# HORIZONTAL ROOT FRACTURES IN PERMANENT TEETH AND THEIR LONG-TERM EFFECTS : A RETROSPECTIVE COHORT STUDY

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**Abstract**

**Aim :** The aim of present study is to assess the long term effects of horizontal root fracture via retrospective cohort study

**Methods** : From 2012 to 2022, we examined radiographic and clinical data from a dental OPDs of dental institutes. Clinical normality and radiographic healing at the fracture line, which are indicators of outcome, were considered for permanent teeth with HRF after a follow-up of about 12 weeks. Multivariable logistic regression analyses were used to identify prognostic markers (P value ~.05).

**Statistical analysis used :** IBM Corp., Chicago, IL's SPSS (Version 27 for Mac) was used to analyze the final data set and overall result was evaluated using the Pearson Chi-Square test.

**Results :** 125 teeth from 103 patients were included. Overall, 92% of the results were positive after a median follow-up of 79 weeks. This comprises teeth that underwent emergency repositioning or splinting at baseline (62.2%) and those that underwent endodontic intervention for the coronal fragment later on (baseline: 85%; follow-ups: 91.8%). There was a significant correlation between incomplete root development and male splinting/repositioning outcome (OR 5 2.58; 95% CI, 1.06-6.24 and OR 5 4.37; 95% CI, 1.16-16.41, respectively) and a lower chance of needing endodontic treatment (OR 5 0.44; 95% CI, 0.20-0.96 and OR 5 0.24; 95% CI, 0.08-0.76, respectively). When compared to prompt presentations within 24 hours, treatment delays longer than one week were substantially linked to a higher chance of needing endodontic treatment (OR 5 3.06; 95% CI, 1.07-8.77; P value,.05).

**Clinical significance :** The complicated traumatic dental injury known as a horizontal root fracture (HRF) impacts the pulp, dentin, cementum, and periodontal ligament. The results of treatment for permanent teeth with HRF were assessed in this retrospective cohort study.

**Key words :** Endodontic treatment; healing; horizontal root fracture; outcome; pulp; traumatic dental injury

## INTRODUCTION

Traumatic dental injuries can compromise the integrity of the dental arch and result in pain, pathologic tooth mobility, functional limitations, and aesthetic concerns[1,2]. These injuries may even be more detrimental to young people's physical, mental, and financial well-being than dental caries and periodontal disease[3,4] Moreover, 67% of worldwide productivity losses are attributable to tooth loss brought on by traumatic dental injuries. Saving damaged teeth requires a preservation-focused strategy, particularly during alveolar growth[3].

A complex traumatic dental injury that affects the pulp, dentin, cementum, and periodontal ligament is called a horizontal root fracture (HRF), often referred to as a transverse root fracture. This fracture typically manifests as mobility, displacement, and discomfort along the root surface in an oblique orientation[2,8].
Splinting, frequent follow-ups, and realigning the misplaced coronal piece are all part of emergency treatment. About 25% of cases requiring endodontic intervention had pulp necrosis, which is more common in the coronal fragment than in the apical fragment. When the fracture line does not heal, endodontic treatment of the coronal fragment is advised[2,10,11].

Treatment becomes difficult, though, when the apical and coronal pulp tissues are simultaneously necrotic. The periodontal tissues may suffer if endodontic therapy is administered through the fracture. If the coronal root fragment offers adequate support and attachment, surgical excision of the apical piece is an alternate choice[12,13].

The management of complex HRF cases that need for endodontic therapy is not well covered in the literature, despite the existence of dental traumatology recommendations [10, 11]. This lack of research makes it more difficult to create evidence-based recommendations for the best course of treatment[14] and increases the risk of traumatic dental injuries for dentists[15,16.] Therefore, the goal of this retrospective study was to evaluate the long-term results of teeth with HRF and look into the prognostic influence of treatment-related, trauma-related, and demographic factors on fracture line healing.

## MATERIALS AND METHODS

### Study Design

The study protocol was reviewed and approved by the Institutional Ethics Committees of the following institutions:

Rama Dental College, Hospital & Research Center, Kanpur — Approval No. RDC/IEC/2023/014

Maharana Pratap Dental College — Approval No. MPDC/IEC/2023/021

All study procedures were conducted in accordance with the Declaration of Helsinki and applicable national ethical guidelines.

**Population**

The following were the requirements for patient inclusion.

1. A history of sub-crestal HRF caused by trauma to a permanent tooth or teeth, verified by clinical and radiographic examination
2. The availability of clinical data (notes and photos) and standard periapical radiographs for HRF cases from the first visit to the most recent follow-up recall
3. A 12-week minimum follow-up period

Excluded were teeth with supra-crestal HRF, widespread periodontal issues, crown or crown-root fractures, or incomplete clinical or radiographic records.

