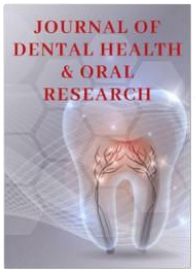

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Research Article

Traumatic Dental Injuries: A Multidisciplinary Approach to Prevention, Care and Rehabilitation

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Abstract

Aims: To comprehensively review the epidemiology, risk factors, clinical presentations, complications and management strategies for Traumatic Dental Injuries (TDIs), with a focus on permanent dentition. The aim is to consolidate current evidence and guidelines to aid clinicians in prevention, diagnosis, treatment and long-term rehabilitation of dental trauma.

Methods: This literature review synthesized recent literature, including international guidelines (e.g., IADT), epidemiological studies and clinical management protocols. Peer-reviewed articles from major dental trauma journals and consensus documents were reviewed to outline classification, risk factors, immediate and long-term management and preventive strategies for TDIs. Special attention was given to permanent dentition and age-specific considerations.

Results: TDIs occur most frequently in children aged 0–10 and decrease significantly with age. Falls, sports injuries and accidents are leading causes of dental trauma in the permanent dentition. Injuries range from mild concussions to severe avulsions and fractures, each requiring tailored management. Delayed or inappropriate treatment can lead to pulpal necrosis, root resorption, malocclusion or psychological effects such as dental anxiety and reduced quality of life. Preventive measures like mouthguards, education and policy change were shown to be effective.

Conclusion: Traumatic dental injuries present a significant clinical and public health challenge, especially in young populations. Early diagnosis and evidence-based management are crucial for minimizing complications. A multidisciplinary and preventive approach—incorporating clinical care, patient education and public policy—is essential for improving patient outcomes and long-term oral health.

Keywords: Trauma; Permanent Dentition; Prevention

Knowledge Transfer Statement

This review consolidates current evidence and international guideline recommendations for the prevention, diagnosis and management of traumatic dental injuries in the permanent dentition. Key takeaways include the importance of risk-factor identification, timely emergency management (particularly for luxation injuries and avulsion), structured follow-up to detect complications (e.g., pulp necrosis and root resorption) and implementation of preventive measures such as mouthguards and safety policies. This synthesis is intended to support clinicians, educators and policymakers in improving patient outcomes and reducing the burden of dental trauma.

Introduction

Traumatic Dental Injuries (TDIs) are some of the most common injuries kids, teenagers and adults face. They happen most often in the first ten years of life, then become much less common as people get older and are rare after age 30 [1]. Understanding the underlying risk factors, prevention and management of TDIs are of utmost importance. In cases of primary dentition, early treatment can help address the trauma and prevent damage to permanent teeth if they're affected. TDIs can also pose serious psychological and financial impacts on the patients. Psychological consequences include but are not limited to Post-Traumatic Stress Disorder (PTSD), low self-esteem, development of dental anxiety. Moreover, there are potential costs associated with treatment of the tooth affected by trauma or potentially replacing it after it has been lost. TDIs can result from a variety of incidents such as falls, assaults and car accidents and their occurrence varies based on factors like gender, age and socioeconomic status [2].

TDIs include a wide range of injuries such as concussions, subluxations, avulsions, intrusions, extrusions and fractures of the root and alveolar bone. These injuries can lead to complications that affect clinical outcomes, psychological well-being, appearance and functionality. Clinically, TDIs can result in infections, pulpal necrosis, malocclusion and temporomandibular disorders (TMJ). Thus, a clinician's ability to quickly and accurately diagnose, treat and rehabilitate those with TDIs is essential for improving patients' quality of life and ensuring a better prognosis [3].

Methods and Materials

A narrative literature review was conducted to summarize contemporary evidence on Traumatic Dental Injuries (TDIs) in the permanent dentition. Sources included international consensus guidelines (including publications from the International Association of Dental Traumatology), peer-reviewed epidemiologic studies and clinical management articles relevant to diagnosis, acute care, follow-up, complications and prevention strategies. The literature was synthesized to provide an overview of etiology and risk factors, classification and clinical features, immediate and long-term management, rehabilitation considerations and prevention across age groups.

