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INTERNATIONAL JOURNAL OF CURRENT RESEARCH

International Journal of Current Research
Vol. 18, Issue, 05, pp.37375-37384, May, 2026
DOI: https://doi.org/10.24941/ijcr.50654.05.2026

ISSN: 0975-833X

RESEARCH ARTICLE

MANAGEMENT OF TRAUMATICALLY INJURED PERMANENT ANTERIOR TEETH IN CHILDREN: A SERIES OF THREE CASE REPORTS

Dr. Surinder Kaur[1] and Dr. Divya, V.[2]

[1]Assistant Prof & Head, Department of Pediatric and Preventive Dentistry, Government Dental College and Hospital, Patiala, Punjab, India; [2]PG, Department of Pediatric and Preventive Dentistry, Government Dental College and Hospital, Patiala, Punjab, India

ARTICLE INFO

Article History:
Received 17th February, 2026
Received in revised form
20th March, 2026
Accepted 24th April, 2026
Published online 30th May, 2026

Keywords:
Dental Trauma, Fragment Reattachment, Apexification, Fiber Post, Composite restoration, Young Permanent Teeth.

Corresponding author:
Dr. Surinder Kaur

ABSTRACT

Introduction: Traumatic dental injuries (TDIs) to anterior teeth are among the most common dental emergencies encountered in children. Management of these injuries depends on the stage of root development, pulpal status, extent of crown loss, and availability of fractured tooth fragments. Conservative and biologically oriented treatment approaches are preferred to preserve tooth structure and maintain esthetics and function. **Case Presentation:** This case series describes the management of three traumatized permanent anterior teeth with varying stages of root development in children. The first case involved a complicated crown fracture managed with root canal treatment, fiber post placement, and fragment reattachment. The second case presented with a non-vital immature permanent incisor and open apex managed by apexification using mineral trioxide aggregate (MTA) followed by composite restoration. The third case involved a traumatized tooth with significant coronal destruction managed with root canal treatment, fiber post, core build-up, and direct composite restoration. **Conclusion:** Management of traumatic injuries to anterior teeth should be individualized according to the extent of injury, pulpal status, and stage of root development. Contemporary minimally invasive restorative techniques combined with endodontic procedures provide predictable esthetic and functional outcomes in growing children.

Citation: Dr. Surinder Kaur and Dr. Divya, V. 2026. "Management of traumatically injured permanent anterior teeth in children: A series of three case reports". ***International Journal of Current Research, 18, (05), 37375-37384.***

INTRODUCTION

Traumatic dental injuries (TDIs) constitute one of the most common dental emergencies encountered in children and adolescents and represent a significant public health concern worldwide. The prevalence of dental trauma in permanent dentition has been reported to range between 20% and 30%, with maxillary central incisors being the most frequently affected teeth owing to their anterior position and increased susceptibility to direct impact. Falls, sports-related injuries, road traffic accidents, and recreational activities are among the leading causes of traumatic injuries in children. Beyond the immediate physical damage, traumatic injuries to anterior teeth can adversely affect mastication, speech, esthetics, psychological well-being, and social interactions, thereby significantly impairing the quality of life of affected children. The management of traumatic injuries in young permanent teeth presents unique clinical challenges because these teeth often exhibit incomplete root development at the time of injury. Trauma during the developmental phase may result in pulpal inflammation, pulpal necrosis, interruption of root maturation, and loss of vitality. Preservation of pulp vitality is considered the ideal treatment outcome; however, in cases where irreversible pulp damage or necrosis occurs, appropriate endodontic intervention becomes essential to maintain the affected tooth within the dental arch and facilitate long-term functional and esthetic rehabilitation. The stage of root development plays a critical role in determining the treatment strategy for traumatized immature permanent teeth. Teeth with open apices and pulpal necrosis require the establishment of an apical barrier before obturation can be achieved. Traditionally, apexification using calcium hydroxide was considered the treatment of choice for such cases. However, prolonged treatment duration, multiple patient visits, and increased risk of cervical root fractures associated with long-term calcium hydroxide therapy have prompted the adoption of newer bioactive materials. Mineral trioxide aggregate (MTA) has emerged as a predictable alternative owing to its excellent biocompatibility, sealing ability, bioactivity, and capacity to induce hard tissue formation. MTA apexification allows rapid creation of an artificial apical barrier, thereby reducing treatment time and improving clinical outcomes in immature non-vital teeth. Coronal rehabilitation of traumatized anterior teeth is equally important for restoring esthetics and function. When the fractured tooth fragment is available and intact, fragment reattachment has become one of the most conservative and biologically favorable treatment options. Advances in adhesive dentistry have significantly enhanced the predictability of this technique, allowing restoration of the original tooth anatomy, color, surface texture, and translucency. Fragment reattachment preserves natural tooth structure, provides superior esthetics, and offers positive psychological benefits to young patients and their parents. Various modifications, including enamel bevels, internal grooves, over-contouring, and the use of fiber posts, have been proposed to improve retention and fracture resistance of reattached fragments. In cases involving extensive coronal destruction, particularly following complicated crown fractures requiring endodontic treatment, the remaining tooth structure may be insufficient to support direct restorative procedures. Fiber-reinforced composite posts have gained widespread acceptance for the restoration of endodontically treated anterior teeth due to their modulus of elasticity being similar to that of dentin. This property facilitates favorable stress distribution along the root and minimizes the risk of catastrophic root fractures. Fiber posts also provide improved retention for coronal restorations while maintaining esthetic outcomes, making them particularly suitable for the rehabilitation of young permanent anterior teeth.