**Data Collection**

Each patient filled out a standardized data collection form in Microsoft Excel 2016, which contained the following details.

1. The demographic data included the tooth type, age, sex, and root growth stage. Using Cvek's[17] criteria, the latter was categorized as follows: One (1/2 root length), two (1/2 root length), three (2/3 root length), four (almost full root length and wide open apical foramen), and five (closed apical foramen and full root growth). The first four stages were regarded as incomplete root development.
2. The position of the fracture line (apical, middle, or cervical third), the severity of coronal fragment dislocation, the etiology of the injury (traffic accidents, sports activities, falls, fights, or hard object impacts), and any concurrent injuries were among the trauma-related details. Concomitant injuries were categorized as either severe (lateral luxation, extrusion, or alveolar fracture) or minor (concussion or subluxation). Dislocation of the coronal fragment was noted as either evident (.2 mm), minor (0.2-2.0 mm), or absent (~0.1 mm)[18].
3. Treatment-related data included endodontic treatment (at baseline or follow-up), splinting with or without repositioning of the dislocated coronal fragment (henceforth referred to as splinting/repositioning), treatment delay, emergency interventions, and the length of splinting.

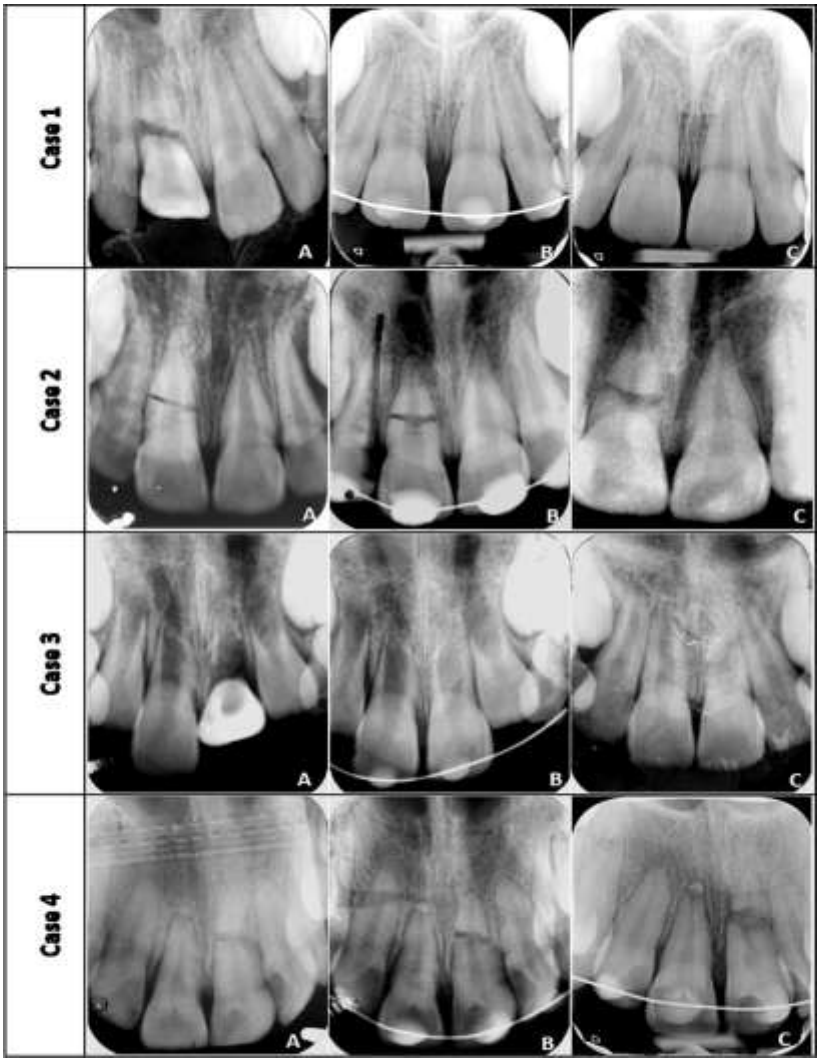
**Outcome Measures and Criteria**

Radiographic healing of the fracture line was categorized into 4 types (I-IV) based on the classification by Andreasen and Hjorting– Hansen[19]. The details are presented in Figure 1. The outcome measure was defined as follows[19,20]

1. Favorable result: lack of clinical signs or symptoms and radiographic evidence of healing (types I–III) at the fracture line.
2. Unfavorable result: the existence of any clinical indications or symptoms that require endodontic intervention or tooth extraction at any time during the patients' follow-up visits, as well as radiographic evidence of nonhealing (type IV) at the fracture line.

Based on available clinical and radiographic examinations, two endodontists evaluated results at certain intervals (up to 4 weeks, 5-8 weeks, 9-12 weeks, 13-24 weeks, 25-52 weeks, more than 52 weeks, and annually thereafter)[10,11]. There was a high degree of agreement (Kappa[5] 89.3%). All radiographs were subjected to a final audit by an independent endodontist who was not involved in patient care. Group discussions were used to settle any disputes.

