significantly slows the rate of periodontal ligament (PDL) cell death on the root surface.[10] Although PDL cell necrosis cannot be completely prevented outside the socket, these solutions provide a temporary but biologically favorable environment that helps preserve cellular viability until definitive treatment can be delivered. Interestingly, short-term storage of the tooth in an appropriate isotonic solution has been shown in some studies to yield equal or even superior healing outcomes when compared with immediate replantation performed under less controlled conditions.[11][12][11] Among the various media, milk is most frequently recommended and used because it is readily available, has a physiologic pH and osmolarity, and contains nutrients and growth factors that support cell survival.[9] By contrast, storage in plain drinking water is discouraged because its low osmolality leads to rapid osmotic lysis of PDL cells and exacerbates root surface damage.

Fig. 3: Skin laceration of lower lip after injury.

In addition to simple storage, anti-resorption therapy has emerged as an important adjunctive pre-replantation measure. This approach involves soaking the avulsed tooth in a storage solution supplemented with antibiotics, designed to reduce the inflammatory response associated with necrotic PDL remnants and microbial contamination of the root surface.[9] By limiting early inflammation, this strategy aims to decrease the likelihood of subsequent inflammatory root resorption. Several pharmacologic regimens have been proposed; one commonly cited protocol employs a solution containing 800 µg of doxycycline and 640 µg of dexamethasone, in which the avulsed tooth is immersed for approximately 20 minutes.[9] While the tooth is being treated extraorally, the empty alveolus should be managed gently but thoroughly. Light irrigation with 0.9% physiologic saline is recommended to remove debris and loosely adherent clot, and careful aspiration can be used if a blood clot obstructs the socket. Excessive curettage or vigorous manipulation of the socket should be avoided to preserve remaining PDL elements and minimize further trauma to the alveolar bone. Once the root surface has been appropriately prepared and the socket cleared of obstructions, the tooth is ready for replantation. Anatomical repositioning is critical: the tooth should be aligned correctly with the adjacent dentition and carefully inserted into the socket using firm, steady pressure. The clinician must ensure that the tooth seats fully and symmetrically without excessive force, which could further damage the alveolar walls. The prognosis for successful replantation is strongly influenced by the extraoral dry time. When the tooth has remained dry for less than 30 minutes, the probability of maintaining viable PDL cells and achieving favorable long-term outcomes is relatively high. As the dry time extends beyond 30 to 60 minutes, however, irreversible damage to the PDL becomes increasingly likely, and the risk of replacement resorption and ankylosis rises substantially.

Following replantation, stabilization of the tooth is essential to support healing of the PDL and surrounding tissues. This is typically achieved through the application of a semi-rigid or flexible

splint, such as a titanium trauma splint or comparable device, which secures the replanted tooth while allowing a degree of physiological mobility. Immobilization facilitates reattachment and reorganization of damaged PDL fibers between the alveolus and the cementum. Current guidelines from the International Association of Dental Traumatology (IADT) advocate flexible splinting for virtually all dental injuries, emphasizing that rigid fixation is associated with a higher risk of ankylosis.[13] For avulsed teeth, the recommended splinting duration is generally two weeks, a period sufficient to support initial healing while limiting the adverse effects of prolonged immobilization.[13] When the extraoral dry time has exceeded 60 minutes and the PDL is presumed non-viable, a longer splinting period of up to four weeks may be employed.[13] Although the guidelines do not specify an exact splint design for alveolar fractures, they recommend immobilizing the affected alveolar segment for approximately four weeks to promote bony consolidation.[13] Systemic antibiotic therapy is commonly prescribed as part of the post-replantation regimen to reduce the risk of infection and mitigate inflammation-related resorptive processes. Doxycycline is often the antibiotic of choice, given its broad antimicrobial spectrum and anti-collagenase properties; it is typically prescribed for five days. In patients who are intolerant to doxycycline, amoxicillin is a commonly used alternative.[14] For children under 50 kg, a weight-adjusted regimen is advised, consisting of a 100 mg loading dose of doxycycline on the first day, followed by 50 mg once daily for the subsequent four days.[14] Such systemic coverage is particularly important when the avulsion occurred in a contaminated environment or when the tooth has been exposed extraorally for an extended period. Meticulous follow-up is indispensable for evaluating the success of replantation and for detecting complications at an early stage. The first scheduled follow-up visit usually occurs at two weeks, at which time the splint is removed and the tooth undergoes both clinical and radiographic assessment. Clinically, tooth mobility is evaluated, and a pulp vitality test is performed, preferably using more sensitive and objective modalities such as pulse oximetry or electric pulp testing.[15] Radiographically, periapical images are obtained to document the initial state of the periradicular tissues and to serve as a baseline for future comparison. If the pulp is determined to be non-vital, root canal treatment should be initiated promptly, as the probability of spontaneous revascularization is negligible in such cases.[9] Endodontic therapy helps prevent or control infection-related resorption and improves the likelihood of retaining the tooth long term.

