

Long-Term Clinical Management of Recurrent Traumatic Crown–Root Fracture in a Permanent Maxillary Incisor Through Fragment Reattachment: A Three-Year Case Report and Outcome Analysis

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ABSTRACT

Traumatic crown–root fractures of permanent anterior teeth represent a complex clinical challenge due to the simultaneous involvement of enamel, dentin, cementum, and, in many cases, the periodontal attachment apparatus. Preservation of aesthetics, restoration of function, maintenance of periodontal health, and prevention of recurrent fracture remain the principal objectives of treatment. Fragment reattachment has emerged as a conservative and biologically favorable treatment modality that preserves natural tooth structure while achieving acceptable esthetic and functional outcomes. Despite advances in adhesive dentistry and trauma management protocols, long-term evidence regarding recurrent traumatic crown–root fractures managed through fragment reattachment remains limited. This research and review article presents a comprehensive analysis of the long-term clinical management of a recurrent traumatic crown–root fracture in a permanent maxillary incisor treated through fragment reattachment and monitored over a three-year period. The study integrates current evidence from dental traumatology literature, evaluates biological and restorative considerations, and examines factors influencing treatment success. The article further discusses diagnostic protocols, adhesive strategies, periodontal management, follow-up assessment, and long-term outcomes associated with conservative fragment reattachment techniques. Findings indicate that successful management depends on accurate diagnosis, preservation of the fractured fragment, appropriate adhesive protocols, periodontal stabilization, and continuous monitoring. Long-term outcomes demonstrate favorable esthetic integration, functional stability, and patient satisfaction when multidisciplinary principles are applied. The study supports fragment reattachment as a viable treatment option for recurrent crown–root fractures while highlighting limitations related to fracture pattern, biological width involvement, and reinjury risk.

Keywords: Crown-root fracture, fragment reattachment, dental trauma, permanent maxillary incisor, adhesive dentistry, traumatic dental injuries, long-term follow-up, esthetic rehabilitation, multidisciplinary treatment, dental traumatology

1. INTRODUCTION

Traumatic dental injuries constitute a significant public health concern, particularly among children, adolescents, and young adults. Anterior teeth, especially maxillary incisors, are disproportionately affected because of their prominent position within the dental arch and their susceptibility to direct impact. Crown–root fractures represent one of the most challenging forms of dental trauma because the fracture line often extends below the gingival margin, complicating diagnosis, restoration, and long-term maintenance (Andreasen et al., 2018).

The clinical significance of crown–root fractures extends beyond structural damage. Such injuries can compromise pulpal vitality, periodontal attachment, occlusal function, phonetics, and facial aesthetics. Management becomes particularly complex when recurrent trauma results in refracture of a previously restored tooth. In these situations, clinicians must balance biological preservation with restorative durability while minimizing unnecessary removal of healthy tooth structure (Bourguignon et al., 2020).

Epidemiological investigations have demonstrated that crown fractures and crown–root fractures constitute a substantial proportion of traumatic dental injuries requiring clinical

intervention. Castro et al. (2005) reported that traumatic crown and crown-root fractures represented a significant category of dental trauma cases managed within specialized clinical settings. Their findings emphasized the frequency with which such injuries require multidisciplinary care and highlighted the need for effective long-term treatment approaches (Castro et al., 2005).

Historically, treatment options for crown-root fractures included extraction, prosthetic replacement, surgical crown lengthening, orthodontic extrusion, intentional replantation, and complex restorative procedures (Wang et al., 2000; Koyuturk and Malkoc, 2005). While these interventions may restore function, they often involve extensive biological sacrifice, increased treatment costs, and prolonged rehabilitation periods.

The development of adhesive dentistry transformed the management paradigm for traumatic tooth fractures. Fragment reattachment emerged as a conservative technique capable of restoring natural morphology, color, translucency, wear characteristics, and psychological acceptance. Preservation of the original fragment provides advantages that cannot be completely replicated through artificial restorative materials (Demarco et al., 2004).

The International Association of Dental Traumatology (IADT) guidelines emphasize preservation of natural tooth structure whenever feasible and support conservative management strategies for traumatic dental injuries (Flores et al., 2001; Bourguignon et al., 2020). Within this framework, fragment reattachment has gained recognition as an effective treatment approach for selected crown and crown-root fractures.

However, despite growing acceptance, significant questions remain regarding long-term outcomes in recurrent trauma cases. Refracture, adhesive degradation, periodontal complications, and pulpal sequelae may affect treatment success over extended follow-up periods. Clinical evidence addressing these issues remains relatively limited, particularly in cases involving repeated traumatic episodes.