**Statistical Considerations**




For regression analysis, we took into account five factors (sex, root growth stage, fracture line location, and dislocation of the coronal fragment and postponement of therapy).
We determined a minimum sample size of 113 teeth to avoid overfitting and guarantee the precision and accuracy of the regression models, assuming a 22% failure probability for teeth with HRF[18]. We carefully reviewed 1,887 available records tooptimise statistical power, and we included 125 teeth from 103 patients who satisfied the inclusion requirements.

IBM Corp., Chicago, IL's SPSS (Version 27 for Mac) was used to analyze the final data set. Continuous and dichotomous data were summarized using descriptive statistics such as means, standard deviations (SD), medians with interquartile ranges (IQR), and percentages. The unadjusted impact of putative predictors on the outcome of baseline interventions, the requirement for endodontic treatment, and the ultimate overall result was evaluated using the Pearson Chi-Square test. Multivariable logistic regression analyses were also conducted to ascertain the adjusted effect of factors.
The findings were presented as 95% confidence intervals (CIs) and odds ratios (ORs). A significance level of 5% was taken into consideration when interpreting the findings of all two-tailed statistical tests.

**Figure 1** – Radiographic progression of healing in horizontal root fracture cases with different types of healing. This figure showcases preoperative (A ), postoperative (B ), and follow-up radiographs (C ) of 4 teeth with HRF. The type of healing is classified according to Andreasen and Hjorting-Hansen's 19 classification, 1) Case 1 (tooth 1.1): Healing with calcified tissue, fragments in close contact, and minimal or no visible fracture line (type I). 2) Case 2 (tooth 1.1): Healing with interproximal connective tissue, fragments appear separated by a narrow radiolucent line, and fractured edges appear rounded (type II). 3) Case 3 (tooth 2.1): Healing with interproximal bone and connective tissue, fragments separated by a distinct bony bridge (type III). 4) Case 4 (teeth 1.1 and 2.1): Nonhealing with interposition of granulation tissue, evidenced by widened space between fragments or radiolucency adjacent to the fracture line (type IV)

## RESULTS

### Descriptive Results

The baseline attributes of the teeth under study are listed in Table 1. A total of 125 teeth from 103 patients—64.1% of whom were male—were included in the study.The patients' median age at presentation was 18.0 (IQR: 11–26; range: 7–59 years). There were 85 patients (82.5%) with one HRF tooth, 14 patients (13.6%) with two HRF teeth, and 4 patients (3.9%) with three HRF teeth. Sports activities accounted for 27 patients (26.2%), traffic accidents for 24 patients (23.3%), falls for 23 patients (22.3%), fights for 19 patients (18.5%), and impacts from hard objects for 10 patients (9.7%) as the primary causes of HRF.The most impacted teeth were maxillary central incisors (n = 5 103, 82.4%). The middle third (64.8%) had the highest percentage of fracture lines, followed by the apical third (23.2%) and cervical third (12.2%). Two teeth (1.6%) had concussions, 37 teeth (29.5%) had subluxations, 43 teeth (34.4%) had extrusions, and 43 teeth (34.4%) had lateral luxations, among other concurrent ailments. Thirty-two percent (n = 5–13) of teeth with lateral luxation also had an alveolar fracture.

### Analysis of treatment strategies and resulting outcomes

Treatment delays ranged from 24 hours to>3 years, with a median of 3 days (IQR: 1–11 days). In particular, 54 teeth in 42 patients (43.2 percent of research teeth) had dental therapy within 2–7 days, and 30 teeth in 28 patients (24% of study teeth) received orthodontic treatment within 24 hours. After one week, the remaining cases—41 teeth in 33 patients, or 32.8% of the study teeth—received dental care.
Every research tooth required an emergency semi-rigid splint. Interestingly, 60.8% of patients had splints for12 weeks (median 16.0, IQR: 10.2-24; mean 16.8 6 8.2, range: 5 to 41 weeks), frequently as a result of very mobile teeth or patient noncompliance following initial splint removal. Additionally, displaced coronal fragments were digitally repositioned in 86 out of 125 teeth (69%) of the total.

Initial evaluations of pulpal health and coronal fragment dislocation served as the basis for the subsequent treatment strategies (Fig. 2).

1. At baseline, 98 teeth that did not need endodontic treatment got emergency splinting and repositioning procedures. Out of these,
   61 teeth (62.2%) showed signs of radiographic healing and clinical normality (20.4% type I, 28.6% type II, and 13.2% type III).
2. A total of 64 teeth required endodontic therapy. Following a coronal fragment pulpectomy, these teeth were treated with calcium hydroxide for two to twenty-four weeks. Mineral trioxide aggregate (MTA) was utilized to obturate the coronal pieces of 57 teeth, and gutta-percha and

resin-based sealant were applied to seven teeth that had fracture lines at the apical third of the root.