Results

Etiologies and Risk Factors

The primary causes of TDIs in permanent dentition include falls, assaults and vehicular accidents, with variations in incidence based on age, gender and socioeconomic status. Young children often experience dental injuries due to falls, while school-aged children and adolescents are more likely to suffer from sports-related injuries or accidents involving other individuals [4]. In adults, assaults and traffic accidents are common etiologic factors [5,6]. Social factors, such as excessive alcohol consumption, also increase the risk of falls and subsequent dental injuries, highlighting the importance of incorporating relevant questions into medical history forms [5,6,8]. Additionally, sports activities are classified by their risk levels, with sports like basketball and cycling deemed medium-risk, while boxing, soccer and hockey are considered high-risk [7].

Falls, particularly among young children and the elderly, are a significant cause of dental trauma. In children, the lack of coordination and their propensity to engage in physical activities make them susceptible to falls that result in dental injuries. For the elderly, falls are often related to factors like muscle weakness, poor balance and environmental hazards [2,6]. In sports, the risk of dental trauma varies significantly with the type of sport and the protective equipment used. Contact sports such as football, hockey and martial arts have higher incidences of dental injuries due to the physical nature of these activities [7].

Assaults and vehicular accidents also contribute significantly to the incidence of dental trauma. Assault-related injuries often involve blunt force to the face, leading to fractures and avulsions. Vehicular accidents can cause severe maxillofacial injuries, particularly in high-speed collisions. The role of alcohol and drug use in increasing the risk of such accidents is well-documented, emphasizing the need for public health interventions to reduce these risk factors (Fig. 1) [1,2,6].

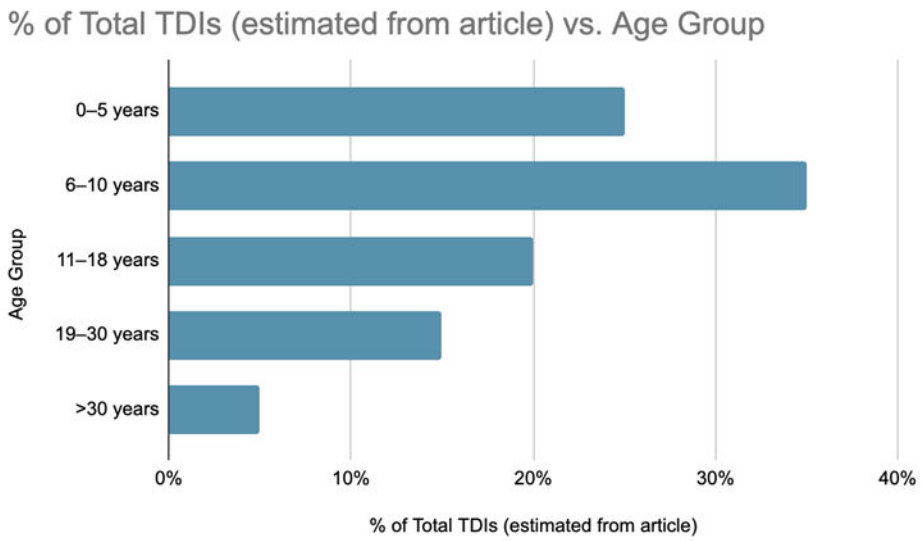

Figure 1: Estimated distribution of traumatic dental injuries by age group. Data approximated from Glendor, 2019; Petti et al., 2019.

Prevention of Facial and Dental Trauma

Prevention strategies for TDIs are categorized into primary, secondary and tertiary measures. Primary prevention strategies are essential in reducing the incidence of dental trauma by preventing it from happening in the first place. Public awareness campaigns and school-based educational programs can play a significant role in informing children and parents about the importance of using protective gear during sports and recreational activities. Schools can implement policies requiring the use of mouthguards in high-risk sports and provide training on emergency response to dental injuries. In sports, custom-made mouthguards, which provide even coverage of all occlusal surfaces and are well-adapted to the teeth, offer the best protection compared to stock or boil-and-bite types [8]. Additionally, environmental modifications, such as installing soft playground surfaces and eliminating tripping hazards at home and in schools, can reduce the risk of falls.