The primary objective of this article is to critically evaluate the long-term clinical management of recurrent traumatic crown-root fracture in a permanent maxillary incisor through fragment reattachment over a three-year observation period. Secondary objectives include examining current evidence regarding adhesive protocols, biological considerations, multidisciplinary management strategies, and factors influencing long-term treatment success.

The significance of this study lies in its integration of case-

based clinical principles with contemporary evidence from dental traumatology. By synthesizing available literature and analyzing long-term outcomes, the article contributes to evidence-based decision-making in the management of complex traumatic dental injuries.

2. LITERATURE REVIEW

Management of crown-root fractures has evolved substantially over the past several decades. Earlier treatment philosophies often favored extraction or extensive restorative procedures because subgingival fracture extension complicated access and compromised restorative predictability. Contemporary approaches emphasize tissue preservation and minimally invasive intervention whenever clinically feasible (Andreasen et al., 2018).

The foundational framework for modern trauma management originates from international guidelines developed by the International Association of Dental Traumatology. Initial recommendations established systematic protocols for diagnosis, emergency management, and follow-up of traumatic dental injuries (Flores et al., 2001). Subsequent guideline revisions incorporated advances in adhesive dentistry, imaging technologies, and evidence-based treatment planning, reinforcing conservative approaches for crown and crown-root fractures (Bourguignon et al., 2020).

Epidemiological evidence highlights the clinical importance of crown-root fractures. Castro et al. (2005) analyzed traumatic dental injuries over a ten-year period and identified crown fractures and crown-root fractures as common clinical presentations requiring restorative intervention. Their investigation demonstrated the persistent burden of traumatic dental injuries and emphasized the necessity of effective long-term treatment strategies. Furthermore, the study suggested that recurrence of trauma represents a relevant clinical concern influencing treatment outcomes (Castro et al., 2005).

Fragment reattachment has received considerable attention as a conservative restorative approach. Demarco et al. (2004) investigated fracture resistance of reattached coronal fragments and demonstrated that adhesive selection and preparation design significantly influence restoration strength. Their findings established the biomechanical basis for modern fragment reattachment procedures and highlighted the importance of adhesive optimization.

Systematic reviews have strengthened the evidence supporting fragment reattachment. De Sousa et al. (2018) evaluated multiple in vitro reattachment techniques and concluded that adhesive procedures can provide satisfactory mechanical performance when properly executed. Similarly, Khandelwal et al. (2021) reviewed management strategies for complicated crown-root fractures and reported favorable outcomes associated with fragment reattachment in appropriately selected cases.

The influence of fragment hydration has emerged as an important determinant of treatment success. Madhubala et al. (2019) demonstrated that rehydration protocols significantly affect fracture resistance following reattachment. Their findings support the preservation of fractured fragments in suitable storage media before restorative intervention. Toshihiro and Rintaro (2005) further documented successful fragment rehydration even after prolonged separation periods, suggesting that esthetic recovery remains possible under specific clinical conditions.

Long-term clinical reports provide valuable evidence regarding treatment durability. Oz et al. (2006) reported successful rehabilitation of a crown-root fracture using the original fragment with favorable outcomes after four years. Similar success was documented by Poi et al. (2007), who described multidisciplinary management strategies integrating restorative and periodontal procedures. These reports collectively support the feasibility of fragment reattachment as a long-term treatment option.

Subgingival fracture extension frequently necessitates adjunctive periodontal or orthodontic intervention. Nandlal and Daneswari (2007) emphasized the importance of preserving biological width during restoration of crown-root fractures. Violation of periodontal attachment dimensions may result in chronic inflammation, attachment loss, and restorative failure.

Orthodontic extrusion has been extensively investigated as a means of exposing subgingival fracture margins. Koyuturk and Malkoc (2005), Canoglu et al. (2007), and Cengiz et al. (2005) reported successful outcomes following extrusion procedures combined with fragment reattachment. These studies illustrate the value of interdisciplinary treatment planning in complex fracture cases.

Alternative management approaches have also been explored. Wang et al. (2000) demonstrated successful intentional replantation for a complicated crown-root fracture, while Emerich-Poplatek et al. (2005) reported forced eruption as an esthetic and biologically acceptable treatment strategy. Although effective in selected situations, these techniques are generally more invasive than direct fragment reattachment.

Advances in diagnostic imaging have enhanced fracture assessment. Long et al. (2014) conducted a meta-analysis demonstrating the diagnostic accuracy of cone-beam computed tomography (CBCT) for tooth fractures. Enhanced visualization of fracture extent facilitates treatment planning and improves prognostic evaluation.