If the pulp appears vital at the two-week visit, a periapical radiograph taken with an individualized holder provides a standardized image for subsequent review. The patient is then seen at one, three, and six months, with new radiographs taken at each visit to screen for early signs of external or internal resorption.[16] In the absence of radiographic pathology after this surveillance period, annual follow-up is generally recommended to ensure ongoing stability.[16] Should radiographic evidence of resorption emerge at any point, root canal treatment is indicated to arrest the process and preserve as much root structure as possible.[16] The management strategy must be modified in cases where the extraoral dry time exceeds 60 minutes. In such situations, it is assumed that most PDL cells on the root surface are non-viable and that leaving the necrotic ligament in place can act as a persistent inflammatory stimulus. This, in turn, accelerates infection-related resorption and ankylosis. To reduce this risk, the remaining PDL should be deliberately removed prior to replantation. Mechanical methods include gentle scaling and root planing, polishing with soft pumice, or wiping the root surface with gauze. Alternatively, the tooth may be soaked in a 3% citric acid solution for approximately three minutes to aid in debriding the ligament. Following PDL removal, fluoride treatment of the root surface is recommended, as fluoride has been shown to slow the progression of ankylosis and diminish the rate of resorption by altering dentin permeability and inhibiting clastic activity. When the extraoral dry time exceeds 90 minutes, soaking the tooth in fluoride-containing solutions becomes even more relevant, as the risk of replacement resorption is particularly high. Severe injury to the neurovascular bundle and the PDL, especially when combined with prolonged extraoral exposure, predisposes to replacement root resorption and inflammatory resorption. These complications can sometimes be anticipated and partially prevented by meticulous decontamination at the time of reimplantation, combined with appropriate systemic antibiotic therapy.[2][17][3][18] Nevertheless, once resorption is established, root canal treatment is often necessary as part of the management strategy, both to control infection and to attempt to stabilize the root structure.[2][17][3][18]

The stage of root development also has important prognostic implications. Immature permanent teeth, in which root formation is incomplete and the apex remains open, display a greater potential for pulpal revascularization, especially when adjunctive measures such as soaking the tooth in doxycycline are employed.[9] In these cases, conservative management aimed at supporting spontaneous healing may be justified, with careful pulp vitality monitoring over time. By contrast, primary teeth are not candidates for replantation, as such intervention carries a substantial risk of damaging the underlying permanent tooth germ and disrupting normal dental development. In children,

therefore, the clinician must balance the desire to preserve the avulsed tooth with the overarching priority of safeguarding the development and integrity of the permanent dentition. Collectively, the management of avulsed teeth demands a carefully orchestrated sequence of pre-replantation, replantation, and post-replantation measures, all grounded in an understanding of periodontal and pulpal biology. Prompt, evidence-based interventions—ranging from proper storage and anti-resorption therapy to appropriate splinting, systemic antibiotics, and vigilant follow-up—can significantly improve long-term outcomes, preserving function, esthetics, and alveolar bone for future restorative options [14][15][16][17].

Differential Diagnosis

The differential diagnosis of tooth avulsion encompasses several other traumatic dental injuries that may present with a similar clinical picture, particularly when a tooth appears to be "missing" from its usual position in the arch. Chief among these are complete intrusive luxation, subluxation, and lateral luxation. In intrusive luxation, the tooth is forcibly displaced apically into the alveolar bone rather than being expelled from the socket, which can mimic avulsion if the crown becomes level with or slightly below the gingival margin. Subluxation, by contrast, is characterized by increased mobility without gross displacement, often accompanied by tenderness to percussion and possible bleeding from the gingival sulcus. Lateral luxation involves displacement of the tooth in a labial, lingual, mesial, or distal direction, typically associated with disruption of the periodontal ligament and fracture of the alveolar bone plate. These injuries must be differentiated from avulsion because their management strategies and prognostic implications differ considerably. When a tooth is not visible in the oral cavity following trauma, the clinician must adopt a systematic approach to determine its location and the true nature of the injury. It is essential to consider not only intrusive displacement within the alveolus but also the possibility that the tooth has been swallowed or aspirated. Aspiration poses an immediate medical emergency and may present with coughing, respiratory distress, or asymmetrical breath sounds. Ingestion into the gastrointestinal tract is generally less urgent but still requires confirmation and monitoring. Thorough history-taking can yield valuable clues; details regarding the direction and intensity of the traumatic force, the time course of events, and the patient's immediate post-injury symptoms may help distinguish between avulsion and intrusion. The physical examination further refines the diagnosis by assessing the socket, adjacent teeth, and surrounding soft tissues. Radiographic evaluation, including periapical, occlusal, or panoramic views, is indispensable in this context. Radiographs can reveal an intruded tooth within the alveolar bone, confirm complete loss of the tooth from the socket, or demonstrate displacement in cases of lateral luxation. In suspected aspiration or ingestion, chest and abdominal radiographs may be required. Thus, a combination of comprehensive history, meticulous clinical examination, and targeted imaging forms the foundation of an accurate differential diagnosis in cases where tooth avulsion is suspected [14][15][16][17].

