



Regenerative Endodontic Treatment in Teeth with Internal Root Resorption: An Insight Over the Available Literature

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ABSTRACT

Internal root resorption (IRR) is a resorptive defect of the root's internal aspect, and its pathogenesis occurs because of the activity of odontoclasts. If left untreated, IRR will eventually cause necrosis of the pulp tissue apical to the resorptive lesion, leading to periapical pathologies and resistance failure of the tooth. Treatment of this kind of pathology encompasses many options ranging from conventional root canal treatment to endodontic surgery. The most recent innovation for the treatment of IRR is revascularization. The present review aims to discuss revascularization as a treatment option for IRR. An extensive search for recent available data regarding this kind of treatment and potential suggestions for the future have been made. Revascularization of teeth with IRR has promising results and should be considered a choice for treating IRR cases as an alternative to conventional root canal treatment.

1. Introduction

Root resorption occurs due to the loss of dental hard tissues due to the action of odontoclasts.^[1] Internal Root Resorption (IRR) is a resorptive defect of the internal aspect of the root,^[2] and it is the less commonly occurring type of root resorption.^[3] The pathogenesis of IRR occurs because of odontoclasts' activity, which are multinucleated cells able to form resorption lacunae.^[2] Although the exact pathophysiological mechanism regarding the resorption process is currently not understood completely, it has been found that Osteoprotegerin, RANK (receptor activator of nuclear factor Kappa-B), and Macrophage Colony-Stimulating Factor (M-CSF) are important components that contribute to the inflammatory cascade within pulp tissue that leads to stem cell differentiation into odontoclasts or macrophages, thereby leading to dentin resorption.^[4] For IRR to occur, the root canal wall's outermost odontoblast layer and pre-dentin must be damaged, leading to odontoclasts exposing the underlying mineralized dentin.^[5] Odontoclasts achieve this exposure by releasing hydrolytic enzymes that degrade dental hard tissues: they demineralize apatite crystals of hard dental tissues through the H⁺-ATPase enzyme. They degenerate dentin proteins through cathepsin K and MMP-9 enzymes.^[3]

In primary teeth, root resorption is a physiological process that is part of a deciduous tooth's life cycle to allow subsequent eruption of the permanent tooth. As with IRR, resorption of primary teeth is mediated by odontoclasts. Primary tooth root resorption begins with odontoblast degeneration and is

then followed by the resorption of exposed dentin and pre-dentin from the inner surface by odontoclast cells.^[6] Regarding the main etiological factors contributing to IRR, the main factor is trauma (due to orthodontic treatment or other types of trauma), followed by pulp inflammation as a result of a carious lesion.^[7] There are two types of IRR described in the literature: Internal Inflammatory Resorption and Internal Replacement Resorption. The distinction between these two types is that, while both types present progressive loss of dentinal tissue, Internal Replacement Resorption involves the deposition of hard tissue that resembles bone or cementum to replace the dentin lost due to resorption.^[3] Clinically, IRR tends to be asymptomatic. However, if left untreated, IRR will eventually cause necrosis of the pulp tissue apical to the resorptive lesion, which consequently can lead to periapical pathologies such as apical periodontitis or apical abscess.^[8]

Furthermore, in some cases, it may present itself as a pink spot or reddish area that is visible on the crown; this represents granulation tissue appearing through the resorbed area.^[3] As these pink spots are more commonly associated with external cervical resorption, they cannot be classified as being pathognomonic of IRR.^[9] The main clinical difference between pink spots caused by internal resorption and External Cervical Resorption (ECR) is in the pink spot location. In the IRR case, the pink spot can be seen centered on the clinical crown.^[10] Whereas in the case of ECR, the pink spot is less visible as it is located at the dentogingival junction, and in some cases, it is found below the free gingival margin.^[9]