- Of these 64 teeth, 27 underwent endodontic therapy at baseline along with relocation and splinting. The causes included evidence of coronal pulpal necrosis linked to a significant delay in seeking treatment, or complete pulp tissue loss in both the apical and coronal fragments (caused by a significantly dislocated coronal fragment in four teeth and a misdiagnosis in six teeth, resulting in a full pulpectomy performed by the referring dentist).
- Following baseline splinting and repositioning, nonhealing along the fracture line was noted for the remaining 37 teeth, requiring endodontic treatment at follow-up consultations. For these teeth, the median time to endodontic treatment was 10.5 weeks (IQR: 5.2–22.2).
- 61 of the 64 teeth satisfied the requirements for a minimum 12-week follow-up. Of them, 88.5% (54 teeth) had positive results and were classified as type I in 13.1% of cases, type II in 23%, and type III in 52.4% of cases.Following a median follow-up of 79.0 weeks (IQR: 31.5-243.0), 92% of the 125 study teeth in the total sample saw positive results. Of the available teeth, 86.7% were available at 4 weeks (52 of 60), 75.0% were available at 5–8 weeks (42 of 56), 84.9% were available at 9–12 weeks (45 of 53), 88.8% were available at 13–24 weeks (71 of 80), 83.9% were available at 25–52 weeks (52 of 62), and 94.4% were available at>52 weeks (67 of 71).A good survival rate of 96% was noted, except for 5 teeth that were pulled following a median follow-up of 32.0 weeks (IQR: 28–55.5).

| **Variable** | **Categories** | | **Frequency (n)** | **Percentage (%)** |
|---|---|---|---|---|
| No. of teeth | N | | 125 | 100 |
| Treatment delay | Within 24hrs | | 30 | 24.0 |
| | 2-7 days | | 54 | 43.2 |
| | 2-4 weeks | | 24 | 19.2 |
| | 5-12 weeks | | 11 | 8.8 |
| | >12 weeks | | 6 | 4.8 |
| Tooth type | Maxillary central incisor | | 103 | 82.4 |
| | Maxillary lateral incisor | | 11 | 8.8 |
| | Mandibular central incisor | | 8 | 6.4 |
| | Mandibular lateral incisor | | 1 | 0.8 |
| | Mandibular canine | | 2 | 1.6 |
| Concomitant injury | Mild | Concussion | 2 | 1.6 |
| | | Subluxation | 37 | 29.6 |
| | Severe | Extrusion | 43 | 34.4 |

| | | | | |
|---|---|---|---|---|
| | | Lateral luxation | 43 | 34.4 |
| Location of the fracture line | Cervical third | | 15 | 12.0 |
| | Middle third | | 81 | 64.8 |
| | Apical third | | 29 | 23.2 |
| Root development | Complete | | 102 | 81.6 |
| | Incomplete | | 23 | 18.4 |
| Severity of coronal fragment dislocation | None/slight | | 72 | 57.6 |
| | Marked | | 53 | 42.4 |
| Duration of splinting | 4-8 weeks | | 17 | 13.6 |
| | 9-12 weeks | | 31 | 24.8 |
| | >12 weeks | | 76 | 60.8 |
| | Missing data | | 1 | 0.8 |
| Primary endodontic intervention | Yes | | 27 | 21.6 |
| | No | | 98 | 78.4 |
| Endodontic intervention performed in follow-up visits | Yes | | 64 | 51.2 |
| | No | | 61 | 48.8 |