Following successful endodontic treatment, complete obturation of the root canal system is essential to prevent reinfection and ensure long-term success. In immature teeth managed with apexification, obturation is typically performed after confirmation of an adequate apical barrier. Advances in obturation techniques and restorative materials have enabled clinicians to achieve predictable sealing of the root canal system while simultaneously restoring structural integrity of the tooth. Direct composite resin restorations continue to play a pivotal role in the esthetic management of traumatized anterior teeth. Contemporary nanohybrid and nanofilled composite materials offer excellent mechanical properties, polishability, color stability, and esthetic integration with adjacent natural teeth. Their conservative nature and ability to preserve sound tooth structure make them the restoration of choice in pediatric and adolescent patients. Given the wide spectrum of traumatic dental injuries and the varying clinical presentations encountered in immature permanent teeth, treatment should be individualized according to the extent of injury, pulpal status, root development, and availability of tooth structure. The integration of biologically based endodontic procedures with minimally invasive restorative techniques has significantly improved the prognosis of traumatized anterior teeth in children. The present case series highlights three different treatment modalities employed in the management of traumatically injured immature permanent anterior teeth, including fragment reattachment following fiber post placement, apexification using mineral trioxide aggregate, and post-endodontic rehabilitation with fiber post-core supported composite restoration. These cases demonstrate the importance of tailored treatment planning and contemporary conservative approaches in achieving favorable functional and esthetic outcomes in growing children.

CASE REPORT 1

A 10-year-old male patient reported to the Department of Pediatric and Preventive Dentistry with a chief complaint of fractured upper front teeth following a fall while playing three days earlier. The patient's medical and dental histories were non-contributory. The fractured tooth fragments had been retrieved by the parents immediately after the injury and were brought to the clinic at the time of presentation. The primary concern of both the patient and his parents was the compromised esthetic appearance of the anterior teeth.

Extraoral examination revealed no facial asymmetry, soft tissue injury, swelling, or tenderness. Intraoral examination showed a complicated crown fracture involving the maxillary right lateral incisor (12) and an uncomplicated crown fracture involving the maxillary right central incisor (11). The fracture of tooth 12 extended into the pulp chamber and was classified as Ellis Class III, whereas tooth 11 exhibited an Ellis Class II fracture involving enamel and dentin without pulpal exposure. The fractured fragments were intact and demonstrated satisfactory adaptation to the remaining tooth structure. Both teeth were fully developed and corresponded to Cvek's Stage V (complete root development). No mobility, displacement, or tenderness to percussion was observed. Radiographic examination revealed complete root formation with no evidence of root fracture, periodontal ligament widening, or periapical pathology. Pulp vitality testing using Endofrost cold spray elicited a positive response from tooth 11, whereas tooth 12 exhibited a questionable response. Considering the patient's age and the recent nature of the injury, an attempt was initially made to preserve pulp vitality in tooth 12. However, persistent pulpal hemorrhage and inability to achieve adequate hemostasis indicated irreversible pulpal inflammation, making root canal treatment the most appropriate treatment option.

Since the fractured fragments were available and demonstrated excellent adaptation, a conservative treatment plan involving fragment reattachment was selected. Fragment reattachment was considered ideal because it preserves natural tooth structure, restores original morphology and translucency, and provides superior esthetic results compared to conventional restorative approaches. Therefore, root canal treatment followed by fiber post-supported fragment reattachment was planned for tooth 12, while simple fragment reattachment was planned for tooth 11. After obtaining informed consent from the parents, local anesthesia was administered using 2% lignocaine hydrochloride containing 1:80,000 adrenaline through buccal and palatal infiltration in the maxillary anterior region. Adequate anesthesia was confirmed, and rubber dam isolation was established to provide a dry operating field and prevent contamination during adhesive procedures. The teeth were isolated using a rubber dam sheet secured with dental floss ligatures. The fractured fragments had been stored dry since the time of injury. Therefore, they were thoroughly cleaned with saline and carefully examined for cracks and adaptation. The fragments were rehydrated in normal saline for 30 minutes before reattachment.