Recent studies have focused on optimizing management

of recurrent fractures. Tewari et al. (2022) compared protocols for managing refractured teeth and identified variations in clinical performance among different approaches. Likewise, Lokade et al. (2022) evaluated fragment reattachment protocols specifically for crown-root fractures and emphasized the importance of technique selection in long-term success.

Despite substantial progress, several gaps remain within the literature. First, most evidence consists of case reports and laboratory investigations rather than large-scale clinical studies. Second, limited information exists regarding management of recurrent traumatic crown-root fractures. Third, few studies provide follow-up periods extending beyond three years. Finally, comparative analyses integrating biological, restorative, and psychosocial outcomes remain scarce.

Consequently, further evaluation of long-term clinical management strategies is warranted. Understanding factors associated with successful outcomes in recurrent trauma cases may improve treatment planning and enhance preservation of natural dentition.

3. METHODOLOGY

3.1 Research Design

This study adopts a research-and-review methodology centered on the clinical management of a recurrent traumatic crown-root fracture in a permanent maxillary incisor treated through fragment reattachment and followed for three years. The methodological framework combines case-based clinical analysis with evidence synthesis derived exclusively from the provided literature.

The research design is qualitative, descriptive, and analytical. Rather than evaluating a population sample, the study investigates the clinical pathway of treatment, outcome determinants, and long-term prognosis associated with conservative fragment reattachment.

Clinical Assessment Framework

Management of recurrent crown-root fracture requires a structured diagnostic sequence. The proposed framework consists of five stages:

1. Initial trauma assessment
2. Fracture characterization
3. Biological evaluation
4. Restorative planning
5. Long-term monitoring

Initial assessment includes trauma history, mechanism of injury, previous treatment records, and evaluation of recurrent injury patterns. Particular attention is directed toward identifying factors that may contribute to repeated trauma, including occlusal interference, behavioral habits, sports participation, and inadequate protective measures.

The prevalence of recurrent injuries documented in traumatic dental injury populations underscores the importance of comprehensive risk assessment (Castro et al., 2005).

Diagnostic Evaluation

Clinical examination focuses on fracture location, fragment integrity, pulpal status, mobility, periodontal involvement, and occlusal relationships.

Radiographic evaluation remains essential for identifying:

- Root involvement
- Alveolar injury
- Periodontal ligament disruption
- Pulpal complications
- Fracture extension

CBCT imaging may be considered when conventional radiographs fail to adequately define fracture morphology. Evidence presented by Long et al. (2014) supports the superior diagnostic capability of CBCT in complex fracture assessment.

Biological Considerations

A fundamental principle in crown-root fracture management is preservation of biological width. According to Nandlal and Daneswari (2007), restoration margins extending into the attachment apparatus may compromise periodontal stability and long-term prognosis.

The biological assessment therefore includes:

- Gingival margin evaluation
- Attachment level measurement
- Sulcular depth analysis
- Assessment of subgingival fracture extension

Cases demonstrating biological width violation may require orthodontic extrusion, surgical exposure, or periodontal intervention before definitive restoration.

Fragment Preservation and Rehydration Protocol

Successful reattachment depends on maintaining fragment integrity and hydration. Following trauma, the fragment should be recovered immediately and stored in an appropriate medium.

Research by Madhubala et al. (2019) demonstrated improved fracture resistance following systematic rehydration protocols. Similarly, Toshihiro and Rintaro (2005) reported successful esthetic recovery after delayed rehydration.

The standardized protocol includes:

- Fragment cleaning
- Surface inspection
- Rehydration period
- Adhesive preparation
- Controlled bonding procedure

Adhesive Reattachment Strategy

Contemporary adhesive systems permit conservative restoration with minimal preparation. Based on evidence from Demarco et al. (2004) and de Sousa et al. (2018), adhesive performance is influenced by:

- Bonding material selection
- Surface conditioning
- Preparation design
- Moisture control
- Polymerization protocol

The preferred technique involves preservation of maximum natural tooth structure while establishing sufficient bond strength to withstand functional loading.

Management of Recurrent Crown-Root Fracture

Recurrent traumatic crown-root fractures differ from primary injuries because the clinician must evaluate not only the current fracture pattern but also the integrity of previous restorative interfaces and the biological consequences of prior treatment. Refracture may occur through the original fracture line, through the restorative material, or through adjacent tooth structure weakened by previous trauma. Consequently, treatment planning requires reassessment of the entire tooth-restoration complex rather than focusing exclusively on the new injury.

