REVASCULARIZATION OF IMMATURE NON-VITAL PERMANENT TEETH - LITERATURE REVIEW AND A CASE STUDY

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ABSTRACT
Apical periodontitis in permanent children’s teeth with incomplete root development is a challenge for endodontists to treat. It is important that highly efficient therapeutic methods and biologically valuable therapies be developed to prevent the loss of these teeth. The aim of the study was to review modern literature on revascularization of non-vital permanent teeth with incomplete root development, and to present a clinical case. The literature review herein reflects the modern concept of revascularization of non-vital permanent teeth with incomplete root development. Clinical protocols are presented on cases with and without the formation of a blood clot. The case study reports the treatment of an immature non-vital permanent tooth using the technique of revascularization that utilises formation of a blood clot and use of a two-component antibiotic paste for disinfection.

One year after treatment the clinical and radiological data showed absence of subjective complaints, thickening of the root walls, apical closure and no periapical pathology of the revascularized tooth. Literature data and the favorable outcome of our case allow us to further research the revascularization of immature non-vital permanent teeth.

Key words: endodontic treatment, revascularization, incomplete root development

INTRODUCTION
Apical periodontitis in immature permanent teeth in children is rather hard to treat. Untimely, incorrect management of such cases is bound to result in permanent teeth loss, disorders of the mandibular growth and masticatory function, and even in speech disorder and facial impairment. To prevent any loss of these teeth it is important to develop highly efficient therapeutic methods and biologically valuable therapies.

OBJECTIVE
To review the most recent literature pertaining to revascularization of non-vital permanent teeth with incomplete root development, and to report a clinical case.

BACKGROUND
Complete loss of vitality of immature permanent teeth in children usually results from complications of caries or traumatic injury to the teeth. Pulp necrosis results in interruption of root development and periapical damage. Endodontic treatment of such teeth is associated with a number of difficulties for the clinician. They can be caused by a very broad apical part of the root canal, thin dentinal walls, as well as an infection in the root canal and periapical space. As a consequence the infected root-canal system cannot be treated and disinfected by routine endodontic protocol with the aggressive use of endodontic files. Lack of apical barrier can cause excessive extrusion and damage of periapical tissues if using standard root canal-filling materials. Lack of adequate apical seal will result in microleakages and persistent infection. Traditional methods in such cases involve stimulating the formation of solid-tissue barrier by calcium hydroxide agents or creation of an artificial apical barrier through MTA to provide optimal root canal filling. This therapeutic technique is known as apexification. Despite the high success rate of apexification, there is still an increased risk of fractures after treatment of necrotic immature teeth.1,2 This applies particularly to teeth with thin,
spear-like tapered walls and very large foramina. Thus a biologically based endodontic therapy must be developed that can allow the hard dental tissues in necrotic immature permanent children’s teeth to develop further.

There have been several experimental studies and clinical cases published recently that offer a biologically-based alternative to the conventional therapeutic methods for non-vital immature teeth. This technique has gained wide popularity under the name of ‘revascularization’; there are authors that consider “regeneration” to be a more appropriate term.

The concept underlying revascularization is not new. It was introduced by Ostby in 1961 and in 1966 Rule and Winter documented apexogenesis in necrotic permanent children’s teeth after reimplantation of avulsed teeth. The pulp of such teeth is necrotic but usually not degenerated and infected. It can act as a matrix into which new tissue can grow and develop. The apical part of pulp has been demonstrated experimentally to be able to remain vital and after reimplantation may proliferate coronally, thus replacing the necrotic pulp. Moreover, most of the crowns of avulsed immature permanent teeth are intact, which hampers the bacterial penetration into the pulp space.

The initial situation is quite different in necrotic infected teeth with symptoms of apical periodontitis. Until recently revascularization in such cases was considered impossible. In 2001 Iwaya et al. and Banchs and Trope in 2004 demonstrated the advantages of this therapeutic approach for further hard tissue formation of teeth with necrotic pulp.

Clinical cases have been reported in which even what little remains of the vital pulp is able to induce root elongation, root wall thickening and apical closure, thus achieving apexogenesis. Necrotic areas should be disinfected for the purpose and then the vital pulp tissues should be covered with an appropriate pulp-coating agent. This clinical approach can be particularly beneficial when in the course of treatment of teeth with pulp necrosis clinicians detects signs of vital pulp (e.g. pain and controlled bleeding).

Some authors refer to this methodology as pulp regeneration without blood clot formation. This actually is an apexogenesis inducing technique implemented with some specific features of the clinical approach that allow the preservation of as much of the vital tissues as it is possible.

**Revascularization without blood clot formation**

This is a technique that can be applied in partial dental pulp necrosis. The first publication of success in the use of this therapeutic approach was by Iwaya et al. in 2001. Reports of other successful clinical cases due to the execution of this methodology were published later.

The first visit begins with dental plaque removal, isolation with cofferdam and preparation of the respective endodontic cavity for the tooth. Purulent hemorrhagic exudate may appear while trephining the tooth.

Then the root canal is probed using usually a small size K-file. Discharge of clear blood and sensitivity reported by the child at a certain level in the root canal indicate that there is vital pulp.