Secondary prevention focuses on mitigating the effects of dental trauma once it has occurred. This involves early intervention and regular check-ups. Prompt and appropriate initial management of dental injuries can prevent complications and improve outcomes. For example, immediate reimplantation of an avulsed tooth or stabilization of a luxated tooth can significantly enhance the prognosis. Regular dental check-ups allow for the early detection and management of trauma-related complications such as root resorption and pulp necrosis [12]. Educating patients and caregivers on the signs of complications and the importance of follow-up care is crucial for secondary prevention [9-11].

Tertiary prevention involves long-term rehabilitation to restore function and aesthetics after dental trauma. Prosthodontic treatments, such as dental implants and crowns, can replace missing or damaged teeth. Orthodontic interventions may be necessary to correct malocclusions resulting from displaced teeth. Advanced restorative techniques, including CAD/CAM technology and digital imaging, can enhance the precision and outcomes of these treatments. Psychological support may also be required to address trauma-related anxiety and self-esteem issues [13]. Table 1 describes the prevention strategies by age group.

Age Group	Common Causes	Prevention Strategies
School-age kids	Sports (practice and tournaments), playground	Mouthguards, school safety policies
Adolescents	Contact sports, fights, assaults	Custom mouthguards, behavior awareness
Adults	Assaults, accidents	Alcohol moderation, seatbelt use
Elderly	Falls, balance loss	Home modifications, balance training

Table 1: Prevention strategies by age group.

Diagnosis, Assessments and Management

Accurate diagnosis and assessment of TDIs are crucial for effective management. Clinical examinations of hard and soft tissue, radiographic evaluations and classification systems help determine the severity and appropriate treatment for each type of injury. Immediate management is vital, particularly for injuries like avulsions, where the viability of the Periodontal Ligament (PDL) and the maturity of the root influence treatment choices and prognosis. Management strategies vary based on the type of injury, encompassing restorative and endodontic considerations, as well as long-term follow-up to monitor for complications such as infection, pulpal necrosis, malocclusion and TMJ disorders. Rehabilitation may involve prosthodontic and orthodontic treatments to address functional and aesthetic concerns, as well as speech and swallowing difficulties. The initial assessment of dental trauma involves a thorough clinical examination to evaluate the extent of injury and identify any associated soft tissue damage. Radiographic imaging, including periapical, panoramic and Cone-Beam Computed Tomography (CBCT) scans, provides detailed information about the type and extent of fractures, displacement and root integrity. The use of CBCT has become increasingly important in the management of complex dental injuries due to its ability to produce three-dimensional images that offer a comprehensive view of the affected area [14].

Management of Specific TDIs:

1. *Concussions and Subluxations*

Concussions involve a minor injury to the tooth-supporting structures without displacement or increased mobility. The Periodontal Ligament (PDL) is inflamed, making the tooth tender to touch. For concussions and subluxations, conservative management is often sufficient. These injuries typically require observation and avoiding further trauma. Subluxations involve slight mobility of the tooth and treatment may include splinting to stabilize the tooth and regular follow-up to monitor for potential complications such as pulp necrosis [15,21]. While prognosis of these TDIs is usually good, regular follow-up appointments are crucial to ensure proper care for these teeth.

2. *Avulsions*

Avulsions represent one of the most severe forms of dental trauma, where the tooth is completely displaced from its socket. The main prognostic determinant in this case is the vitality of the PDL cells. Immediate reimplantation within the first 20 minutes is the ideal treatment in permanent dentition, followed by splinting and possible endodontic treatment. However, multiple sources report that extraoral time exceeding 30 minutes would significantly decrease the prognosis. The success of reimplantation depends on other factors as well, such as the storage medium used for the tooth and the promptness of treatment [6,16,11]. The preferred storage media that are osmotically balanced such as milk. This is while transportation of the tooth in water would significantly decrease prognosis due to PDL cell rupture due to the osmotic difference. Treatment of avulsed permanent teeth also differs based on whether the apex is open or closed [16].