Endodontic treatment was initiated on tooth 12 by preparing an access cavity under rubber dam isolation. Working length determination was performed using an electronic apex locator and confirmed radiographically. Biomechanical preparation of the canal was carried out using rotary nickel-titanium instruments with copious irrigation using 2.5% sodium hypochlorite. Following instrumentation, the canal was irrigated with 17% EDTA to remove the smear layer and then flushed with normal saline. The canal was dried using sterile paper points and obturated using gutta-percha and resin sealer through the lateral condensation technique. A postoperative radiograph confirmed satisfactory obturation. Following obturation, post space preparation was performed by removing the coronal portion of gutta-percha while maintaining an adequate apical seal of approximately 4–5 mm. The post space was prepared using a peeso reamer corresponding to the dimensions of the selected fiber post. A glass fiber post was chosen because of its favorable biomechanical properties and modulus of elasticity similar to dentin, allowing more uniform stress distribution within the root. The fiber post was tried in the canal to verify proper adaptation and length. The canal walls were conditioned according to the manufacturer's instructions, and a bonding agent was applied. Dual-cure resin cement was introduced into the prepared canal space, and the fiber post was seated to full depth. Excess cement was removed and light curing was performed to ensure complete polymerization. To accommodate the fiber post, a corresponding channel was prepared on the internal aspect of the fractured fragment.

The fragment was repeatedly tried in position to verify passive seating and accurate adaptation to the remaining tooth structure. Once satisfactory adaptation was confirmed, both the fragment and tooth surfaces were etched using 37% phosphoric acid for 15 seconds, thoroughly rinsed, and gently air dried. A bonding agent was then applied to both surfaces and light cured. A thin layer of dual-cure composite resin was applied to the prepared tooth surface and the internal surface of the fragment. The fragment was carefully repositioned over the fiber post and aligned precisely with the remaining tooth structure. Excess resin was removed before polymerization, and light curing was carried out from the facial, palatal, and incisal aspects to ensure complete curing.

To further improve fracture resistance and mask the fracture line, a post-reattachment bevel was prepared along the fracture interface. Additional composite resin was placed over the bevel and light cured. This technique enhanced both the mechanical strength and esthetic outcome of the restoration. The fractured central incisor (11) was managed using a similar adhesive protocol. Since the pulp remained vital and no pulpal exposure was present, endodontic treatment was not required.

The fragment was rehydrated, etched, bonded, and reattached directly using dual-cure composite resin. Following reattachment of both fragments, finishing and polishing procedures were performed using fine-grit diamond burs, polishing discs, and polishing paste to obtain a smooth and natural surface texture. Occlusion was carefully evaluated in centric and eccentric movements, and premature contacts were eliminated. The patient was instructed to avoid biting hard foods with the restored teeth and to maintain meticulous oral hygiene. Follow-up examinations demonstrated satisfactory esthetic integration, functional stability, and absence of clinical symptoms. The restored teeth exhibited excellent color match and preservation of natural tooth anatomy, confirming the success of the conservative treatment approach.

Figure 1. Preoperative photograph

Figure 2. Preoperative radiograph

Figure 3. Master cone fitting after biomechanical preparation

Figure 4. Radiograph showing post space prepared after obturation

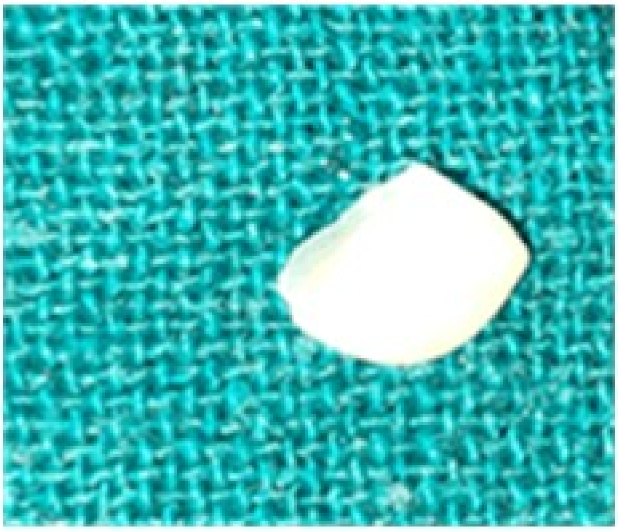

Figure 5. Fractured fragment of 12

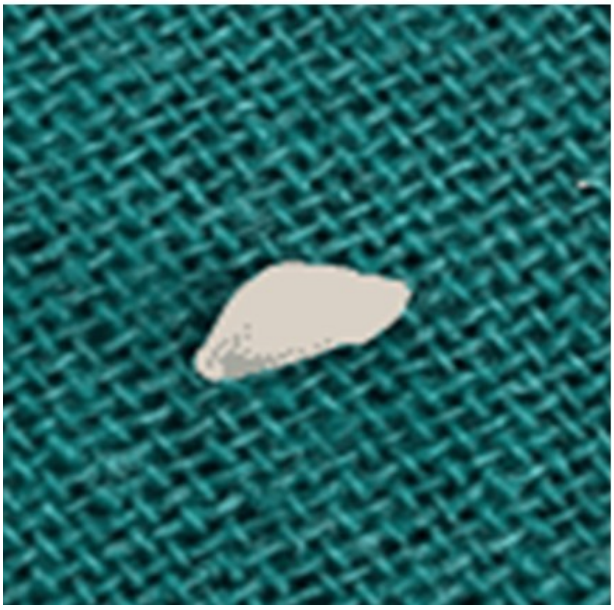

Figure 6. Fractured fragment of 11

Figure 7. Space preparation on fractured fragment of 12 for accommodation of coronal end of the fiber post

