Journal of Positive School Psychology http://journalppw.com
2022, Vol. 6, No. 5, 641 – 649

"Mid-root perforation repair with Mineral Trioxide Aggregate and Endodontic rehabilitation with Fibre Reinforced Post- A Case Report"

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Abstract

Root perforations can occur as a consequence of pathological processes or during routine endodontic treatment that can result in significantly compromised endodontic treatment outcomes, especially when bacterial infection is allowed to establish with the seal between the root canal obturation material and the periradicular tissue is compromised. Hence, one of the most difficult challenges in dentistry is the reconstruction of an endodontically treated tooth with perforation, maintaining aesthetics and functional integrity. Mid-root perforations can be further complicated by its close proximity to the gingival sulcus, pre-empting proper precautions to avoid future contamination. Use of the proper biomaterial, along with adhesive posts enhances the longevity of such compromised teeth. This case report describes the successful management of iatrogenic root perforation in an endodontically treated maxillary central incisor with Mineral Tri-oxide Aggregate, as well as the use of Fibre-reinforced composite post for composite core build-up to enhance the strength and fracture resistance of the tooth. During the first appointment the sealing of the perforation defect was achieved with the placement of Mineral Trioxide Aggregate. On the second appointment, post space preparation was done followed by luting of the fibre post using dual cure resin luting cement and Composite resin was layered around the post to form the core. Tooth preparation was carried out and during the subsequent appointment, Zirconia crown was cemented with dual cure resin luting cement. The patient was regularly recalled for follow up visits during which the tooth remained asymptomatic clinically and significant healing was observed radiographically.

Keywords: Endodontic management; Perforation repair; Maxillary Central incisor; post endodontic restoration.

INTRODUCTION

Iatrogenic procedural errors during endodontic therapy are common in regular clinical practice and one among them is coronal and radicular perforations. Perforation is a communication that occurs mechanically or pathologically between the external tooth surface and the anatomically complex canal system. [1] Root perforations can occur during access cavity preparation, root canal instrumentation, post space preparation, or as a result of internal resorption extending into the peri-radicular tissues, causing loss of integrity of the root and destruction of the adjacent periodontal tissues. In his clinical investigation, Kvinnsland et al estimated a 47% incidence of crown/root perforations during endodontic therapy and a 53% incidence of perforations during post space preparation. [2]

Perforations can be repaired either conventionally through the access cavity preparation or surgically. When an intra-canal approach fails to repair the perforation due to inaccessibility or those where a concomitant management of the periodontium is required, surgical repair is indicated. [1] The elimination and prevention of infection at the perforation site determines the prognosis of its repair. [1] Furthermore, sealing the perforation site with a novel biocompatible material will minimize periodontal inflammation and enhance healing. [3-6]

Traditionally dental amalgam, calcium hydroxide and zinc oxide eugenol (ZOE) have been employed in perforation management. [7,8] Ongoing search for biocompatible, non-degradable, antimicrobial materials with superior sealing ability has resulted in the use of bio-materials, including resin modified glass ionomer cement, mineral trioxide aggregate (MTA), Biodentine, bioactive glass, and decalcified freeze-dried bone. [9-12]

One of the first calcium silicate cements introduced in dentistry was MTA, which was initially promoted as a perforation repair material. Research revealed the clinical success of MTA in periapical surgery as a retrograde filling material, in direct pulp capping for remineralization and reparative dentin formation, during apexification procedures to create an apical barrier in blunderbuss canals and for the treatment of radicular resorption in establishing an apical seal. MTA is primarily composed of tri and di-calcium silicate, tri-calcium aluminate, tetra-calcium aluminoferrite, calcium oxide, bismuth oxide and silicon dioxide which when hydrated solidifies to generate a colloidal gel in 3 hours. In vitro studies support the use of MTA as a perforation repair material due to its mild inflammatory reactions. [13] MTA also has excellent biocompatibility, superior sealing ability due to chemical adhesion to the tooth structure, antimicrobial efficacy, radiopacity due to the presence of bismuth oxide and its potential to set in the presence of blood. In-vivo pathological and iatrogenic perforations repaired with MTA exhibits significantly less leakage than conventional dental materials due to its ability to induce osteogenesis and cementogenesis. [14]

Endodontically treated teeth with compromised coronal tooth structure were previously reconstructed with a cast post and core and a full crown. Unfortunately, retention loss and root fractures are the main drawbacks; hence they have been increasingly substituted by Pre-fabricated Fibre re-inforced composite (FRC) posts due to superior esthetics, micromechanical adhesion to the tooth structure and reduced chair-side time. [15] FRC posts are composed of resin matrix with randomly oriented E-glass fibers and inorganic particulate fillers. When compared to traditional particulate filler restorative composites, in-vitro research has revealed significant improvements in their load-bearing capacity, flexural strength, fracture toughness and control of polymerization shrinkage stress. [16]

This case report describes a clinical approach to mid-root perforation repair with MTA in a maxillary central incisor and reinforcement of the root with FRC post to restore the aesthetics and functional integrity of the tooth. The following case report guidelines were followed in reporting this present case: The CARE Guidelines: Consensus-based

Clinical Case Reporting Guideline Development [17] and Heart views: Guidelines to write a case report [18].