**Table 1 -** Baseline Characteristics of Study Teeth With Horizontal Root Fracture

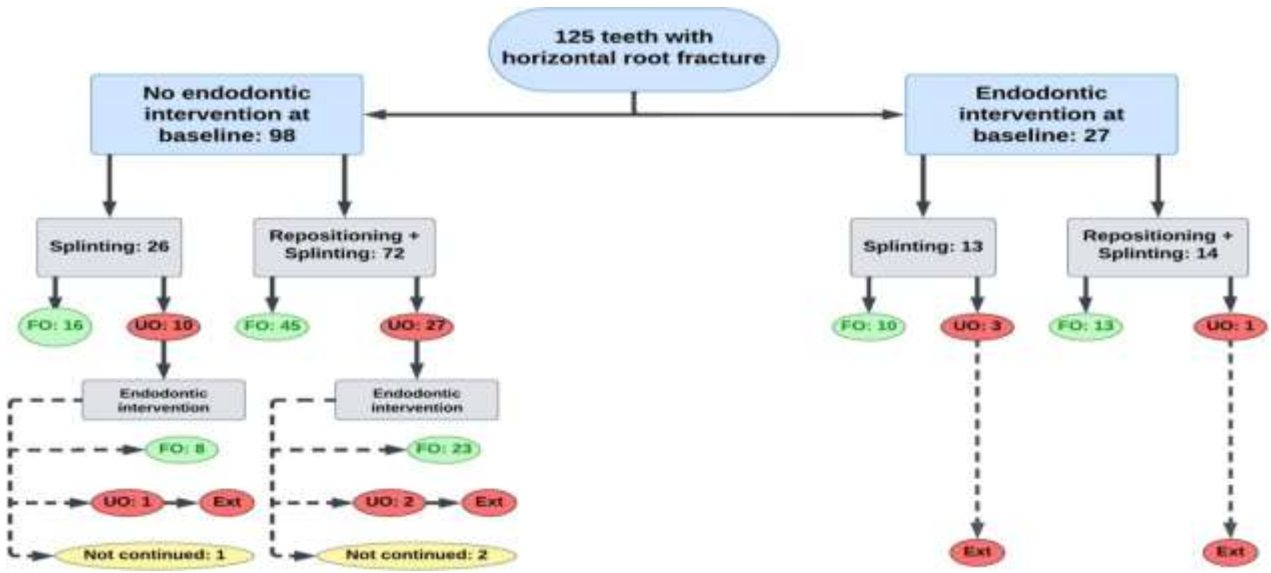


**Figure 2** – Flowchart illustrating the treatment interventions and outcome of the study teeth with horizontal root fracture.

**Analysis of prognostic factors**

According to preliminary univariate analyses, baseline splinting/repositioning and the requirement for endodontic treatment (either at baseline or follow-up appointments) were significantly correlated with age, sex, and root development stage. The requirement for endodontic therapy was impacted by treatment delays. The position of the fracture line, the degree of coronal fragment displacement, and concurrent luxation injuries, however, had no discernible impact on the outcome of emergency care or the requirement for endodontic therapy. At their most recent follow-up, no factors affected the study teeth's final results.

Because of its strong association with root development, age was not included in the final multivariable models (Pearson). P value: .01, correlation coefficient: 50.502. The following prognostic factors were identified by the final analyses.

1. Male gender was substantially linked to a decreased chance of needing endodontic treatment (42.1% vs. 65.3%, adjusted OR 50.44; 95% CI, 0.20–96) and a better outcome of emergency intervention (71.4% vs. 48.6%, adjusted OR 52.58; 95% CI, 1.06-6.24).

2. The probability of requiring endodontic treatment was significantly lower for incomplete root development compared to completeroot development (21.7% vs. 57.8%, OR 5 0.24; 95% CI, 0.08–0.76), and the outcome of the baseline intervention was better(85.7% vs. 57.1%, OR 54.37; 95% CI, 1.16-16.41).

3. There was a significant correlation between the chance of needing endodontic treatment with treatment delays longer than one week as compared to timely presentations within 24 hours (68.3% vs. 33.3%, OR 53.06; 95% CI, 1.07–8.77; P value<.05).

**DISCUSSION**

The present retrospective analysis confirmed earlier findings that HRF is more common in men and largely affects maxillary central incisors, with fractures primarily found in the middle third of the roots [18, 22, 25].Prior research on HRF cases shows variation in prognostic variables, as well as survival and healing rates [9,13,18,20-29].

In the current study, we observed a notable 96% retention rate for study teeth with HRF following a median follow-up of 79.0 weeks. This is higher than rates that have been previously reported, which ranges between 80% [24] to 91% [26]. Additionally, radiographic healing at the fracture line and the lack of clinical signs or symptoms demonstrates that 92% of the study teeth had a positive outcome.