Figure 8. Postoperative radiograph after fiber post placement of 12 and fragment reattachment on 11 and 12

Figure 9. Postoperative photograph

CASE REPORT 2

A 9-year-old male patient reported to the Department of Pediatric and Preventive Dentistry with a chief complaint of pain in the upper front tooth while chewing food and occasional nocturnal pain. The patient gave a history of trauma to the maxillary anterior region approximately six months earlier following a fall. No treatment had been sought immediately after the injury. The patient's medical history was non-contributory, and no systemic illness was reported. Extraoral examination revealed no facial swelling, sinus tract, or soft tissue abnormalities. Intraoral examination demonstrated a complicated crown fracture involving the maxillary central incisor. The fracture extended into the pulp chamber and was classified as an Ellis Class III fracture. The affected tooth exhibited discoloration compared to the adjacent teeth and was mildly tender on percussion. No abnormal mobility was present. Based on clinical and radiographic findings, the tooth corresponded to Cvek's Stage IV of root development, indicating incomplete root formation with a wide-open apex. Radiographic examination revealed an immature permanent central incisor with thin dentinal walls and an incompletely formed root apex. A periapical radiolucency suggestive of chronic apical periodontitis. Pulp vitality testing using Endofrost cold spray failed to elicit a response, confirming pulpal necrosis. Considering the presence of an immature root with a non-vital pulp and open apex, apexification using mineral trioxide aggregate (MTA) was planned to establish an apical barrier and facilitate subsequent obturation.

After obtaining informed consent from the parents, local anesthesia was administered using 2% lignocaine hydrochloride containing 1:80,000 adrenaline through buccal and palatal infiltration. Following confirmation of adequate anesthesia, the tooth was isolated using a rubber dam to provide a dry and aseptic operating field throughout the procedure. Endodontic access was established using a high-speed round diamond bur under water coolant. Upon gaining access to the pulp chamber, necrotic pulpal remnants were removed and canal patency was confirmed. Working length determination was performed using an electronic apex locator and verified radiographically. Because the root canal walls were thin and fragile, instrumentation was carried out cautiously to avoid unnecessary dentin removal and reduce the risk of root fracture. Biomechanical preparation was performed using hand K-files in a circumferential filing motion. Copious irrigation was carried out throughout the procedure using 2.5% sodium hypochlorite to achieve effective disinfection of the root canal system. A final rinse with 17% EDTA was performed to remove the smear layer and improve adaptation of the obturation materials. The canal was subsequently flushed with normal saline and dried using sterile paper points. Following complete canal debridement, calcium hydroxide paste was placed as an intracanal medicament to eliminate residual microorganisms and promote resolution of periapical inflammation. The access cavity was temporarily sealed using a restorative material, and the patient was recalled after two weeks. At the subsequent appointment, the patient was asymptomatic and reported complete resolution of pain. Clinical examination revealed no tenderness to percussion, and the canal was found to be dry and free from exudate. The temporary restoration and calcium hydroxide dressing were removed, and the canal was irrigated thoroughly with sodium hypochlorite, EDTA, and normal saline. The canal was then dried with sterile paper points. To facilitate controlled placement of mineral trioxide aggregate and prevent apical extrusion, a resorbable collagen matrix was gently placed at the apical end of the canal, creating an internal matrix. Mineral trioxide aggregate (MTA) was then mixed according to the manufacturer's instructions and delivered into the apical region using an MTA carrier. The material was carefully condensed using hand pluggers to create an apical barrier approximately 4–5 mm thick. A radiograph was obtained to verify the position and thickness of the MTA plug. A moist cotton pellet was placed over the MTA, and the access cavity was temporarily sealed to allow complete setting of the material. The patient was recalled after 24 hours. At the next appointment, the set of the MTA was confirmed clinically using an endodontic plugger. Following confirmation of adequate hardening, obturation of the remaining canal space was completed using thermoplasticized gutta-percha and an endodontic sealer. A postoperative radiograph confirmed satisfactory adaptation of the MTA apical barrier and homogenous obturation of the root canal system.