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There are a few methods to diagnose internal root resorption. The most accurate diagnoses are through radiographical methods. In periapical radiographs, the resorption is seen as a "swelling" of the root canal's middle third. The resorption area is radiolucent, rounded/oval-shaped, and with clearly defined margins.^[11] More recently, Cone Beam Computed Tomography (CBCT) has been found to have increased accuracy, sensitivity, and specificity compared to periapical radiographs in the diagnosis of root resorption lesions. The advantage of using CBCT over periapical X-rays is that it gives a three-dimensional view of the resorption instead of the two-dimensional image seen in periapical radiographs.^[12]

Furthermore, research has shown that CBCT helps to make a faster diagnosis of resorptive lesions by determining if they are external or internal and confirming the size and location of the lesion.^[12] Using CBCT for diagnosis makes it easier to identify an IRR lesion (clearly defined borders of lesion and root canal not radiographically visible in the defect).^[12] One drawback of CBCT is that the radiation emitted levels are much higher than conventional radiograph techniques. Therefore CBCTs should be used judiciously and only when completely necessary.^[12]

Treatment for IRR

Traditionally root canal treatment has been the treatment of choice. Root canal treatment of IRR requires instrumentation with wide diameter files, abundant irrigation (especially if there is a periapical pathology present), and root canal obturation with thermoplastic gutta-percha.^[13] In some cases, a surgical approach is indicated, predominantly when the area of resorption cannot be accessed through the canal. Therefore, this technique requires raising a flap, removing cortical bone, and placing a filling material at the resorption area.^[4]

A surgical technique could be the treatment of choice in some cases of perforating internal root resorption. Perforating IRR occurs when the root resorption has progressed through the tooth and has reached the periodontium, leading to complications such as pain, periodontal bleeding, and most importantly, difficulty in obturation, hence the need for a surgical flap raising procedure.^[14] Finally, the most recent innovation in the treatment of IRR, and this paper's focus is regenerative endodontic treatment.

Regenerative Endodontics

Revascularization is a treatment method that allows for the regeneration of the root by reestablishing blood flow to the tooth.^[15] Pulp revascularization has been primarily indicated for pulp necrosis cases in permanent teeth with open apices (immature teeth).^[15] The revascularization treatment technique is comprised of two clinical sessions. The first session consists of a root canal opening followed by a minimal root canal instrumentation and copious disinfection with an irrigation agent such as 1% Sodium Hypochlorite (NaOCl) Chlorhexidine. The first studies on this field purposed to follow the procedure with the placement of a tri-antibiotic paste (Ciprofloxacin, Metronidazole, Minocycline) or double (ciprofloxacin, metronidazole) inside the canal, and then temporary obturation above.^[16] Although these options have been proven to give successful revascularization treatment results, they have disadvantages, including

discoloration, bacterial resistance, and allergic reactions. As an alternative to tri-antibiotic paste, Calcium Hydroxide (CH) paste can also be placed inside the canals for 1 to 3 months.^[2] Advantages of CH paste include its effective bleeding control, prevention of reinfection,^[17] and effectiveness in IRR perforation cases compared to tri-antibiotic paste.^[2] Possible downsides

of using CH paste as an intracanal medication include partial obliteration of the root canal and decreased fracture resistance of the root.^[18]

In the second clinical session (14-30 days later), after removing the temporary obturation, the tri-antibiotic paste or CH paste is removed through copious irrigation of the canal using 1% Sodium Hypochlorite and 17% Ethylenediaminetetraacetic acid (EDTA). A file is then used to provoke bleeding of the periapical tissues, and a blood clot forms inside the canal. Final sealing is then achieved by placing a biomaterial such as Mineral trioxide aggregate (MTA) at the root canals' entrance and below the cemento-enamel junction.^[15] MTA has been shown to have adequate mechanical characteristics, antibacterial effects, radiopacity, and the ability to set quickly in the presence of blood.^[19] The entirety of the treatment (both clinical sessions) should always be performed under rubber dam isolation.^[2, 20] Regarding the biological significance of pulp revascularization, its success depends on the potential of remaining pulp, apical, and periodontal stem cells to differentiate. These stem cells can differentiate into a highly vascularized living tissue that fills the pulp space. As well as this, the odontoblasts differentiate from stem cells and will subsequently lead to hard tissue apposition. These processes permit the root maturation and apical development of immature permanent teeth.^[21]