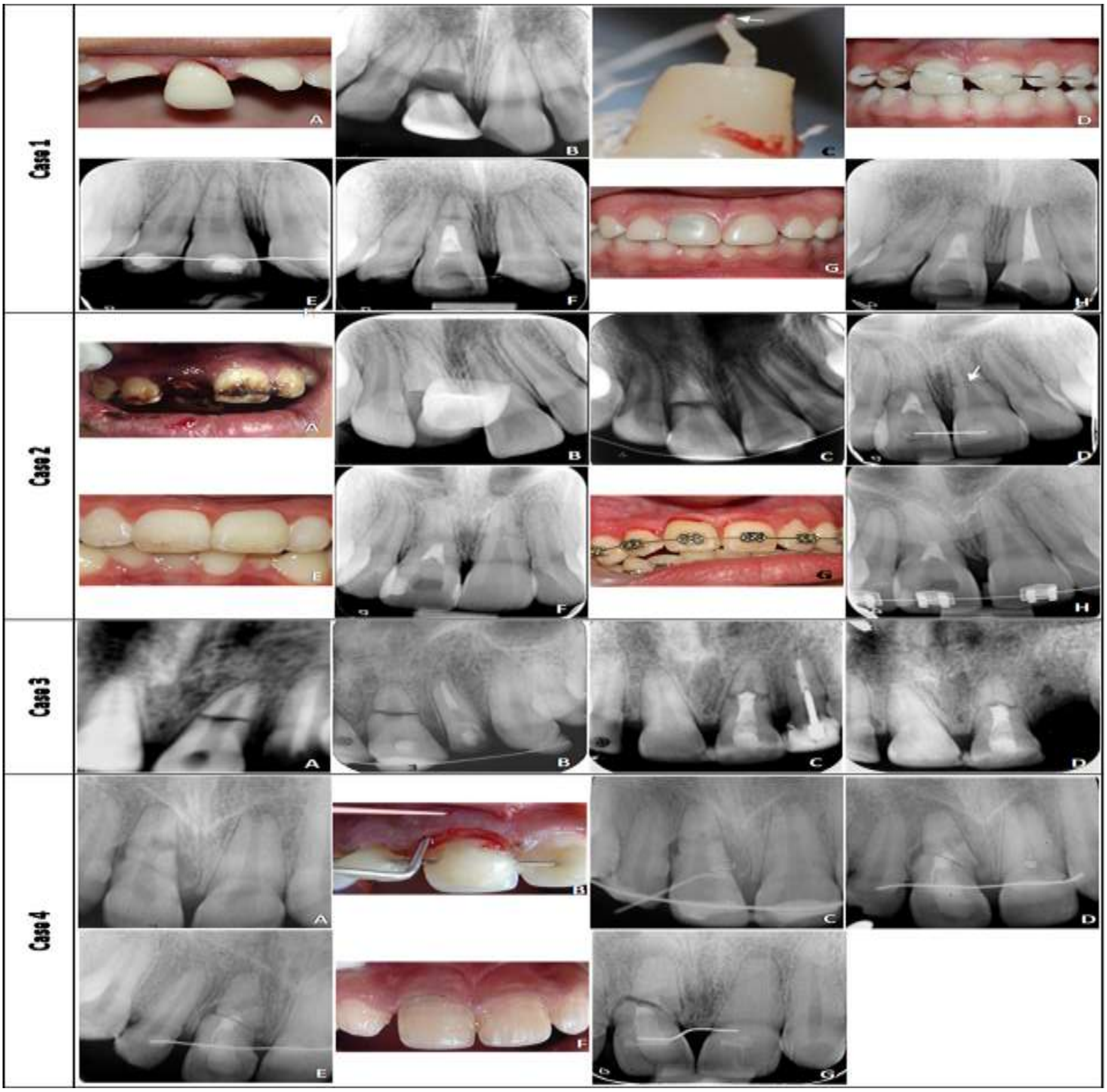



**Figure 3-** Four complex examples of horizontal root fractures had favorable long-term results. Two right central incisors with HRF are shown in Cases 1 and 2. In Case 1, a male patient, age 11, showed up within 24 hours of the injury, and in case 2, a male patient, age 10, showed up one week later. Both patients (1A-2 A and 1B-2 B) had significant dislocation of the coronal pieces, as validated by clinical evaluations and radiographic assessments. The whole coronal fragments that were free were avulsed during the repositioning process. At baseline, the following procedures were carried out: splinting, immediate replantation, and close reduction (1D, 1E, and 2C); pulpectomy, calcium hydroxide medication, and temporary restoration at 1 week; obturation of coronal fragments with MTA and temporary restoration (1F and 2D) at 3 weeks; splint removal and resin composite restoration at 12 weeks (Case 1) and 16 weeks (Case 2). In tooth 2.1 (arrowhead in 2D), an undiscovered HRF was discovered during the splint removal of instance 2, necessitating no additional treatment. Both situations had a positive outcome. With pulp canal obliteration in the apical pieces and type I healing at the fracture sites, they continued to be asymptomatic. Case 1: at age 6 (1G with some darkening of

the crown) and 1H; Case 2: at age 3 (2E and 2F) and age 5 (2G and 2H). Case 3: Four weeks following the injury, a 32-year-old man with an HRF in tooth 2.1 appeared. The referring dentist was initially unaware of the HRF, which led to a full pulpectomy for both the coronal and apical fragments (3A). Splinting, calcium hydroxide medication, and temporary restoration (3B) were done at baseline; coronal fragment obturation with MTA and temporary restoration (3C) was done at 6 weeks; and splint removal and resin composite repair were done at 16 weeks. The tooth remained asymptomatic, with type II healing at the fracture line and pulp canal obliteration in the apical fragment (3D), and the result during the six-year follow-up was positive. Case 4: One day following trauma, a 15-year-old male patient was referred with subluxation (no dislocation) in tooth 1.1 (4A). Existing evidence of a deep periodontal pocket and a sinus tract connected to an unhealed HRF from a prior stressful incident that occurred seven months ago (4B and 4C). The following actions were taken: Splinting and calcium hydroxide treatment were carried out at baseline (4B); coronal pieces were obturated with MTA and a temporary restoration at 8 weeks; the splint was taken out and a resin composite restoration was placed at 16 weeks; nevertheless, because of the tooth's ongoing movement, the splint was placed permanently (4D).The end results were positive; the fracture line healed type III after 6 years (4E) and 12 years (4F and 4G), and the tooth remained asymptomatic.

