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Review Article

Dentistry Section

A Review on Perforation Repair Materials

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ABSTRACT

Perforation is an artificial communication between the root canal system and supporting tissues of the teeth. Root perforation complicates the treatment and deprives the prognosis if not properly managed. A wide variety of materials to seal the perforations have been suggested in literature. There are many comparative studies showing the efficacy of one material over the other. Literature shows many reviews on diagnosis, treatment plan and factors affecting prognosis of perforation repair; but none of these articles elaborated upon various materials available to seal the perforation. The present article aims at describing all the materials used for perforation repair from the past till date; it also offers a literature review of all the articles published over last four decades referred to the treatment of perforation with various root repair materials.

Keywords: Hydroxyapatite, Internal matrix, MTA, Perforation

INTRODUCTION

Root perforations can occur pathologically as a result of resorption and caries or iatrogenically during root canal treatment [1]. Such perforations might compromise the treatment outcome and persist as a significant complication if not repaired. Perforation might occur during preparation of access cavities, post space or may occur as a result of extension of internal resorption into periradicular tissues [2].

Classification: Classification of root perforations, proposed by Fuss & Trope Coronal perforation–coronal to the level of crestal bone and epithelial attachment with minimal damage to the supporting tissues and easy access, Good Prognosis.

Crestal perforation–at the level of the epithelial attachment into the crestal bone, Questionable Prognosis.

Apical perforation–apical to the crestal bone and the epithelial attachment, Good Prognosis.

In multi-rooted teeth where the furcation is perforated, the prognosis differs according to the factors described for single-rooted teeth. Accidental root perforations do occur in approximately 2–12% of endodontically treated teeth that might have serious implications [3-8]. This perforation acts as an open channel encouraging bacterial entry either from root canal or periodontal tissues or both eliciting inflammatory response that results in fistulae including bone resorptive processes may follow. When perforation occurs laterally or in furcation area there might be over growth of gingival epithelium towards the perforation site worsening prognosis of the tooth [9].

Sufficient data is available regarding the prognosis of a tooth with perforation defects. Factors determining the prognosis include size and location of the defect, time, duration of exposure to contamination, the material used to repair it, the possibility of sealing the perforation and the accessibility to the main canal [10-12].

Always small perforation apical to the crestal bone which is closed immediately will have a good prognosis. Factor that is under the control of operator is the choice of material to be used that enhances treatment outcome. Traditionally Amalgam, EBA, Calcium phosphate, Cavit were used as root repair material. Information about the new materials introduced is essential to determine its advantages and disadvantages. The idea of the present review is to bring to light about all the perforation repair materials.

IDEAL REQUIREMENTS OF ROOT REPAIR MATERIAL [13]

It should provide adequate seal.

It should be biocompatible.

It should have ability to produce osteogenesis and cemento-genesis.

It should be bacteriostatic, and radiopaque.

It should also be beneficial to use a resorbable matrix in which a sealing material can be condensed.

It should be relatively inexpensive.

It should be non-toxic, non-cariogenic and easy to place.

No material offers all of these properties. In search for the ideal material, numerous sealing materials and techniques have been tested over the years with varying success. The present article deals with various perforation repair materials available from the origin till date.

Various materials used for perforation repair include

1. Indium foil
2. Amalgam
3. Plaster of Paris
4. Zinc Oxide Eugenol
5. Super EBA
6. IRM (Intermediate Restorative Material)
7. Gutta Percha
8. Cavit
9. Glass Ionomer Cement
10. Metal-Modified Glass Ionomer Cement
11. Composite
12. Dentin chips
13. Decalcified Freezed Dried Bone
14. Calcium Phosphate Cement
15. Tricalcium Phosphate Cement
16. Hydroxyapatite
17. Calcium hydroxide
18. Portland Cement

19. MTA
20. Biodentine
21. Endosequence
22. Bioaggregate
23. New Endodontic Cement.

INDIUM FOIL

Historically Indium foil was used as a perforation repair material mainly to prevent gross overfilling [14]. However, it has been reported that use of indium foil lead to greater severity of bone resorption as compared to groups where perforation was repaired without use of indium foil.

Aguirre R et al., assumed that amalgam and indium foil would coalesce to provide a satisfactory seal. They condensed amalgam over indium foil matrices to prevent extrusion of amalgam. But results of that study showed that amalgam alone provided significantly better clinical and histological results than indium foil matrices for the repair of furcation perforations [14].

AMALGAM

One of the multi-purpose materials from the ancient days is amalgam. Though it is most commonly used as restorative material but was also experimented to fill endodontic perforations.