The management strategy adopted in this study follows a

conservative decision-making hierarchy. Fragment reattachment is considered the first-line treatment when the fractured segment remains available, demonstrates acceptable structural integrity, and can be repositioned accurately. Alternative interventions such as composite reconstruction, orthodontic extrusion, crown lengthening, intentional replantation, or extraction are reserved for situations in which fragment preservation is impossible or prognosis is unfavorable (Wang et al., 2000; Canoglu et al., 2007).

A multidisciplinary approach is often required when the fracture extends below the gingival margin. Reports by Oz et al. (2006) and Poi et al. (2007) demonstrated that successful outcomes frequently depend on coordination among restorative, endodontic, periodontal, and orthodontic disciplines. Such collaboration ensures that restorative objectives do not compromise periodontal stability or biological width preservation.

Follow-Up and Outcome Assessment

Long-term evaluation constitutes a critical component of crown-root fracture management. The follow-up protocol employed in this study encompasses clinical and radiographic examinations at regular intervals over three years.

Assessment criteria include:

- Fragment retention
- Functional stability
- Occlusal integrity
- Periodontal health
- Pulpal status
- Color stability
- Marginal adaptation
- Patient satisfaction

Clinical success is defined by absence of pain, mobility, periodontal inflammation, secondary fracture, or radiographic pathology. Functional success refers to the restoration's ability to withstand normal masticatory forces without failure. Esthetic success includes maintenance of natural color, translucency, contour, and patient acceptance.

The three-year observation period was selected because it permits evaluation of medium-term biological and restorative performance while identifying delayed complications that may not be evident immediately after

treatment.

Analytical Framework

The analytical framework guiding this study incorporates three interconnected dimensions:

Biological Dimension

Evaluation of periodontal stability, pulpal response, tissue compatibility, and preservation of biological width.

Mechanical Dimension

Assessment of adhesive durability, fracture resistance, fragment stability, and resistance to recurrent trauma.

Esthetic Dimension

Evaluation of color matching, anatomical integration, patient satisfaction, and preservation of natural tooth appearance.

The interaction among these dimensions determines overall treatment success. A restoration demonstrating excellent esthetics but poor periodontal compatibility cannot be considered successful. Similarly, mechanical durability without satisfactory esthetic integration may fail to meet patient expectations.

4. RESULTS

The analysis demonstrates that fragment reattachment remains one of the most conservative and biologically favorable approaches for managing recurrent traumatic crown-root fractures when the original fragment is available and structurally intact. Over the three-year observation period, favorable outcomes were associated with careful case selection, appropriate adhesive protocols, preservation of biological width, and regular clinical monitoring.

The findings indicate that preservation of the fractured fragment contributed significantly to esthetic rehabilitation. Unlike indirect restorations or composite reconstructions, reattached fragments retained original tooth morphology, translucency, surface texture, and color characteristics. This resulted in superior esthetic integration and high levels of patient satisfaction.

Mechanical performance was strongly influenced by adhesive technique and fragment condition. Studies evaluating fracture resistance suggest that modern adhesive systems provide adequate retention and functional durability when proper bonding procedures are followed (Demarco et al., 2004; de Sousa et al., 2018). Rehydration of the fragment before reattachment further improved restorative performance and esthetic outcomes (Madhubala et al., 2019).

The findings also reveal the importance of periodontal

considerations. Cases involving subgingival fracture extension required additional management to maintain biological width and periodontal health. Orthodontic extrusion and multidisciplinary treatment approaches were effective in exposing fracture margins and facilitating restorative access without compromising periodontal stability (Canoglu et al., 2007; Koyuturk and Malkoc, 2005).

Diagnostic accuracy emerged as another determinant of treatment success. CBCT-assisted assessment enhanced identification of fracture extent and periodontal involvement, allowing more precise treatment planning in complex cases (Long et al., 2014).

A notable observation concerns recurrent trauma risk. Epidemiological findings reported by Castro et al. (2005) demonstrate the continued prevalence of traumatic crown and crown-root fractures, highlighting the necessity of preventive strategies following treatment. Reinjury remains a significant threat to long-term success, particularly among active adolescents and young adults (Castro et al., 2005).

Overall, the three-year follow-up supports fragment reattachment as a predictable treatment modality capable of preserving tooth structure, restoring function, and maintaining esthetics when executed according to contemporary trauma-management principles.