CASE REPORT

A fractured front tooth was the major complaint of a 27-year-old male patient who visited the Department of Conservative Dentistry and Endodontics, SRM Dental College, Ramapuram, Chennai. Reviewing the dental record of the patient, it was found that he underwent root canal treatment in tooth #21, three months ago. On clinical examination, Tooth #21 had an Ellis type III fracture and an access cavity extending on the palatal surface that was restored with IRM. [Figure 1A].

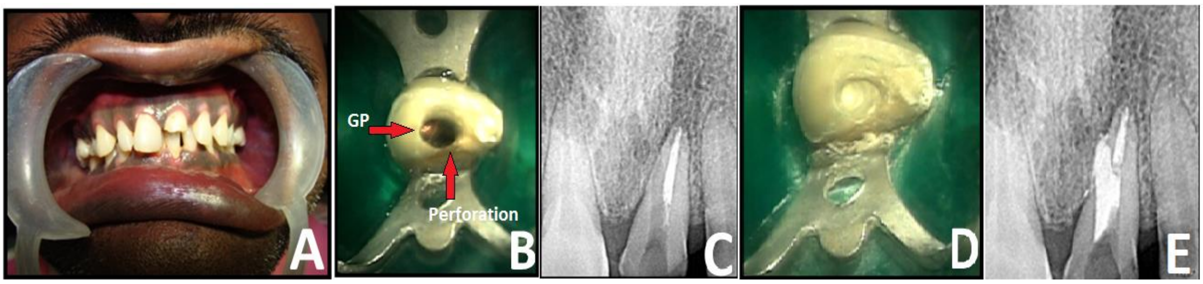

Figure 1: *A) Pre-operative intra-oral image of #21; B) Image taken under the DOM with remaining Gutta percha and perforation defect; C) Pre-operative radiograph of mid root perforation; D) Image taken under the DOM after sealing the perforation with MTA; E) Radiograph showing perforation sealed with MTA.*

Currently, the patient did not have pain on percussion and palpation, with normal periodontal probing depth and no mobility. Radiographic analysis revealed presence of gutta-percha at the apical third of the root with attempted post space preparation and a perforation in the mid-root region of #21; the latter being confirmed when examined under dental operating microscope (DOM) (OPMI Pico, Zeiss; Germany) [Figure 1B & 1C]. Given the compromised tooth structure and overall prognosis, the treatment plan outlined was root perforation repair with MTA, root reinforcement with FRC post along with composite resin core build up followed by placement of full crown in #21. During the first appointment isolation was achieved with the help of rubber dam to provide a controlled operating field. The canal was thoroughly irrigated with copious amount of 0.2% chlorhexidine and saline solution and dried with paper points. MTA (White Pro-Root MTA; Dentsply Maillefer Switzerland) was mixed as per the manufacturer's instructions and packed into the perforation site using MTA carrier- Messing Gun (Produits Dentaires Vevey, Switzerland). MTA was condensed to seal the defect using Schilder’s hand plugger (Dentsply Caulk Milford De, Delaware, USA) which was confirmed radiographically and clinically under the DOM [Figure 1D & 1E]. The orifice was covered with a damp cotton pellet and the tooth was sealed with Cavit G (3 M ESPE, St Paul, Minnesota, USA). The patient was recalled after 48 hours to allow proper setting of the MTA.

On the second appointment, the tooth was isolated, followed by post space preparation using a size 2 FRC post space preparation drill (Postec Plus drill; Ivoclar Vivadent, Liechtenstein, Austria) and the adaptability of the FRC post to the canal walls was checked by post insertion into the prepared canal which was confirmed radiographically [Figure 2A & 2B]. This was followed by luting of the fibre post using dual cure resin luting cement (Clearfil SA Cement, Kuraray Noritake Dental Inc., Kurashiki, Japan) as per manufacturer’s instructions, since this dual cure luting cement was reported to exhibit the highest bond strength according to Bitter et al, 2006.[19] Two coats of self-etch bonding agent (Prime and Bond NT; Dentsply Caulk Milford De, Delaware, USA) was applied to the extruded part of the fibre post using an applicator tip, air dried for 10 seconds and light-cured for further 10 seconds. Composite resin (Clearfil Photo

Core(CPC); Kuraray medical, Okayama, Japan) was layered around the post sequentially in 2 mm increments to form the core [Figure 2C].