In a study by Mahmoud et al.,, Amalgam when used as repair material for furcation perforation showed superior sealing properties as compared to cavit and calcium hydroxide [15]. In other study by Benenati et al.,, Amalgam was found to be a more acceptable repair material than vertically condensed warm gutta-percha [16].

PLASTER OF PARIS

One of the materials which have a wide range of use in the fields of medicine and dentistry is plaster of paris (β-calcium sulphate hemihydrate). Guliford recommended Plaster of Paris for furcation perforation repair long back in 1901 [17]. Placement of repair material to provide a perfect seal is a difficult task; this can be overcome with the provision of a biocompatible matrix [18]. As the matrix material remains in the periodontal ligament space, it must be biocompatible and preferably resorbable. Plaster of paris is one such material with its rate of resorption equaling to rate of new bone growing into the tissue [19]. It has been used as a bone substitute for filling defects and also acts as a space filler [19].

In a study, on effect of matrix placement on furcation perforation repair, plaster of Paris matrix improved the seal with amalgam, but not with Ketacsilver [20].

ZINC OXIDE EUGENOL

One of the therapeutic cement used for various purposes in the field of dentistry is Zinc oxide eugenol.

Bramante et al., reported that perforations repaired with ZOE showed poor prognosis; they showed that it can cause severe inflammatory reactions with abscess formation and resorption of the alveolar crest when used as furcation perforation repair material [21].

SUPER ETHOXY BENZOIC ACID (SUPER EBA)

Super EBA is an alumina-reinforced zinc oxide–eugenol cement. It was used for sealing of perforations of the floor of the pulp chamber or further down inside the root canal. It has advantageous properties such as its ease of manipulation and its outstanding biological compatibility with the periapical tissues [22]; its high adhesiveness and adaptation to the dentinal walls is an additional advantage [22].

According to a study by J Kenneth Weldon et al., Super-EBA allowed significantly less microleakage than MTA at 24 hours; the combination of MTA and Super-EBA provided a more rapid seal than MTA alone [23]. In a study by Luke G Moloney et al., EBA cement provided a superior seal in lateral root perforations to silver glass-ionomer cement while amalgam was intermediate between the two [24].

INTERMEDIATE RESTORATIVE MATERIAL (IRM)

Intermediate Restorative Material is reinforced zinc oxide–eugenol cement. When used without an internal matrix it showed a significant leakage, so it should be used only with the aid of a matrix [25]. A study by Francesco Mannocci et al., showed that IRM leaked significantly less than amalgam when used for repair of experimentally induced lateral perforations [26].

When Amalgam, IRM and a mineral trioxide aggregate were tested for repair of experimentally created root perforations, the results showed that the mineral trioxide aggregate had significantly less leakage than IRM or amalgam [27].

GUTTAPERCHA

Introduced by Bowman in 1867. Guttapercha is the most commonly used core material in endodontics. When used for repair of perforation Lantz and Persson reported that gutta-percha resulted in lesser inflammation than zinc phosphate cement or amalgam [28,29]. However, Benenati et al., concluded that Gutta-percha repairs failed more often than amalgam repairs [16].

CAVIT

Cavit is a pre-mixed polyvinyl paste that does not contain eugenol [30]. Due to its properties such as ease of manipulation and adequate sealing ability, it was preferred to fill endodontic perforation [31].

It was reported that Cavit produced a seal superior to zinc oxide eugenol cement, zinc phosphate cement, gutta-percha, or temporary stopping and equal to amalgam [32]. Widerman et al., stated that Cavit did not inhibit the healing of lesions at the site of a perforation, nor was there significant likelihood of a lesion developing adjacent to a perforation filled with Cavit when no lesion was present there initially [31].

GLASSIONOMER CEMENT

It is a powder liquid system. Powder is composed of silica, alumina, aluminium fluoride, calcium fluoride, sodium fluoride, aluminium phosphate and liquid consisting of polyacrylic acid, tartaric acid and water. When used as perforation repair material, Alhadainy and Himel found that light-cured glass ionomer cement exhibited a better seal than amalgam or Cavit when used for furcation perforations repair [33]. A subsequent study suggested that light-cured glass ionomer cement has superior sealing ability compared to chemically cured glass ionomer cement [34].

In another study, James et al., concluded that there was no significant difference in the mean extent of dye leakage among the three groups that is light-cured glass ionomer cement, calcium phosphate cement, or light-cured glass ionomer cement placed over a Calcium Phosphate Cement matrix when used for perforation repair [35]. Overall it is shown that Glass Ionomer Cement exhibits a greater sealing potential than conventional materials due to its adhesion property.

METAL-MODIFIED GLASSIONOMER CEMENTS

Silver glass-ionomer cement is a product of sintering pure silver to aluminosilicate. It has the properties like bonding to dentin, radiopacity, rapid set and ease of delivery. Due to these properties it has also been used for perforation repair [24].