3. *Intrusions and Extrusions*

Intrusions and extrusions involve the displacement of the tooth into or out of the alveolar bone, respectively. Intrusions can cause significant damage to the PDL and pulp, often requiring repositioning and splinting. Extrusions involve partial displacement of the tooth out of its socket and management includes repositioning, splinting and endodontic evaluation. Both conditions require close monitoring for complications such as pulp necrosis and root resorption [15-18]. Intrusions occur when the tooth is pushed into the alveolar bone, leading to PDL damage and potential pulpal necrosis. Intrusions could sometimes push the tooth completely apically, which could make the clinician consider avulsion as a differential diagnosis. In these cases, radiographs could be warranted occasionally to check for the tooth/tooth fragments. Management depends on the extent of intrusion and the age of the patient. Both conditions require repositioning and splinting, followed by endodontic evaluation and treatment if necessary [17,19].

4. *Lateral Luxations*

Lateral luxations involve displacement of the tooth in a direction other than axially, often accompanied by fractures of the alveolar bone. Treatment includes repositioning the tooth, splinting and monitoring for complications. Endodontic treatment may be required depending on the severity of the injury and the age of the tooth [15,17,19].

5. *Root Fractures*

Root fractures can occur at any level along the root and the prognosis depends on the location of the fracture, with more apical fractures having a better prognosis. Root fractures can be classified as horizontal, vertical and oblique, with vertical fractures demonstrating the worst prognosis and requiring extractions. In other cases, treatment involves splinting the tooth and monitoring for healing or complications, with surgical intervention sometimes necessary to remove a fractured root fragment [22].

6. Crown Fractures

Crown fractures can be uncomplicated, involving only enamel and dentin or complicated, involving the pulp. Uncomplicated fractures are treated with restorative procedures to rebuild the tooth structure, while complicated fractures require endodontic treatment to preserve the vitality of the pulp, followed by restoration. Advanced restorative techniques, such as the use of dental composites, ceramics and CAD/CAM technology, can enhance the outcomes of these treatments [20,23, 24]. Table 2 summarizes the types of TDIs and their management.

Injury types	Clinical features	Immediate management	Long-term follow-up
Concussion	Tender, no mobility	Observation	Monitor for pulpal changes
Subluxation	Slight mobility, no displacement	Splint (if needed)	Pulp vitality testing
Avulsion	Tooth out of socket	Reimplant (permanent only), splint	Endodontics if needed, resorption risk
Intrusion	Tooth pushed into socket	Reposition or monitor	Risk of necrosis, resorption
Lateral luxation	Displacement with alveolar fracture	Reposition, splint	Endodontic assessment
Root fracture	Mobility varies	Splint, possibly surgery	Monitor or extract fragment
Crown fracture	Uncomplicated vs. complicated	Restoration vs. endo + restoration	Esthetics, vitality monitoring

Table 2: Types of TDIs and their management.

Possible Complications and Outcomes

TDIs can lead to a range of complications, both clinical and psychological. Clinically, patients may experience infections, pulpal necrosis, malocclusion and TMJ disorders. Psychologically, TDIs can affect self-esteem, social interactions and may lead to Post-Traumatic Stress Disorder (PTSD) and dental anxiety. The aesthetic and functional outcomes of dental trauma are significant, impacting a patient's quality of life and overall well-being [2,3,5].