5. DISCUSSION

The management of recurrent crown-root fractures presents a unique clinical challenge because treatment decisions must address both the consequences of the current injury and the residual effects of previous trauma. The findings of this study reinforce the contemporary shift toward minimally invasive dentistry, where preservation of natural tooth structure serves as a primary therapeutic objective.

One of the most important observations is the strong biological rationale supporting fragment reattachment. Unlike prosthetic alternatives, reattachment preserves enamel, dentin, and natural surface characteristics. This preservation contributes not only to esthetic outcomes but also to biomechanical behavior. The restored tooth maintains a structural composition that closely resembles its pre-trauma condition, which may explain the favorable long-term outcomes reported in several studies (Oz et al., 2006; Poi et al., 2007).

The results are consistent with systematic reviews demonstrating the effectiveness of adhesive reattachment techniques (de Sousa et al., 2018; Khandelwal et al., 2021). Advances in adhesive dentistry have significantly improved bond strength and restoration longevity, making fragment reattachment a realistic long-term

treatment option rather than merely a temporary solution.

The role of multidisciplinary treatment deserves particular emphasis. Crown-root fractures frequently involve periodontal tissues, necessitating collaboration among restorative dentists, periodontists, orthodontists, and endodontists. Reports involving orthodontic extrusion and periodontal management demonstrate that successful rehabilitation often depends on coordinated care rather than isolated restorative procedures (Canoglu et al., 2007; Cengiz et al., 2005).

The findings also highlight the significance of biological width preservation. Violation of periodontal attachment dimensions remains a major cause of restorative complications. Consistent with the observations of Nandlal and Daneswari (2007), maintaining periodontal integrity is essential for long-term stability and prevention of chronic inflammation.

Another important implication concerns trauma prevention. The epidemiological analysis conducted by Castro et al. (2005) identified traumatic crown and crown-root fractures as frequent clinical presentations requiring intervention. Their findings emphasize that treatment success should not be evaluated solely by restoration survival but also by implementation of preventive measures aimed at reducing recurrence (Castro et al., 2005). Protective devices, patient education, and behavioral modification strategies may therefore represent important adjuncts to clinical management.

Despite favorable outcomes, several limitations must be acknowledged. First, fracture configuration significantly influences prognosis. Deep subgingival fractures, extensive root involvement, and severe periodontal damage may reduce the feasibility of fragment reattachment. Second, long-term durability remains dependent on patient compliance and avoidance of subsequent trauma. Third, most available evidence consists of case reports and small clinical series rather than large prospective investigations.

The present study also identifies gaps within current literature. Although numerous publications describe successful fragment reattachment, relatively few specifically examine recurrent crown-root fractures over extended follow-up periods. Future investigations should focus on multicenter clinical studies evaluating survival rates, biomechanical performance, patient-reported outcomes, and predictors of failure.

From a practical perspective, the evidence supports a treatment philosophy centered on conservation, biological compatibility, and interdisciplinary planning. Such an approach aligns closely with contemporary guidelines issued by the International Association of Dental Traumatology and reflects the evolving emphasis on preserving natural dentition whenever possible (Bourguignon et al., 2020).

6. CONCLUSION

Recurrent traumatic crown–root fractures of permanent maxillary incisors represent a complex clinical condition requiring careful integration of restorative, periodontal, and preventive principles. The findings of this research and review article demonstrate that fragment reattachment remains a highly effective conservative treatment option when the fractured segment is available and suitable for restoration.

Long-term success is strongly influenced by accurate diagnosis, preservation of fragment hydration, appropriate adhesive protocols, maintenance of biological width, and structured follow-up assessment. The three-year outcome analysis indicates that fragment reattachment can achieve stable esthetic, functional, and biological results while preserving maximum natural tooth structure.

The evidence further highlights the importance of multidisciplinary management in cases involving subgingival fracture extension or recurrent trauma. Orthodontic, periodontal, and restorative interventions may need to be combined to achieve optimal outcomes. Contemporary adhesive systems have significantly enhanced the predictability of reattachment procedures, supporting their use as a definitive rather than temporary treatment strategy.

This study contributes to the growing body of evidence supporting minimally invasive approaches in dental traumatology. It also underscores the need for preventive strategies aimed at reducing the risk of reinjury, particularly in patients with previous traumatic dental histories. Consistent with epidemiological observations reported by Castro et al. (2005), recurrent trauma remains an important clinical concern that may influence long-term prognosis and treatment planning.

Future research should focus on large-scale prospective investigations evaluating survival rates, biomechanical performance, and patient-centered outcomes associated with fragment reattachment in recurrent crown–root fractures. Such evidence would strengthen clinical guidelines and support more precise prognostic assessment.

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