Within the first five to eight weeks, 25% of HRF cases in this research experienced early difficulties. Notably, in 88.5% of HRF instances, endodontic intervention for the coronal fragment produced a positive result, when necessaryat baseline or follow-up. This emphasizes how crucial it is to have close observation during the first two months following splinting and to have endodontic treatment as soon as possible in order to handle issues and lower the chance of tooth loss.Without taking endodontic intervention into account, past studies have mainly examined the rate of healing along the fracture line after splinting or repositioning. These studies' reported healing rates range from 45% to 78% [18,22-25,27,28].With 62% recovery rate for teeth that only required splinting or repositioning as an emergency measure at this range includes baseline.The findings are in line with the frequencies of 60% to 62.5% reported by Majorana et al.[27] and Caliskan et al.[25], but they surpass the 45% shown by Welbury et al.[28] since they included borderline cases with both HRF and crown fractures.However, our incidence is lower than the 77–78% reported by Andreasen et al· [18,22] and Cvek et al. [23,24], which may be because they included younger participants who had five-day treatment delays.

Healing rates varied from 50% to 89% in studies including HRF cases that needed endodontic intervention[13,21,24–26]. Using MTA[21] resulted in a greater rate of 89.5%, whereas gutta-percha-filled teeth with or without intra-radicular splinting had lower rates of 50–69% [24, 26].Additionally, after at least three months of follow-up, our study showed that 88.5% of endodontically treated teeth had healed. These results highlight MTA's possible advantage in fostering effective healing in HRF patients where endodontic therapy is necessary.We also studied at how healing results and the requirement for endodontic therapy in teeth with HRF are influenced by patient characteristics, trauma-related variables, and treatment modalities.We observed that emergency measures had a better effect on male patients, lowering the requirement for endodontic therapy. This contrasts with the findings of Andreasen et al.[18], which showed that women experienced a higher frequency of hard tissue repair.

This is linked to the female patients' more immature root development and less severe damage. Different groups of boys with maybe superior risk indicators were found in our investigation.Males in our study, for example, had a higher percentage of patients under the age of 18, shorter treatment delays, and HRF cases with no or slight coronal fragment displacement or incomplete root development, though these differences were not statistically significant. These results imply that the male participants in our study displayed traits linked to a potentially superior result.Therefore, although sex is presented in our study as a possible "risk marker," we are unable to define it as a "risk indicator" for HRF outcomes. These findings may be further refined when additional data becomes available in subsequent studies.

According to research, teeth with partial root development are less likely to experience HRF than teeth with complete development, and 81.6% of the teeth in this study had entire root development at baseline[2,9,19].That's probably because immature teeth have more flexibility in their sockets, which may lessen the incidence of HRF[9,19]. Additionally, our findings support earlier research[18,22–24], which showed better results in immature teeth with HRF. This is probably caused by elements such a higher density of the vasculature system, a bigger volume of pulp tissue, increased availability of inflammatory mediators, and closeness to the main vascular supply[30,31].Our research also showed a strong correlation between the necessity for endodontic intervention later and treatment delays longer than one week. This runs counter to earlier studies[18,22–24] that failed to determine the effect of delays—typically up to five dayson pulp necrosis.Lack of knowledge about dental trauma management may be the cause of patient delays in obtaining dental care, and the degree of coronal fragment displacement affects how quickly patients seek therapy.In-order to minimize needless treatment delays, these findings emphasize the necessity of public education on dental emergency and postdental trauma measures. Even yet, there was a good likelihood that out of the total cases 73% cases with the delayed referrals would still have a good fracture line outcome.

Treatment recommendations for classified trauma patients are provided by recent dental traumatology guidelines[10, 11]. On the other hand, there is little advice available for handling complex HRF cases[13,26]. Our research points to the possibility of recovery even in complex situations.Consequently, a preservation strategy must to be given top priority, particularly for patients who are in the crucial stage of alveolar development when it might not be possible to replace an implant because of insufficient alveolar ridge dimensions. We looked at two subgroups of complex HRF cases from our database (Fig. 3) to highlight this issue, pointing out the limitations of the size of the sample these subgroups.