The next step is chemical disinfection of the upper non-vital part of the canal without mechanical instrumentation. Irrigations are done mostly with NaOCl or 3% H₂O₂. The canal is dried and its upper part is filled with antibiotic paste for continuous disinfection, after which the tooth is tightly sealed. Hoshino et al. demonstrated in 1996 that the antibiotic paste they used was effective in disinfecting the root-canal system. Their results were later confirmed by other researchers.

In its original form, this paste was a mixture of ciprofloxacin, minocyclin and metronidazol in equal amounts (250 mg) and vehiculum (distilled water, macrogol ointment, propylene glycol, etc.). The antibiotic paste is prepared in situ, immediately before treatment, placed into the root canal with a lentulo spiral and the tooth is restored temporarily. Recommended treatment time with the triple antibiotic paste in the canal is 3-4 weeks. The procedure can be repeated if exudation persists at the next visit.

In case there is no exudation it is necessary to confirm the presence of vital pulp inside the root canal. This is done by visual inspection, preferably using magnifying devices and by carefully probing the pulp with a canal instrument. Sensation of pain indicated the pulp is vital. Pulp covering agent is applied next. Iwaya et al. use calcium hydroxide, while mineral trioxide aggregate is preferred in more recent studies. Therapy ends with a permanent bacteria-tight coronal restoration.

Shing al al. proposes a one step revascularization in partial necrosis of the dental pulp without using a triple antibiotic paste.

In cases in which the pulp is completely necrotic...
the technique of apexogenesis described above may not get the desired results. Hence another treatment approach is needed.

**Revascularization by formation of intra-coronal blood clot**

Many researchers now use quite similar revascularization protocols.\(^4,6-8,12-16,18,19\) They all endorse the three essential prerequisites for successful treatment by this method: efficient disinfection of the root canal system; availability of a matrix to initiate the growth of new tissue; bacteria-tight coronal seal. Thus we create conditions similar to those in avulsed teeth reimplantation, which makes the process of revascularisation possible. This usually takes three visits.

The main goal of the first visit is disinfection of the canal. This is hard to achieve in immature teeth and infected necrosis of the dental pulp. The main obstacle herein is the inability to use mechanical instruments because of the thin root walls. Therefore efficient disinfection is achieved mainly by irrigation solutions and application of intra-canal medications. The visit begins with removal of tooth crown plaque. Then the tooth is isolated by cofferdam. Its use is mandatory in every stage of the treatment. The next clinical step is preparation of endodontic cavity and chemical treatment of the root canal using NaOCL in higher concentrations (5.25 – 6.00%).

The canal is finally washed with distilled water, dried out, and treated with the triple antibiotic paste for continuous disinfection. The visit ends with temporary obturation.

The main goal of the second visit is providing a matrix by stimulating bleeding of the periapical area and the formation of blood clot at the level of the cemento-enamel junction. This phase starts with the removal of the antibiotic paste by irrigation with NaOCL, followed by distilled water. The root canal is dried with paper points and bleeding is induced from the periapical area using mostly K-file size 25 or 30. Bleeding is stopped by sterile cotton pellets with saline at or slightly below the cementoenamel junction. After stopping the bleeding, it is important to wait for about 15 minutes in order to obtain a stable blood clot. Then MTA is carefully introduced on the blood clot. The visit ends with the placement of wet swab over MTA and temporary obturation.

The stable blood clot is necessary to prevent the possible extrusion of MTA in the apical direction. If this happens, the active root surface and the matrix are reduced as well as the chances of success.

The third visit is usually several days after the second; it is devoted to providing a coronal seal impermeable to bacteria. Modern adhesive systems and composites are frequently used. Thus a double coronal seal is produced - MTA and adhesive composite restoration.

The question whether this methodology can properly be referred to as revascularization raises a lot of controversy. According to some authors the reported successful clinical cases using this clinical protocol are examples of pulp regeneration, i.e. of restored dentin-pulp complex which is in fact how stem cells begin to be used in endodontics.\(^3,5,12,18-20\)

Science cannot yet give an exact answer whether it is revascularization or regeneration. In fact, this method differs from apexifixation because not only the apex is closed, but the root walls become thickened. It is not correct to term it apexogenesis either, because principally this is a technique that uses any remaining vital pulp to thicken the root walls and achieve apical closure. However, there is no vital pulp when the pulp necrosis is complete. What happens clearly is that the pulp restores its vitality. One of the possible explanations is that a few vital pulp cells may remain in the apical end of the root canal. These cells might migrate into the newly formed matrix and differentiate into odontoblasts under the influence of Hertwig’s epithelial root sheath cells, which are quite resistant to destruction, even in the face of inflammation. The newly formed odontoblasts can start producing dentin. As a result the root walls thicken and lengthen, and the apical foramen closes. This strengthens the root against fracture.\(^8\) Another possible mechanism for continued root development is migration of undifferentiated mesenchymal cells of tooth papilla onto the newly formed matrix. Evoking of bleeding in revascularization procedures has been demonstrated to trigger significant accumulation of undifferentiated mesenchymal cells originating from the periapical tissues into the canal space.\(^21\) There they can attach to existing dentinal walls and differentiate into odontoblasts. Proliferation of cells of the periodontal ligament is also possible. The presence of cement and Sharpey’s fibers in the newly formed tissue is the evidence in support of this hypothesis. Migration of undifferentiated mesenchymal cells from the bone in the bone-like tissue is also not ruled out.\(^7,22\)