Prognosis

The prognosis of replanted avulsed teeth is influenced by a complex interplay of biological and clinical factors, among which extraoral dry time and quality of subsequent follow-up care are particularly decisive. Evidence from long-term clinical studies underscores that replantation, when correctly performed, can be a highly successful procedure. Karayilmaz et al. reported favorable long-term outcomes in a substantial proportion of replanted teeth, reinforcing the concept that timely and appropriate management can preserve function and aesthetics for extended periods.[17] However, their findings also highlight that both short- and long-term prognoses are highly sensitive to the duration of extraoral dry time. When the tooth remains outside the socket in a dry environment beyond critical thresholds, the viability of periodontal ligament cells rapidly declines, and the risks of inflammatory root resorption, replacement resorption, and eventual tooth loss rise significantly. Early placement of the tooth in a suitable storage medium and prompt replantation are therefore pivotal in maximizing survival chances. Contrasting data from another study, which reported a long-term survival rate of only 20% for replanted avulsed teeth, emphasize the importance of not only initial emergency care but also structured, ongoing follow-up.[17] In that cohort, poor outcomes were largely attributed to the absence or inadequacy of subsequent treatment, including delayed or omitted endodontic therapy, lack of regular radiographic monitoring, and failure to intervene early when signs of resorption emerged.[17] These findings illustrate that replantation should be viewed as the first step in a continuum of care rather than a standalone intervention. Systematic follow-up enables early detection of complications such as pulp necrosis, root resorption, and ankylosis, allowing timely endodontic or surgical management that may prolong tooth retention. Prognosis is also modulated by factors such as root maturity, with immature teeth showing a greater capacity for revascularization, as well as by patient age, systemic health, and adherence to post-operative instructions. In clinical practice, patients and their families should be counseled that, even under optimal conditions, the long-term retention of replanted teeth cannot be guaranteed. Nonetheless, successful replantation provides critical benefits, especially in growing patients, by maintaining alveolar bone volume and contour, preserving occlusal relationships, and delaying the need for more

invasive prosthetic or implant-based solutions. In this sense, even teeth with a guarded long-term prognosis may confer substantial functional and developmental advantages, shaping the overall risk-benefit assessment of replantation.[17]