Clinical Complications

- *Infections:* Dental trauma can expose the pulp to oral bacteria, leading to infections and abscess formation. Prompt endodontic treatment in some cases is essential to manage infections and prevent further complications [2,12,25]. In other cases, the dental practitioner may consider the prescription of antibiotics to prevent future infection development. However, the patient should be educated about the signs and symptoms of infection to allow timely and effective management should such happen.
- *Pulpal Necrosis:* Damage to the pulp's blood supply can result in necrosis, requiring endodontic intervention to remove the necrotic tissue and prevent infection [2,12,25]. This damage could be apparent during the initial presentation at the dental office or develop later on as a response to the trauma. This is a reason why regular follow-up for TDI cases is of great importance to prevent this issue or address it should it happen.
- *Malocclusion:* Displacement or loss of teeth can disrupt the alignment of the dental arch, leading to malocclusion. Such can happen with extruded teeth that don't get repositioned at the time of treatment or teeth that are luxated laterally, for example. Orthodontic treatment may be necessary to correct the alignment and occlusal plane.
- *TMJ Disorders:* Trauma to the teeth and jaw can affect the Temporomandibular Joint (TMJ), leading to pain, dysfunction and difficulty in chewing. Patients should be aware that even if the TMJ appears to be normal at the time of the trauma, pain and inflammation could build up as time passes. This is another important reason for regular follow-up so such possible issues could be addressed. Management includes pharmacological and non-pharmacological approaches, along with non-surgical and surgical approaches. Examples include physical therapy, splint therapy and in severe cases, surgical intervention [2,26].

Psychological Complications

- *Self-Esteem and Social Interactions:* The appearance of the teeth plays a crucial role in self-esteem and social interactions. Dental trauma, especially in the anterior region, can significantly impact a patient's confidence and willingness to engage in social activities [27,28].
- *Post-Traumatic Stress Disorder (PTSD):* The traumatic nature of dental injuries can lead to PTSD, characterized by anxiety, flashbacks and avoidance behaviors related to the trauma. Psychological counseling and support are essential for managing PTSD [29]. Such traumatic experiences could later translate into dental anxiety and refusal of seeking care in patients.
- *Dental Anxiety:* Previous traumatic dental experiences can lead to dental anxiety, making patients apprehensive about future dental visits. Dentists should employ strategies to reduce anxiety, such as creating a calming environment, using sedation techniques and building a trusting relationship with the patient [27,29].

Discussion

Traumatic dental injuries remain a prevalent clinical and public health concern, particularly in children and adolescents, with important functional, esthetic and psychosocial consequences. The evidence highlights that prognosis is strongly influenced by early and appropriate management, especially in severe injuries such as avulsion and intrusion where periodontal ligament viability, extraoral time and stage of root development determine outcomes. A consistent theme across the literature is the need for structured follow-up, as complications such as pulp necrosis, infection-related inflammatory resorption and ankylosis may emerge months to years after the initial event.

Prevention requires an interdisciplinary approach that extends beyond the dental clinic, including school- and community-based education, enforcement of protective equipment use in sports and environmental modifications to reduce fall risk. Advances in digital imaging and restorative workflows may improve diagnostic accuracy and rehabilitation outcomes, but these tools should be used judiciously and guided by radiation safety principles. Overall, integrating evidence-based acute care with prevention, long-term monitoring and rehabilitation planning is essential to optimize outcomes and reduce the lifelong burden of TDIs.

Future Considerations

Advances in prevention and treatment, along with health policy implications, are essential for improving the management of dental traumas. The use of technology, such as digital imaging (CBCT) and CAD/CAM systems for surgical guides and prosthesis fabrication, offers promising improvements in diagnosis and treatment planning. Future research should focus on enhancing preventive measures, optimizing treatment protocols and integrating technological innovations to improve patient outcomes.

Health Policy and Public Awareness

- *School-Based Interventions:* Implementing educational programs in schools to raise awareness about dental trauma and preventive measures can significantly reduce the incidence of TDIs among children. These programs should include training for teachers and students on the importance of wearing mouthguards during sports and the proper management of dental injuries. Further training schedules for parents could facilitate more effective preventive measures.
- *Public Health Campaigns:* Public health campaigns should aim to educate the general population about the risk factors associated with dental trauma and the benefits of preventive measures. These campaigns can use various media platforms to reach a broad audience and disseminate information effectively. Moreover, basic management of trauma prior to arriving at the dentist could help significantly increase the chances of tooth survival. An example of this could be through raising awareness on initial management of avulsed teeth by transporting them either in the socket or in an osmotically balanced medium such as milk.
- *Health Policy:* Policymakers should consider mandating the use of protective equipment, such as mouthguards, in high-risk sports and implementing regulations to improve the safety of public spaces, reducing the risk of falls and accidents that can lead to dental trauma. Additionally, policymakers could propose insurance coverage of custom-made mouthguards to further encourage the use of these devices compared to stock mouthguards.