On the other hand the blood clot itself is rich in growth factors which can play an important
role in regeneration. These factors can stimulate the differentiation and maturation of odontoblasts, fibroblasts, cementoblasts, etc. This turns the blood clot into a very suitable matrix for differentiation and growth of tissues.3,5,7

The most recent reports in this field have shown that the outcome of increasing the thickening of the canal walls is much more predictable compared with that of continued root development.23

A CASE STUDY

The case we present here is the first successful revascularization of immature non-vital permanent tooth documented in Bulgaria. The patient was a 13-year old girl with a history of severe pain and swelling in the distal portion of the right mandibular half two weeks prior to treatment. The patient reported unceasing pain, albeit with less intensity to the moment of our treatment. The dentist who started the treatment removed the filling of tooth 46 and made a temporary obturation. He prescribed an antibiotic agent and referred the parents to a pediatric dentist.

Clinical examination revealed the presence of mild swelling in the intact tooth 45 and temporary obturation of tooth 46 (Fig. 1A). Periodontal probing showed no deviation from normal values (depth of the gingival sulcus up to 2 mm). The electro-odonto-diagnostics device found no tooth vitality of the examined tooth. The initial X rays (Fig. 1B) revealed incomplete root development of tooth 45, wide apical foramen and diffuse bone changes.

At the beginning of the treatment we did not anaesthetise the patient in order to firmly establish that tooth 45 was not vital. In preparing the endodontic cavity we found carious dentin (Fig. 2A) and lack of pain. Upon insertion of a paper point in the root canal the presence of hemorrhagic purulent exudate was found. The root canal was washed with 2.5% sodium hypochlorite solution, activated by means of ultrasound. At the end of the visit a two-component antibiotic paste (ciprofloxacin and metronidazole) was placed to last for three weeks and a temporary obturation with glass ionomer cement was made.

At the next visit, we removed the antibiotic paste, then induced bleeding with K-file size 20 (Fig. 2B) and placed MTA on the blood clot. We again applied temporary filling to the tooth.

On the next day the tooth was restored with photo composite (Fig. 2C).

Simultaneously an x-ray was made after placing MTA (Fig. 3A).

We assigned two control x rays - digital retroalveolar radiograph on the fourth month (Fig. 3B) and parallel radiograph 1 year after treatment (Figure 3C). As early as the fourth month thickening of root walls was found, closure of the apical foramen and absence of periapical pathology.

Lack of subjective symptoms, clinical examination and parallel radiographs one year after treatment confirmed the favorable treatment outcome.

CONCLUSIONS

Revascularization of non-vital permanent children’s teeth with incomplete root development and necrotic pulp is a biologically based alternative to traditional healing methods. Despite controversial recent data about what type of tissue is obtained as a result of the treatment, there is no doubt that the result of revascularization of non-vital necrotic-pulp teeth is thickening and/or further development of the root walls, hence enhanced strength to fractures.
Future research needs to further develop the idea of regeneration and not limit it to immature children’s permanent teeth but to apply it to teeth with complete root development.

REFERENCES


РЕВАСКУЛЯРИЗАЦИЯ НЕВИТАЛЬНЫХ ПОСТОЯННЫХ ЗУБОВ С НЕЗАКОНЧЕННЫМ РАЗВИТИЕМ КОРНЕЙ – ЛИТЕРАТУРНЫЙ ОБЗОР И СОБСТВЕННЫЙ КЛИНИЧЕСКИЙ СЛУЧАЙ

Й. Тарпоманов, М. Куклева

РЕЗЮМЕ
Эндодонтическое лечение апикального периодонтита при постоянных детских зубах с незаконченным развитием корней представляет своего рода провокацию для врачей по дентальной медицине. Создание лечебных методик с высокой успеваемостью и биологической стоимостью имеет важное значение для предотвращения потери зубов.

Работа ставит себе целью представить обзор современной научной литературы относительно реваскуляризации невитальных постоянных зубов с незаконченным развитием корней, как и представить свой собственный случай.

И изготовленный авторами литературный обзор отражает современную концепцию реваскуляризации невитальных постоянных зубов с незаконченным корневым развитием. Представлены клинические протоколы о наличии корней без или со сформированным сгустком крови.

Собственный клинический случай представляет лечение такого зуба по методике реваскуляризации зуба со сформированным сгустком крови, при чем для дезинфекции использована двухкомпонентная антибиотическая паста.

Клинические и рентгенологические данные год после проведенного лечения показывают отсутствие субъективных жалоб, утолщения корневых стенок, закрытия апикального отверстия и исчезновения периапикальной патологии реваскуляризованных авторами зубов.

Данные в литературе и благоприятный исход проведенного лечения дают авторам основание продолжить исследования относительно реваскуляризации невитальных постоянных зубов с незаконченным развитием корней.