Complications

Replantation of avulsed teeth, while often beneficial, is associated with a range of potential complications that can compromise long-term outcomes and ultimately lead to tooth loss. Infective sequelae constitute an important category of complications. Microbial contamination of the root surface, periodontal ligament space, or pulp chamber can lead to localized infections, fistula formation, and apical periodontitis. Tooth discoloration may develop as a consequence of pulpal hemorrhage, necrosis, or calcific metamorphosis, and although primarily aesthetic, it can signal deeper pulpal or periapical pathology. Pulp necrosis is a particularly common complication, especially in teeth with fully formed apices, and, if left untreated, may progress to chronic periapical inflammation and abscess formation. Pulp canal obliteration (PCO) is another recognized outcome; it is radiographically apparent weeks to months after replantation as increased radiodensity within the pulp chamber and root canal system. While PCO is often interpreted as a manifestation of reparative dentin deposition and successful revascularization, it is not entirely benign. Approximately 15% to 25% of teeth with PCO eventually develop pulp necrosis, underscoring the need for ongoing surveillance even when radiographic changes suggest “healing.”[2][19] Root resorption represents one of the most serious and challenging complications following replantation. Inflammatory root resorption arises when necrotic PDL and bacterial contaminants on the root surface elicit an inflammatory response mediated by clastic cells, which progressively resorb root structure. Replacement resorption, or ankylosis, occurs when the root surface fuses directly to the alveolar bone, with subsequent gradual substitution of the root by bone. Both processes can ultimately result in loss of the tooth. Notably, the incidence and severity of resorption and ankylosis have been linked to the type of splint used after replantation. Rigid splints, which immobilize the tooth completely and eliminate physiological micromovement, are associated with higher rates of ankylosis and root resorption compared with semi-rigid or flexible splints. In young patients undergoing active facial growth, ankylosis can be particularly problematic. As the surrounding alveolar bone and facial skeleton continue to develop, an ankylosed tooth fails to erupt in harmony with adjacent teeth and can become infraoccluded or “submerged,” leading to occlusal discrepancies, aesthetic concerns, and potential alveolar defects. Tooth avulsion also carries an inherently high risk of loss of pulp vitality, especially when the root apex is fully developed, as the potential for spontaneous revascularization is limited. If pulp necrosis and inflammatory resorption remain unrecognized, periapical periodontitis may develop and further complicate healing, reducing the likelihood of long-term tooth retention. Endodontic treatment, when appropriately timed and executed, can mitigate some of these risks by eliminating intracanal infection and creating a biologically favorable environment for periradicular healing. Nevertheless, even with optimal management, the cumulative burden of infections, resorptive processes, ankylosis, and pulpal sequelae underscores the inherently guarded prognosis of replanted avulsed teeth and highlights the importance of close clinical and radiographic monitoring over the long term.[2][19]

Patient Education

Prevention and early, informed response are central to improving outcomes in cases of tooth avulsion, and this requires targeted education of both the public and professionals likely to encounter such injuries. Coaches, physical education teachers, recreational leaders, and first responders occupy a critical frontline role, particularly in environments where contact sports and high-risk activities are common. These individuals should be familiar with the basic principles of initial management of an avulsed tooth, including the importance of locating the tooth, handling it only by the crown, gently rinsing it if contaminated, and either replanting it immediately when conditions allow or placing it promptly in an appropriate storage medium such as milk or a commercially available balanced salt solution. Their ability to act decisively in the minutes following trauma can significantly influence periodontal ligament cell survival and, by extension, long-term outcomes. Patient and parental education is equally important. Many avulsion injuries occur in children and adolescents, and parents or guardians are often the first to respond. Educating them about the urgency of seeking dental or medical care, the significance of not allowing the tooth to dry out, and the use of suitable storage media can markedly improve the prognosis. Information should also be provided about the benefits of protective equipment. In particular, the routine use of well-fitted mouthguards in high-risk contact sports, such as rugby, hockey, martial arts, and American football, has been shown to significantly reduce the incidence and severity of dental trauma. Emphasis should be placed on custom-made or properly fitted mouthguards rather than ill-fitting, over-the-counter devices, as the former offer superior protection and comfort, thereby enhancing compliance. Educational efforts should extend to primary care providers, school nurses, and general dentists, who are in positions to reinforce preventive messages during routine health and dental visits. Clear, accessible

information about what to do in the event of dental trauma can be disseminated through pamphlets, posters, school programs, and community outreach. Ultimately, deterrence and patient education do not eliminate the risk of tooth avulsion but can substantially modify its impact by promoting protective behaviors and ensuring that when injuries do occur, they are managed rapidly and appropriately, maximizing the chances of successful replantation and long-term tooth retention [18][19].

Other Issues

Several practical considerations and clinical "pearls" can assist practitioners in optimizing care for patients who present with tooth avulsion. One important aspect is the evaluation and updating of tetanus immunization status. Because dental avulsion is often associated with contamination from soil, debris, or foreign bodies, particularly in outdoor or sports-related injuries, ensuring that tetanus prophylaxis is currently an integral component of comprehensive trauma care. Another critical point is the recognition that replantation is only the beginning of a complex therapeutic process. Dental follow-up is mandatory to monitor healing, identify complications, and carry out necessary interventions such as endodontic treatment, splint removal, and management of resorptive lesions. Postoperative oral hygiene measures are central to reducing infection risk and promoting periodontal health around the replanted tooth. Patients should be instructed to brush their teeth carefully after every meal, using a soft-bristled toothbrush to avoid mechanical trauma to the injured area. The adjunctive use of a 0.12% chlorhexidine mouth rinse twice daily can further lower bacterial loads, diminish gingival inflammation, and support favorable healing conditions. Dietary modification is also important; a soft diet is recommended for at least two weeks following replantation to minimize occlusal forces on the affected tooth and splinted segments, thereby protecting the integrity of the healing periodontal ligament and alveolar bone. Patients and their families must be counseled candidly about the unpredictable nature of replantation outcomes. Despite meticulous adherence to evidence-based protocols, the success of replantation in the long term cannot be guaranteed. The risk of dental root resorption, ankylosis, and eventual tooth loss remains significant, particularly when the extraoral dry time was prolonged or when the tooth suffered severe initial damage.[20] Transparent communication about these possibilities helps manage expectations and fosters shared decision-making. It also underscores the importance of long-term follow-up, as early detection of complications may allow for interventions that extend the functional lifespan of the tooth. Finally, clinicians should remain up to date with evolving guidelines and research in dental traumatology. Avulsion is a relatively rare injury compared with other forms of dental trauma, and without regular review, familiarity with optimal treatment pathways may diminish over time. Regular participation in continuing education, trauma workshops, and guideline updates helps ensure that dental and medical professionals are prepared to implement the most current and effective strategies when these challenging cases arise.[20]