Zvi Fuss et al., evaluated the sealing ability of silver glass ionomer cement (Chelon silver) in treating furcation perforations in vitro and compared it with amalgam. Results have shown that perforations repaired with Chelon Silver leaked significantly less than those repaired with amalgam and their leakage was lower than that of the intact pulp chamber group though this difference was not significant. [36]. Studies found that resin-modified glass ionomer cement provided a better seal than amalgam or Cavit [20,26,33] and was superior to the conventional, chemically set glass ionomer cement and composite resin when used to seal furcation perforations [17].

COMPOSITE

Bisfil 2B a self-curing hybrid composite had been tried as perforation repair material. Bisfil had shown better sealing ability than amalgam and Intermediate Restorative Material when used for lateral perforation repair. However, the drawback of this material is it had shown highest rate of overfilling when used to repair lateral perforations [26].

DENTIN CHIPS

It is used as matrix in repair of perforation defects. Petersson et al., used dentin chips as matrices under AH26 for obturating perforation defects. They reported periodontal pocket formation apical to the perforation regardless of the technique used [37].

DECALCIFIED FREEZED DRIED BONE (DFDB)

DFDB chips are biocompatible, relatively nontoxic, easy to obtain, easy to use, relatively inexpensive, easy to manipulate, completely degrades during the repair process and acts as an excellent barrier against which filling material could be placed. When packed into the bony defect they mix with the blood present and "weld" together into a solid mass to completely fill the defect [13].

In a study by Hartwell et al., he found both positive and negative findings associated with the use of DFDB as a perforation repair material. The positives include the excellent clinical and radiographic findings at the end of 6 months. All teeth exhibited normal appearing periodontal soft tissues, absence of any periodontal pockets or furcation defects and absence of inflammation in 85% of samples. The negative findings included absence of new bone formation and epithelial growth in all specimens [13].

CALCIUM PHOSPHATE CEMENT (CPC)

Calcium phosphate cement (CPC) is a mixture of two calcium phosphate compounds of which one is acidic that may be either dicalcium phosphate dehydrate {$CaHPO_4$"$2H_20$}, or anhydrous dicalcium phosphate {$CaHPO_4$}, and the other basic tetra calcium phosphate {$Ca_4(PO_4)$}2 . Water is used as a vehicle for dissolution of the reactants and precipitation of the product [35]. The setting reaction is

$$Ca_4(PO_4)2 + CaHPO_4 \bullet 2H_20 \text{----->} Ca_5(PO_4)3OH + 2H_20$$

Where the end-product is hydroxyapatite. Calcium phosphate cement is shown to be highly compatible with hard and soft tissues, and is replaced by bone via osteoconduction and concurrent cement absorption.

In a study by James et al., Calcium phosphate cement showed no significant differences in the percent leakage or perforation depth when compared with light-cure glass ionomer cement, however, extrusion of Calcium Phosphate Cement was noted in all specimens while glass ionomer cement exhibited no extrusion [35]. The tricalcium phosphate was very inert, never being associated with inflammatory cells or necrotic bone when used subjacent to the defect in bone marrow spaces [38].

TRICALCIUM PHOSPHATE

Tricalcium phosphate consist of biodegradable ceramic (Synthograft) and had shown a very promising application in periodontal therapy because they are compatible with periodontal tissues. When used as perforation repair material tricalcium phosphate showed evidence of healing by the presence of layers of epithelium, collagen, and bone, with few inflammatory cells at the perforation site [38] but the degree of inflammation it caused was greater than Amalgam, hydroxyapatite and less than calcium hydroxide [38,39].

HYDROXYAPATITE

It can be used both as an internal matrix and as a direct perforation repair material. When used as furcation perforation repair material has shown to reconstruct furcation bone loss due to iatrogenic root perforation [40]. When used as an internal matrix to prevent the extrusion of materials such as amalgam or glassionomer acts as a stable matrix supporting the repair material that is going to be placed subsequently [18].

CALCIUM HYDROXIDE

Since its introduction by Herman in 1920's, it was used for a wide range of purposes in both conservative field and endodontics. It is a substance that is biologically compatible with pulpal and periodontal tissues. By composition calcium hydroxide consists of a base paste and catalyst paste.

Base paste consists of 1-methyl trimethyl enedisalicylate, Calcium sulphate, Titanium dioxide, Calcium tungstate orbarium sulphate and Catalyst paste consists of Calcium hydroxide, Zinc oxide, Zinc stearate, Ethylene toluene, Sulphonamide.