In current practice, revascularization is becoming an increasingly popular technique. Compared to apexification and apical barrier techniques, revascularization benefits from promoting root development and apical growth. The clinical objectives that must be achieved to reach a successful clinical outcome during revascularization include root canal disinfection through abundant irrigation, the formation of a scaffold through inducing bleeding and subsequent blood clot formation inside the root canal, and finally, the building of an adequate coronal seal to prevent reinfection.^[22]

Regenerative Endodontics and IRR

The concept explored in this paper is the application of the revascularization technique in the treatment of IRR. It is a recent innovation in Endodontics as IRR has usually been treated with a conventional root canal treatment. In recent years, regenerative endodontic procedures such as revascularization have been explored as an alternative option in treating root resorption.^[22] Pulp revascularization is a procedure that aims to reestablish new vital tissue to replace previously vital tissue that has been lost to pulp necrosis. A possible advantage of revascularization techniques over traditional root canal therapy in the treatment of IRR is that it provides the replacement of missing dental tissues. Therefore the possibility of achieving an improved prognosis is a real possibility.^[2] This is especially the case in immature permanent teeth because the potential for further maturation reduces the risk of root fracture and subsequent tooth loss later in life.^[23]

There is limited information regarding the application of revascularization for IRR treatment; only three clinical reports have been published to date.^[2, 20, 24] The lack of research suggests that the effectiveness cannot be definitively confirmed until further investigations are carried out. Also, because these treatments were only carried out in the last five years, there is no information available on the revascularization procedure's long-term results and durability (Table 1).

Despite these limitations, the results presented in those case reports are significant and should serve as a starting point for revascularization treatment in teeth with IRR. Nevertheless, the results from all of these cases indicate the effectiveness of revascularization when treating teeth with IRR. In all of the

treatments, revascularization proved to be successful. Positive results were obtained: all previous symptoms disappeared, existing root resorption was arrested, and the root canal walls increased in thickness after treatment, which decreases the likelihood of a fracture of the root. Thus, revascularization

should be considered a choice for treating IRR cases instead of conventional root canal treatment. It has been shown to lead to positive outcomes in IRR treatment.

Table 1. Summary of the most relevant data published in the available literature.

	Tambakad et al. [24]	Saoud et al. [20]	Kaval et al. [2]
Tooth affected	21. Avulsion	11. Trauma	22.N/A
Diagnosis	Symptomatic Apical Periodontitis + IRR + External Inflammatory root resorption	Acute Apical Abscess + Perforating IRR	Symptomatic Apical Periodontitis + Perforating IRR
Intracanal medicament used	Biantibiotic paste	Calcium Hydroxide 1st Session Triantibiotic paste 2nd Session	Calcium Hydroxide
Time elapsed between clinical sessions	N/A	Two weeks (between 1st and 2nd) and two weeks (between 2nd and 3rd)	Four weeks (between 1st and 2nd) and three months (between 2nd and 3rd)
A Session for a blood clot	1st session PRP	3rd session	3rd session
Final irrigation	Saline solution+PRP	NaOCl + Saline solution + 17% EDTA	1 % NaOCl + 17% EDTA + distilled water
Instrumentation	Extraoral 1,5-2mm diameter	Up to size #40 K-file	Up to size #45 K-file
Final Sealing Material	Glass ionomer cement+composite	MTA+composite	MTA+composite
Treatment Outcome	Stable and functional tooth No further root maturation	Stable and functional tooth Healing of resorption and periapical lesion	Asymptomatic tooth Hard tissue formation in the site of previously perforated resorption
Time to Follow-up	12 months	19 months	24 onths

2. Conclusions

Revascularization has been proven to be very effective when treating root resorption. It should be considered a choice to treat IRR cases as an alternative to conventional root canal treatment. However, the quantity of research so far has been extremely limited. Therefore, moving forward, researchers must continue to perform the revascularization procedure in teeth with root resorption, always adhering correctly to the treatment protocol.

Conflict of Interest

The authors declared that there is no conflict of interest.

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