Following successful obturation, attention was directed toward coronal rehabilitation. The access cavity and fractured crown portion were restored using a nanohybrid composite resin. The enamel margins were etched with 37% phosphoric acid for 15 seconds, rinsed thoroughly, and gently air-dried. A universal bonding agent was applied and light-cured according to the manufacturer's instructions. Composite resin was then placed incrementally to reconstruct the lost tooth structure. Each increment was individually light-cured to ensure complete polymerization and minimize polymerization shrinkage. After achieving the desired contour and anatomy, finishing and polishing procedures were carried out using fine-grit finishing burs, polishing discs, and polishing paste. Particular attention was paid to reproducing the natural morphology and incisal characteristics of the adjacent central incisor. Occlusion was evaluated in centric and eccentric movements, and any premature contacts were adjusted. The patient was instructed regarding oral hygiene maintenance and advised to avoid excessive forces on the restored tooth. Periodic clinical and radiographic follow-up examinations were scheduled. Follow-up evaluation demonstrated satisfactory healing of the periapical tissues, successful formation of an apical barrier, absence of clinical symptoms, and restoration of normal function and esthetics. The tooth remained asymptomatic, and radiographic examination showed favorable healing, indicating the success of the apexification procedure and subsequent restorative treatment.

Figure 10: Preoperative photograph

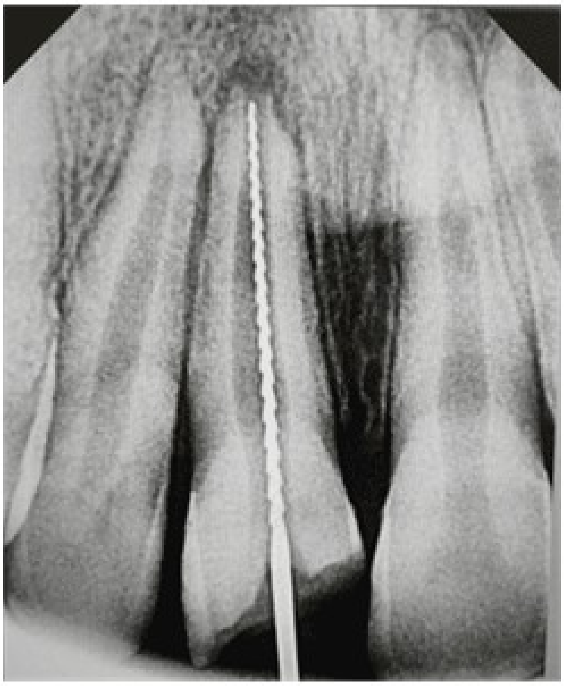

Figure 11: Working length radiograph of 11

Figure 12. Radiograph showing MTA apical plug in tooth 11

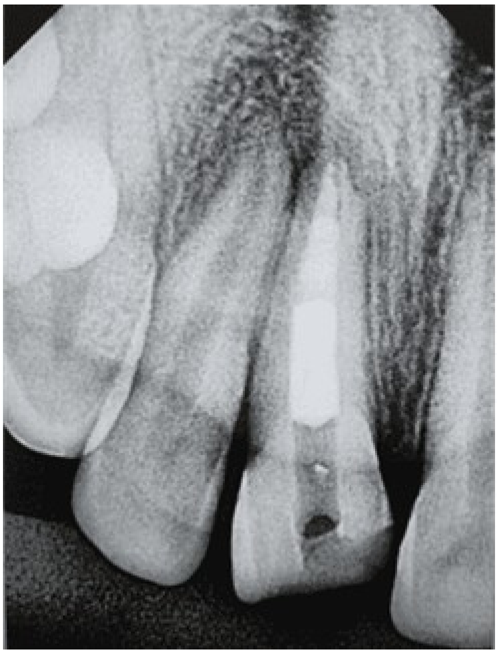

Figure 13. Canal obturated using thermo plasticized gutta percha on 11

Figure 14: Postoperative radiograph after composite buildup

Figure 15. Postoperative photograph

CASE REPORT 3

An 8-year-old female patient reported to the Department of Pediatric and Preventive Dentistry with a chief complaint of fractured upper front teeth. The patient's parents revealed a history of trauma to the maxillary anterior region approximately three months earlier following a fall while playing. No immediate dental treatment had been sought following the injury. The patient was primarily concerned about the unaesthetic appearance of the fractured tooth and occasional discomfort during biting. Her medical history was non-contributory, and no relevant systemic conditions were reported. Extraoral examination revealed no evidence of facial swelling, soft tissue injury, or facial asymmetry. Intraoral examination demonstrated a complicated crown fracture involving the maxillary left central incisor (21) and an uncomplicated crown fracture involving the adjacent maxillary right central incisor (11). The fracture involving tooth 21 extended into the pulp chamber and was classified as an Ellis Class III fracture, whereas tooth 11 exhibited an Ellis Class II fracture involving enamel and dentin without pulpal exposure. The fractured tooth structure of 21 was significantly compromised, and the lost fragment was unavailable for reattachment. Both teeth exhibited complete root development corresponding to Cvek's Stage V (complete root development). Clinical examination revealed mild discoloration of tooth 21 when compared with the adjacent teeth. The tooth was non-responsive to thermal vitality testing using Endofrost cold spray, whereas tooth 11 responded normally. No mobility was present, and periodontal probing depths were within normal limits. Percussion testing elicited mild tenderness in relation to tooth 21. Radiographic examination revealed complete root formation with no evidence of root fracture. A slight widening of the periodontal ligament space was evident in relation to tooth 21, suggesting pulpal necrosis with symptomatic apical periodontitis. Based on the clinical and radiographic findings, a diagnosis of pulpal necrosis secondary to traumatic crown fracture was established for tooth 21. Considering the extensive loss of coronal tooth structure and the absence of the fractured fragment, a treatment plan involving root canal treatment followed by fiber post-supported composite core restoration was formulated. The objective was to restore function, reinforce the weakened tooth structure, and achieve satisfactory esthetics while preserving as much remaining tooth structure as possible. After obtaining informed consent from the parents, local anesthesia was administered using 2% lignocaine hydrochloride containing 1:80,000 adrenaline through buccal and palatal infiltration in the anterior maxillary region.