1. Complete loss of apical pulp tissue, which is frequently connected to highly dislocated coronal fragments, or unintentional pulpectomy in symptomatic teeth where HRF was not diagnosed can result in the total loss of pulp tissue in both coronal and apical pieces.Attempts to obturate both coronal and apical fragments in these situations carries the danger of material extrusion as well as possible failure. On the other hand, removing the apical portion surgically reduces tooth support and adds to the expense and effort.For ten of these teeth, our study used a conservative strategy that included intra-canal treatment. Using calcium hydroxide, the coronal fragment is obturated by MTA, and the repair is permanent.These patients demonstrated a median follow-up is of about 248.5 weeks (ranging from 28 to 450 weeks). effective recovery. This implies that a pulpless apical fragment does not impede the healing process when it is appropriately protected from bacterial growth at the fracture line.

2. The risk of tooth loss is increased when there is excessive tooth mobility when baseline splinting is removed, especially when HRF is situated in the cervical third of the root[20]. Remarkably, extraction may be required in 70% of these cases[24]. The risk is associated with the type of healing, as the coronal fragment's resistance to pressures is reduced by its connective tissue's healing (types II or III)[20,24,29,32].On the other hand, tooth loss is independent of the site of the fracture when teeth with

HRF recover with calcified tissue (type I).[20, 24]. Similar to nearby non-injured teeth, this group exhibits normal movement following splint removal[2]. After removing the baseline splinting, we saw significant movement in 30 teeth with HRF in the middle or cervical third.Permanent splinting using orthodontic retainers was used to increase survival. Following a median follow-up of 139.5 weeks (IQR: 39.0-277.5; range: 32 to 629), type II healing was observed along the fracture line in 27 teeth. The other three, on the other hand, developed extensive periodontal pockets and subsequently showed a non-healing type IV patterns after initially exhibiting type II healing. In these situations, it is essential to emphasize good dental hygiene in-order to maintain periodontal health and raise the likelihood that teeth will survive.

We acknowledge the limitations of the study. The following observations were made.

1. Potential problems such as irregular follow-up calls, missed data, biases in the selection process, and confounding from nonrandomization are introduced by the chart review design's retrospective character.

2. Most of the participants in this study did not have a baseline cone beam computed tomography (CBCT). While CBCT pictures are superior to traditional radiography images in identifying tooth and/or alveolar process fractures[33], our method places a higher priority on periapical radiographs and comprehensive clinical examinations when evaluating patients with dental traumatology[33].Furthermore, our patients had financial difficulties due to the additional expense of CBCT, which is frequently not covered by insurance. As a result, we follow the recommendation that CBCT not be used frequently unless its advantages greatly exceed any possible risks[34].We restricted the use of CBCT to particular cases related to clinical ambiguity, insufficient 2D radiographic imaging, or legal cases commonly referred from the forensic dentistry department following ALARA (As Low As Reasonably Achievable) fundamentals, for patients the radiation doses and taking into account the necessity for swift action during the baseline visit.

3. At first, patients' follow-up appointments were planned in accordance with dental traumatology recommendations[10, 11]. However, because of things like living in remote places, having a difficult commute, and noncompliance, participants' adherence to these timetables differed. Recall appointments were selected by some patients based on convenience or when symptoms were present.Furthermore, our 12-week follow-up time is consistent with evidence indicating the reliability of assessments at 3-6 weeks[9] or 12 weeks[21] post-trauma, while being shorter than certain studies[13,18,24,29] with follow-up times ranging from 6 to 12 months. However, the median follow-up period in this study was 79 weeks, and this limitation only applies to three cases.Longer follow-ups, however, can provide a more thorough insight of the process of healing in teeth with HRF, particularly for clinical decisions in young patients whose maxillofacial growth must be considered.

4. The restricted size of the samples in our subgroup's cases with problems might restrict the strength of clinical recommendations.
Implementing a large-scale, prospective study incorporating these distinct categories of traumatic oral injuries would be optimal but may not be practical due to their relatively low occurrence.

Notwithstanding these drawbacks, our research has several advantages. The study, which was carried out in a dental trauma center that serves more than 8 million people in the area, made use of a strong and extensive dataset that covered 16 years.
Our thorough statistical analysis helps to clarify the variables affecting the prospects of teeth with

HRF.Advanced imaging methods such as CBCT or TurboReg analysis[35] may be used in future studies to thoroughly evaluate bone height and root development in HRF cases. This enlarged scope can improve overall results in dental trauma by offering insightful information about for a long-time healing rate and the best course of therapy.

## CONCLUSION

The results of our investigation show that permanent teeth treated with HRF typically have positive outcomes. Better baseline results and a lower chance of requiring endodontic treatment were linked with males (as in sex) and partial root development. On the contrary, delayed appearance increases the requirement for endodontic intervention. These results underline the necessity of earlier diagnosis, customized interventions, and continuous monitoring for maximizing results obtained teeth with HRF.

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