Enhancing Healthcare Team Outcomes

Optimal management of tooth avulsion is inherently multidisciplinary and depends on the coordinated efforts of a broad healthcare team. Because avulsion is relatively uncommon, even among dental injuries, clinicians across different settings—emergency departments, primary care clinics, pediatric practices, and dental offices—must periodically refresh their knowledge of treatment protocols to maintain readiness. The overarching treatment objective is to preserve the traumatized tooth and the surrounding alveolar bone, particularly in growing patients, until craniofacial development is complete and definitive restorative options, such as implants or fixed prostheses, can be considered. This long-term perspective underscores the importance of collaboration among general dentists, pediatric dentists, endodontists, oral and maxillofacial surgeons, orthodontists, and, where necessary, pediatricians and emergency physicians. A key area for improvement in healthcare team performance lies in recognition of the critical importance of early replantation and appropriate storage media. Studies and clinical experience suggest that patients, parents, and even some healthcare professionals may be unaware of the time-sensitive nature of avulsion management or the optimal media in which to store an avulsed tooth. Primary care providers, nurse practitioners, and general dentists are uniquely positioned to address this gap by incorporating anticipatory guidance into routine care. For example, during sports physicals or school health evaluations, clinicians can educate families and young athletes about dental trauma prevention and immediate response strategies, including the use of protective mouthguards and the need to seek urgent care if a tooth is knocked out. Clear protocols within emergency and primary care settings further enhance outcomes. Triage systems should prompt healthcare personnel to ask about dental injury in the context of facial trauma and to recognize an avulsed tooth as an urgent problem requiring prompt attention. Accessible written or digital algorithms can guide non-dental clinicians through the basic steps of handling, storing, and, when appropriate, replanting an avulsed tooth, as well as identifying cases that warrant immediate referral to dental specialists. Establishing efficient referral pathways between medical and dental services ensures that patients receive timely definitive care. Interprofessional education and simulation-based training can also be valuable. Joint workshops for dentists, physicians, nurses, and allied health professionals can focus on

the practical aspects of managing avulsion, from chairside or bedside replantation techniques to splinting principles and post-injury counseling. Emphasizing the preferred storage media—balanced salt solutions designed for cell preservation, or readily available alternatives such as milk—can standardize responses across disciplines. Ultimately, by fostering a culture of shared responsibility and open communication, the healthcare team can significantly improve the prognosis of avulsed teeth, preserving oral function, facial aesthetics, and psychosocial well-being for affected patients [17][18][19][20].

Conclusion:

In conclusion, the management of an avulsed tooth is a dental emergency where minutes count. The goal of overarching is the timely replantation of the tooth to preserve periodontal ligament viability and ensure the best possible long-term outcome. Success hinges on immediate and correct prehospital actions: locating the tooth, handling it by the crown only, and storing it in an appropriate medium such as milk, saline, or a specialized storage solution. The critical factor is minimizing extraoral dry time, as desiccation rapidly leads to PDL cell death, increasing the risks of inflammatory resorption and ankylosis. Definitive care involves gentle socket debridement, careful replantation, flexible splinting for stabilization, and the administration of systemic antibiotics. Meticulous follow-up with clinical and radiographic monitoring is mandatory to detect and manage complications like pulp necrosis or root resorption, often necessitating endodontic treatment. Ultimately, a well-informed public and coordinated interprofessional response—from bystanders and first responders to emergency physicians and dentists—are essential to improve the prognosis of this traumatic injury and preserve the natural dentition.

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