Figure 16. Preoperative photograph

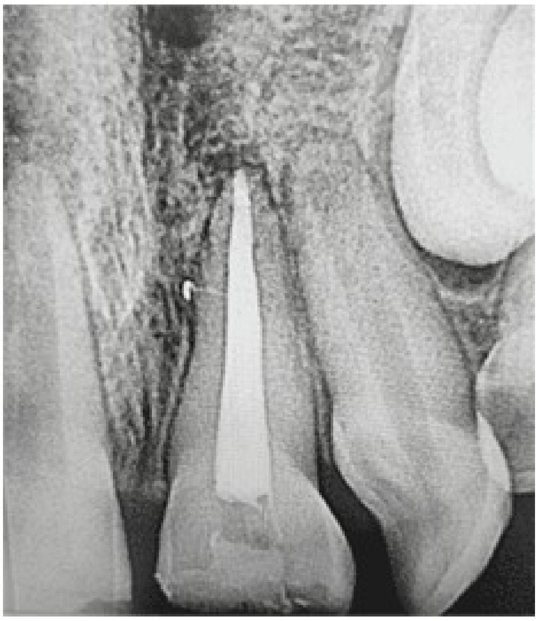

Figure 17. Radiograph after conventional obturation of 21

Figure 18: Radiograph after post space preparation on 21

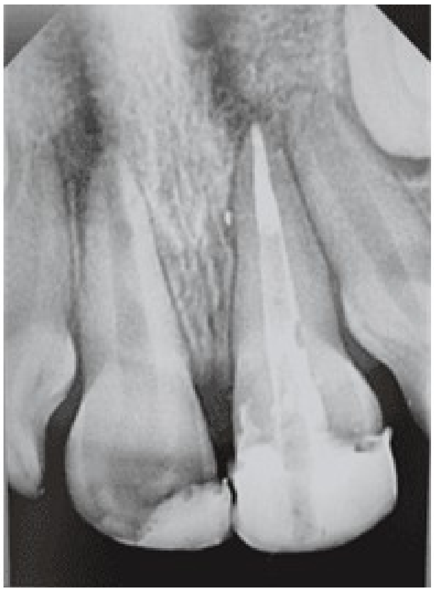

Figure 19: Radiograph after fiber post placement and composite build up of 21

Figure 20. Postoperative photograph

Following confirmation of profound anesthesia, rubber dam isolation was achieved to provide an aseptic and moisture-free operating field. An endodontic access cavity was prepared in tooth 21 using a round diamond bur under copious water coolant. Upon access opening, necrotic pulpal tissue remnants were identified and removed. Working length determination was carried out using an electronic apex locator and subsequently confirmed radiographically. Biomechanical preparation of the root canal system was performed using rotary nickel-titanium instruments in a crown-down sequence. Throughout instrumentation, copious irrigation was carried out using 2.5% sodium hypochlorite to facilitate disinfection and dissolution of organic debris. Following completion of canal shaping, a final irrigation protocol was performed using 17% EDTA to remove the smear layer and expose dentinal tubules, followed by a final rinse with normal saline. The canal was dried thoroughly using sterile absorbent paper points until complete dryness was achieved. Obturation was carried out using gutta-percha cones and resin-based endodontic sealer employing the lateral condensation technique. A postoperative radiograph was obtained to verify the quality and extent of obturation. The radiograph demonstrated satisfactory three-dimensional filling of the canal with an adequate apical seal. Following successful obturation, preparation of the post space was undertaken. The coronal portion of gutta-percha was removed using Peeso reamers while maintaining approximately 4–5 mm of gutta-percha apically to preserve the integrity of the apical seal. Post space preparation was completed according to the dimensions of the selected fiber post, taking care to preserve the remaining radicular dentin and avoid weakening of the root structure. A prefabricated glass fiber post was selected because of its favorable biomechanical properties, esthetic advantages, and modulus of elasticity comparable to dentin. The post was tried within the prepared canal to verify passive fit and appropriate length. The canal walls were cleaned and conditioned according to the manufacturer's recommendations. A dual-cure adhesive system was applied according to the manufacturer's instructions. Dual-cure resin cement was introduced into the canal using a lentulo spiral and the fiber post was carefully seated into position. Excess cement was removed and polymerization was completed using a curing light. Following successful post cementation, a composite resin core build-up was performed to replace the lost coronal tooth structure. The remaining enamel margins were etched with 37% phosphoric acid for 15 seconds, rinsed thoroughly, and gently air-dried. A universal adhesive bonding system was applied and light cured according to the manufacturer's instructions. Incremental layers of nanohybrid composite resin were subsequently placed and sculpted to recreate the lost crown morphology. Each increment was individually light cured to minimize polymerization shrinkage and ensure adequate depth of cure.