For the final phase of the treatment, tooth preparation was carried out with a circumferential 2mm shoulder finish line to receive a zirconia crown [Figure 2D]. Gingival retraction was performed prior to impression taking using a gingival retraction cord (Ultrapak 000; Ultradent, USA). Addition silicone impression material (Aquasil; Dentsply, Germany) was used to create the impression using two- stage putty wash technique. Temporary crown was prepared using auto-polymerizing resin (Visalys Temp; Kettenbach, Germany) and was then cemented with non-eugenol luting cement ((Clearfil SA Cement, Kuraray Noritake Dental Inc., Kurashiki, Japan). During the subsequent appointment the fabricated Zirconia crown was cemented with dual cure resin luting cement (Ketac Cem, 3M ESPE, Germany) [Figure 2E].

Figure 2: *A) Clinical image of FRC post placement in 21; B) Radiograph taken to check adaptability of the FRC post; C) Composite resin core build up; D) Crown preparation; E) Zirconia crown luted in 21.*

Immediate post-operative radiograph was taken [Figure 3A]. The patient was recalled after a week with no complaints and the tooth also appeared to be functionally stable. The patient was again recalled after 6 months and 1 year during which the tooth remained asymptomatic clinically and significant healing was observed radiographically [Figure 3B & 3C].

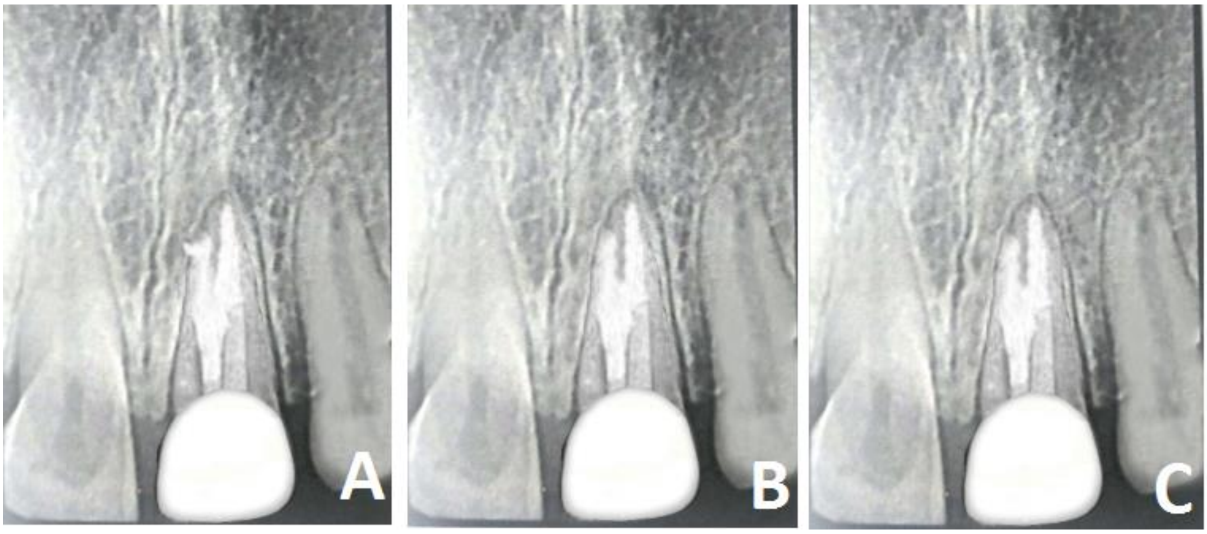

Figure 3: *A) Immediate post-operative radiograph; B) Follow-up radiograph after 6 months; C) Follow-up radiograph after 1 year.*

DISCUSSION

Root perforation is an undesirable phenomenon that can develop during caries removal, endodontic therapy and post-space preparation. Various factors such as size and site of the defect; the amount of time elapsed between the creation and closure of the perforation defect; microbial contamination and proper selection of the perforation repair material determine the success of the treatment and its prognosis. [20]

Fuss and Trope classified root perforations according to the parameters that influence the final treatment outcome [Table 1]. [1] According to this classification, the type of perforation reported in the current case report is classified as a large defect since it occurred during post-space preparation, which is often considered to have a poor prognosis, more so as more time elapses between the occurrence and management. However, there were no signs of bone degradation surrounding the perforation defect or peri-apically on the pre-operative radiograph, though the patient reported after three months of initial treatment. Hence, the endodontic retreatment was not performed to avoid weakening the radicular dentin and moreover the remaining gutta percha was intact maintaining the apical seal. This may be one of the main reasons our treatment method yielded a favourable prognosis.