Technological Innovations

- Digital Imaging: The use of Cone-Beam Computed Tomography (CBCT) provides detailed images of the dental and maxillofacial structures, aiding in accurate diagnosis and treatment planning for dental trauma cases. CBCT can help identify fractures, root resorption and other complications that may not be visible on conventional radiographs [14,30]. It is however

of utmost importance for dental practitioners to stick to the ALARA principles of X-ray prescription to ensure minimal patient exposure

- *CAD/CAM Systems:* Computer-Aided Design and Computer-Aided Manufacturing (CAD/CAM) systems allow for the precise fabrication of dental restorations and surgical guides. These technologies can enhance the accuracy and efficiency of restorative and surgical procedures, improving patient outcomes [30]. Such systems are especially useful for the fabrication of crowns in case of trauma cases that present with restorable crown fractures.
- *Telemedicine:* Telemedicine platforms can facilitate remote consultations and follow-ups for dental trauma patients, especially in rural or underserved areas. This approach can ensure timely access to care and continuous monitoring of the healing process. The lack of adequate access to dental care in rural areas could pose the risk of significantly decreased prognosis of teeth with dental trauma, which could be addressed with telemedicine measures

Future Research Directions:

- *Preventive Strategies:* Research should focus on developing and evaluating new preventive strategies, such as improved mouthguard designs and materials, to enhance protection against dental trauma. Studies should also investigate the effectiveness of educational interventions in different populations and settings.
- *Treatment Protocols:* Ongoing research is needed to refine treatment protocols for various types of dental injuries, considering factors such as age, injury severity and patient preferences. Randomized controlled trials and systematic reviews can provide high-quality evidence to inform clinical practice.
- *Long-Term Outcomes:* Longitudinal studies are essential to understand the long-term outcomes of dental trauma and the effectiveness of different treatment approaches. These studies can help identify factors associated with successful healing and complications, guiding clinicians in making evidence-based decisions.

Conclusion

Traumatic Dental Injuries (TDI) in both the permanent and primary dentition remain a significant concern in pediatric and adult populations due to their potential for long-term esthetic, functional and psychological consequences. This literature review has highlighted the etiology, prevention, management and possible complications associated with dental trauma in permanent dentition. While dental trauma across different age groups could have different risk factors, the dentist should always consider the possibility of abuse when managing cases involving dental or facial trauma. This holds not only in kids, but also in adults and elderly who present with signs and symptoms that are not in line with the history of chief complaint obtained while history taking.

Regarding the management of TIDs, timely-diagnosis, evidence-based clinical decision-making and personalized treatment strategies are of essence. Management of TDIs further depends on the type and severity of injury, along with the developmental status of the dentition. While TDIs have common presentations in both primary and permanent dentition, addressing the same TDI in each stage of development could vary significantly. Despite the recent advancements in technologies such as CAD/CAM and CBCT, the prognosis of TDI treatment depends heavily on timely intervention and regular follow-up care. Preventive strategies including education, policy making and use of protective gear are some of the most critical means of reducing the global and personal burden of dental trauma. However, disparities in access to care, awareness and practitioner preparedness to address TDIs pose a challenge for prognosis of these cases. Continued research and advancements in technology will play a vital role in enhancing the prevention and treatment of dental injuries, ultimately improving the quality of life for affected individuals. Collaboration among dental professionals, policymakers, educators and researchers is essential to address the challenges posed by dental trauma and to ensure the best possible care for patients.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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Data Availability Statement
Not applicable.

Ethical Statement
The project did not meet the definition of human subject research under the purview of the IRB according to federal regulations and therefore, was exempt.

Informed Consent Statement
Informed consent was taken for this study.

Authors' Contributions
All authors contributed equally to this paper.

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