The crown anatomy was carefully reconstructed with particular attention to incisal edge position, labial contour, proximal contacts, and symmetry with the contralateral central incisor. After completion of the build-up, finishing procedures were carried out using fine-grit finishing burs and abrasive discs. Final polishing was performed using polishing cups and diamond polishing paste to obtain a smooth, highly lustrous surface that closely resembled natural enamel. Occlusion was evaluated in centric relation, protrusive movements, and lateral excursions. Any premature contacts were selectively adjusted to prevent excessive functional loading of the restored tooth. Postoperative instructions were provided, including recommendations to avoid biting hard objects with the anterior teeth and to maintain meticulous oral hygiene. The patient was recalled periodically for clinical and radiographic follow-up. At subsequent review appointments, tooth 21 remained asymptomatic and functional. No tenderness, mobility, or signs of periapical pathology were observed. The composite restoration maintained excellent color stability and marginal adaptation, and the patient expressed satisfaction with the esthetic outcome. Radiographic examination demonstrated satisfactory periapical healing and maintenance of the apical seal, confirming the success of the endodontic and restorative treatment procedures. The combination of root canal treatment, fiber post reinforcement, composite core build-up, and direct esthetic restoration provided a conservative and predictable approach for rehabilitation of the traumatized anterior tooth, restoring both function and esthetics while preserving the remaining natural tooth structure.

DISCUSSION

Traumatic dental injuries (TDIs) involving permanent anterior teeth are among the most common dental emergencies encountered in children and adolescents. The maxillary incisors are particularly susceptible because of their anterior position within the dental arch and their exposure to direct impact during falls, sports activities, and recreational accidents. Epidemiological studies have reported a prevalence of traumatic injuries to permanent teeth ranging from 20% to 30% in children, with maxillary central incisors being the most frequently affected teeth. Beyond the physical loss of tooth structure, traumatic injuries can significantly affect esthetics, phonetics, mastication, self-esteem, and psychosocial development. Therefore, successful management requires not only restoration of function and appearance but also preservation of biological integrity and future tooth survival. The management of traumatized permanent teeth is primarily determined by the stage of root development, pulpal status, extent of structural damage, and availability of fractured tooth fragments. Cvek's classification of root development provides an important clinical guide in determining the most appropriate treatment strategy. Immature teeth with open apices possess greater healing potential because of their rich vascular supply and regenerative capacity. Consequently, preservation of pulp vitality should always be considered the first treatment option whenever clinically feasible. The ultimate goal is to maintain pulp vitality and promote continued root development through apexogenesis, thereby allowing thickening of dentinal walls and closure of the root apex.

Vital pulp therapy plays a pivotal role in the management of complicated crown fractures in immature permanent teeth. Procedures such as direct pulp capping, partial pulpotomy, and cervical pulpotomy have demonstrated high success rates when performed under appropriate clinical conditions. Among these procedures, partial pulpotomy is considered the treatment of choice for recent traumatic pulp exposures in immature permanent teeth because only a small portion of inflamed coronal pulp tissue is removed while preserving healthy radicular pulp. Successful pulp preservation facilitates continued root maturation and significantly improves the long-term prognosis of the tooth. However, when pulp vitality cannot be maintained due to extensive inflammation, bacterial contamination, delayed presentation, or pulpal necrosis, endodontic treatment becomes necessary. Fragment reattachment has emerged as one of the most conservative and biologically acceptable treatment modalities for crown fractures when the fractured fragment is available. Unlike conventional restorations, fragment reattachment restores the original tooth anatomy, translucency, surface texture, color, and wear characteristics.