P Bogaerts et al., used calcium hydroxide as matrix and Super EBA as the material for perforation repair. It lead to good clinical results with positive outcome [41]. In another study by Clovis Monteiro Bramante et al., specimens dressed with calcium hydroxide paste plus iodoform for perforation repair showed necrosis at the site of perforation and different levels of cementum hyperplasia [21].

PORTLAND CEMENT

Portland cement was invented and patented by Koseph Aspdinin 1824 in England. It is the most common type of cement in use around the world composed of tricalcium silicate, dicalcium silicate, tricalcium aluminate, tetra calcium alumino ferrate and hydrated calcium sulfate [42]. It induces bone and cementum formation when used as perforation repair material but does not provide a fluid tight seal [42]. In a study by Shahriar S et al., Portland cement showed better sealing ability than MTA when used for furcal perforation repair [43].

Mineral Trioxide Aggregate

Mineral trioxide aggregate is commonly employed material with wide range of uses. Since its introduction by Mahmoud Torabinejad in 1992 it gained a wide role and emerged as a widely accepted material for various purposes.

MTA consists of fine hydrophilic particles of Tricalcium silicate, Tricalcium aluminate, Tricalcium oxide, Silicate oxide, calcium sulphate dihydrate, tetracalcium aluminoferrite and small amounts of mineral oxides (bismuthoxide) [44]. It has a mean setting time of 165±5 minutes [45]. MTA stimulates cementoblasts to produce matrix for cementum formation and is biocompatible with the periradicular tissues thus shows a superior sealing ability when used for perforation repair [46].

When Amalgam, IRM and mineral trioxide aggregate were tested for repair of experimentally created root perforations; results showed that the MTA had significantly less leakage than IRM or amalgam [27]. According to Weldon JK et al., the combination of MTA and Super-EBA provided a more rapid seal than MTA alone [23].

BIODENTINE

Biodentine is a calcium silicate-based bioactive material. It is a powder liquid system, powder composed of Tri-calcium silicate, Di-calcium silicate, Calcium carbonate and oxide, Iron oxide, Zirconium oxide. Liquid consist of Calcium chloride, Hydro soluble polymer.

It is easy to handle owing to its ease of manipulation and a short setting time approximately 12 minutes, has high alkaline pH and is a biocompatible material makes it a favourable material for perforation repair [47,48]. In a study by Guneser et al.,, Biodentine showed considerable performance as a perforation repair material even after being exposed to various endodontic irrigants as compared to MTA [49].

ENDOSEQUENCE

EndoSequence is a bioceramic material. Bioceramics refers to the combination of calcium silicate and calcium phosphate. It is composed of calcium silicates, zirconium oxide, tantalumoxide, calcium phosphate monobasic and filler agents. It has a working time of more than 30 minutes and a setting reaction initiated by moisture with a final set achieved in approximately 4 hours. It is produced with nanosphere particles that allow the material to enter into the dentinal tubules and interact with the moisture present in the dentin. This creates a mechanical bond on setting and renders the material with exceptional dimensional stability, along with this the material has superior biocompatibility characteristics due to its high pH [50,51].

Endosequence root repair material simulates tissue fluid, phosphate buffered saline and results in precipitation of apatite crystals that become larger with increasing immersion times concluding it to be bioactive [52]. In a study by Jeevani et al., Endosequence showed better sealing ability when compared to MTA and Biodentine as furcation repair materials [53].

BIOAGGREGATE

Bioaggregate is a bioceramic material composed of tricalcium silicate, dicalcium silicate, calcium phosphate monobasic, amorphous silicon di oxide and tantalumpent oxide [54]. It induces mineralized tissue formation and precipitation of apatite crystals that become larger with increasing immersion time ssuggesting it to be bioactive [52]. It has comparable biocompatibility and sealing ability to MTA [54]. In a study by Hashem et al., concluded that MTA is more influenced by acidic pH than Bioaggregate when used as perforation repair material [55].

NEW ENDODONTIC CEMENT

"New endodontic cement (NEC)" a bioactive material consisting of different calcium compounds was later termed as Calcium Enriched Mixture (CEM). It is composed of calcium oxide, calcium phosphate, calcium carbonate, calcium silicate, calcium sulfate, calcium hydroxide, and calcium chloride [56]. It has a setting time of less than 1 hour and sets in aqueous medium [57].

It is composed of different calcium compounds, it produces greater amount of calcium and phosphate ions which most likely forms hydroxyapatite in higher concentrations and this would make CEM cement preferable as a furcal perforation repair material in close proximity to the exposed periodontium [56]. Asgary et al., observed cementogenesis and periodontal regeneration when CEM was used as perforation repair material [58].

CONCLUSION

Perforation repair is a frustrating problem to the dentist. So through idea regarding its restorability is essential which includes knowledge of site, size, time of perforation and various materials used.

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