Table 1: *Classification of Tooth perforations*

CATEGORY	DESCRIPTION	PROGNOSIS
Fresh perforation	Occurred under aseptic condition treated as soon as possible after the initial observation.	Good
Old perforation	Previous perforation with bacterial contamination left untreated.	Questionable
Small perforation	Size of defect less than #20 endodontic instruments with minimal trauma to the issue and ease of sealability.	Good
Large perforation	Commonly occurring during post space preparation creating significant tissue damage, difficulty in achieving an optimal seal. Also associated with bacterial contamination and coronal microleakage.	Questionable
Coronal perforation	Located coronal to alveolar crest with easy access and associated with minimal trauma to the adjacent tissues.	Good
Crestal perforation	Located at the equivalent to the level of alveolar crest and epithelial attachment.	Questionable
Apical perforation	Located apical to the alveolar crest.	Good

White MTA was selected as the perforation repair material due to its greater radiopacity, capacity to initiate osteogenesis and generate a calcific barrier. This may be attributed to MTA's alkaline pH (12.5) and bioactive nature due to its composition primarily consisting of calcium silicate. It also stimulates alkaline phosphatase, calcium-dependent pyrophosphatase enzymes that can induce calcific barrier formation. [14]

In addition, an in-vitro investigation revealed that MTA can increase osteoblastogenesis via the Atf6–osteocalcin axis as endoplasmic reticulum stress signalling and limit osteoclast activity by reducing RANKL-induced osteoclastic differentiation. Another study found that instances of root perforations treated non–surgically with MTA had an 80.9% success rate. Table 2 summarises a few case reports that report a good prognosis on using MTA as a perforation repair material. [21-26]

Table 2: *Case reports that report a good prognosis on using MTA as a perforation repair material*

AUTHOR	DESCRIPTION OF THE PERFORATION
Alzahrani O et al, 2021 [21]	Old perforation- Previously root canal treated tooth with perforation in the apical part of the distobuccal root.
Alves RAA_et al, 2021 [22]	Apical perforation- Root perforation in the middle third of the buccal surface and superior to alveolar crest.
Evans MD et al, 2021 [23]	Apical Perforation- Mid-root perforation on the labial aspect of the tooth approximately approximately 5mm superior to the alveolar crest.
Cosme-Silva L et al, 2016 [24]	Large Perforation- Iatrogenically prepared during post removal.
Kerner S et al, 2015 [25]	Large perforation- Iatrogenically produced during access cavity preparation.
Riccitiello F et al, 2013 [26]	Large perforation- Iatrogenically produced in the middle third of the root.

In this case study, tooth reinforcement was done with a post because its primary purpose is to retain the core in a tooth where there has been extensive coronal tooth structure loss. [27] The pulp chambers in anterior teeth are typically too small to provide adequate retention and resistance for a tooth core without a post. [25] Moreover, anterior tooth require posts since they are subjected to more lateral and shearing forces when compared to molars. [27]

Endodontic rehabilitation aims to increase the fracture resistance of the tooth as well as preserve the residual tooth structure. In this current case, FRC post with a composite resin core was preferred over cast post due to its superior aesthetics, micromechanical bonding and long-term clinical performance by strengthening the residual tooth structure creating what is termed as a monoblock effect. [15] FRC posts demonstrate elastic modulus, fatigue strength and flexural strength equivalent to that of the radicular dentin, thus enabling uniform stress distribution during masticatory function. [28] Furthermore, placement of FRC post provides a lower core-dentin interface, resulting in low peak stresses inside the root canal system and creates a stress field that is similar to the natural tooth structure. [29] An in- vitro study revealed that the failure rate was higher in teeth rehabilitated with cast post and core than in teeth rehabilitated with FRC post, justifying the use of FRC post in our study.[16] Another reason is that when compared to other perforation repair materials, the amount of reduction in bond strength is much less with MTA. [30]

Resin composite is a preferred core build-up material for FRC posts because of their compositional similarity, and enhanced bonding to the silanated post. [31] CPC used as a core material is a light-curing hybrid composite having a high filler content and high translucency, as well as a 7-mm cure depth. According to several studies, Clearfil Core has a stronger mechanical stress resistance than other materials, making it a better core material. [32-34]

In this case, reinforcing the remaining tooth structure with a post to compensate for the loss of coronal and radicular dentin resulted in successful clinical results after a 2-year follow-up. Additional reinforcement was achieved by placement of zirconia crowns since FRC post retention may be reduced after clinical function over time, resulting in decreased bond strength. [35]

CONCLUSION

Any procedural error requires meticulous evaluation and planning with multiple phases of treatment to execute the appropriate solution that is long lasting. Repair of the large, iatrogenic perforation, along with adequate reinforcement and support of the radicular and coronal tooth structure resulted in the revival of a hopeless tooth. This case report describes the successful management of one such procedural error with the use of a biomaterial to seal the perforation and rehabilitation of the root canal and coronal tooth structure with FRC post, composite build-up and zirconia crown. The two year follow-up showed excellent healing, aesthetics and function.

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