It also provides significant psychological benefits to young patients and their parents by preserving the natural tooth structure. Contemporary adhesive systems have substantially improved the predictability and longevity of fragment reattachment procedures, making them an attractive treatment option for anterior tooth fractures. A critical factor influencing the success of fragment reattachment is the hydration status of the fractured fragment. Fragments are often brought to the clinic after being stored in a dry environment, resulting in dehydration of enamel and dentin. Dehydration may adversely affect the esthetic outcome and mechanical properties of the restored tooth. Rehydration of the fragment before bonding has therefore become an essential step in contemporary reattachment protocols. Pre-bonding rehydration using normal saline improves resin penetration into the tooth substrate, prevents collapse of enamel and dentinal collagen structures, minimizes the development of micro-fractures, and enhances the overall fracture resistance of the restored tooth. Furthermore, rehydration significantly improves immediate esthetic outcomes by restoring the natural optical properties of enamel and dentin and improving color matching with the remaining tooth structure. These findings emphasize the importance of appropriate fragment storage and rehydration prior to reattachment procedures. Several modifications have been proposed to improve the strength and longevity of fragment reattachment. Bevel preparation, internal grooves, chamfer designs, over-contouring techniques, and fiber reinforcement have all been shown to increase the bonding surface area and improve stress distribution across the fracture interface. Preparation of a post-reattachment bevel following initial bonding further enhances esthetics while increasing resistance to future dislodgement and fracture. These modifications contribute to improved clinical performance and durability of reattached fragments. When traumatic injuries are associated with pulpal necrosis in immature permanent teeth, treatment becomes more complex because of incomplete root development and the presence of an open apex. Conventional root canal obturation is difficult in the absence of an apical constriction. Historically, calcium hydroxide apexification was considered the standard treatment for such cases; however, prolonged treatment duration, multiple patient visits, and increased risk of cervical root fractures have limited its contemporary use. The development of mineral trioxide aggregate (MTA) has revolutionized the management of immature non-vital teeth.

MTA apexification enables the creation of an artificial apical barrier within a significantly shorter period compared with traditional calcium hydroxide techniques. The material exhibits excellent biocompatibility, sealing ability, antimicrobial properties, and bioactivity. MTA promotes hard tissue barrier formation and provides a predictable apical stop against which obturation materials can be condensed. The use of a resorbable collagen matrix as an internal barrier further facilitates controlled placement of MTA and minimizes the risk of extrusion into periapical tissues. These advantages have resulted in widespread acceptance of MTA apexification as a reliable treatment modality for immature permanent teeth with pulpal necrosis. Successful endodontic treatment depends not only on the formation of an apical barrier but also on adequate canal disinfection and obturation. Thorough biomechanical preparation combined with effective irrigation protocols is essential for elimination of microorganisms and prevention of reinfection. Following apexification or conventional root canal therapy, obturation of the root canal system establishes a three-dimensional seal that prevents bacterial ingress and contributes to long-term periapical healing. Thermoplasticized gutta-percha techniques have gained popularity because of their ability to adapt closely to canal irregularities and provide a more homogenous root canal filling. In cases involving extensive loss of coronal tooth structure, additional reinforcement is often required to restore function and prevent fracture of the remaining tooth. Fiber-reinforced posts have become the preferred option for restoration of endodontically treated anterior teeth because their modulus of elasticity closely approximates that of dentin. This similarity allows more uniform distribution of functional stresses and reduces the risk of catastrophic root fracture. In addition, fiber posts possess excellent esthetic properties owing to their translucency, making them particularly suitable for restoration of anterior teeth. They also provide improved retention for both reattached fragments and direct composite restorations.

Composite resin remains the restorative material of choice for rehabilitation of traumatized anterior teeth because of its excellent esthetic qualities, conservative nature, and adhesive capabilities. Modern nanohybrid and nanofilled composite materials exhibit improved mechanical properties, color stability, polishability, and wear resistance. When combined with contemporary adhesive systems, composite restorations allow conservative reconstruction of fractured teeth while preserving maximum healthy tooth structure. Incremental placement techniques further improve adaptation and reduce polymerization shrinkage, contributing to long-term restoration success. The favorable outcomes achieved through contemporary treatment modalities highlight the importance of biologically based and minimally invasive treatment strategies in pediatric dentistry. Preservation of pulp vitality whenever possible, maintenance of root development, conservation of natural tooth structure, and restoration of esthetics should remain the primary objectives in the management of traumatic dental injuries. Advances in adhesive dentistry, bioactive endodontic materials, and fiber-reinforced restorative systems have significantly expanded the range of conservative treatment options available to clinicians and improved the prognosis of traumatized anterior teeth.

Long-term clinical and radiographic follow-up remains indispensable for monitoring pulpal status, periapical healing, restoration integrity, and continued tooth function. Regular follow-up allows early detection of complications such as pulp necrosis, root resorption, restoration failure, discoloration, or post debonding and facilitates timely intervention when required. Overall, the successful rehabilitation of traumatically injured anterior teeth requires a comprehensive understanding of pulp biology, root development, adhesive dentistry, and restorative principles. A treatment philosophy centered on preservation of vitality, conservation of tooth structure, and minimally invasive intervention provides the most predictable pathway toward achieving durable functional and esthetic outcomes in growing children.

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