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Dental Pulp Revascularization of an Open-apex Maxillary Central Incisor Using Autologous Concentrated Growth Factor in a fifth decade patient

Saaid Al Shehadat[1*], Ali Alqabbani[2], Hany Mohamed Aly Ahmed[3]

[1] *Preventive and Restorative Dentistry; College of Dental Medicine,University of Sharjah,United Arab Emirates*

[2] *Oral and Craniofacial Health Science, College of Dental Medicine, University of Sharjah, Sharjah, United Arab Emirates*

[3] *Faculty of Dentistry, University Malaya, Kuala Lumpur, Malaysia*

ABSTRACT

This report presents a case of revascularization of an open-apex maxillary central incisor in a 46-year-old patient using concentrated growth factor (CGF). After disinfection protocol, the apical foramen was mechanically enlarged, and autologous CGF gel was prepared and placed into the root canal to a level close to the cemento-enamel junction. The follow-up evaluation confirmed the clinical success of the treatment with restoration of tooth sensation within 6 months. The previous flat-shaped apex morphology of the tooth changed into a more rounded shape but with no real change in the length of the root or in the size of the canal. This case report shows the potential of using root canal revascularization technique to treat non-vital teeth in elder patients with the advantage of restoration tooth sensation. The promising role of the concentrated growth factor in dental pulp regeneration is also highlighted.

Keywords: Concentrated growth factor; platelet concentrate; regenerative endodontics, revitalization, revascularization

INTRODUCTION

The root canal treatment (RCT) of immature permanent teeth with infected pulp and periapical pathosis has always been challenging. 3D apical sealing following conventional RCT is never guaranteed at the open apex of an immature tooth. The risk of post-operative cervical fracture after RCT is another serious issue to be considered [1] because the dentinal walls of the root canal in immature teeth is thin. In some cases, poor crown–root ratio with a risk of tooth mobility presents an additional clinical challenge[2]. For a long time, apexification procedures were considered the treatment of such teeth. This treatment may close the open apex successfully and result in the healing of apical pathosis; however, it cannot improve the root–crown ratio or increase the thickness of the dentinal walls as the deposition of mineralized tissue after apexification is restricted to the apical part[3].

Root canal revascularization (RCR) via blood clotting is relatively a new treatment procedure that has been approved by the American Dental Association to treat immature permanent teeth with necrotic pulps[4]. RCR is a cell-free approach where the pulp is repaired/regenerated by the stimulation, proliferation, migration, and differentiation of in situ endogenous cells (cell homing approach[5]. The regenerative cells are likely stem cells that migrated from the apical region into the root canal through the wide-open apex[6]. This interpretation was supported by reports documented that intracanal blood has more stem cells compared with systemic blood when RCR via blood clotting is applied[7]. The growth factors released from platelets and dentinal walls stimulate the migration and differentiation of the stem cells[8]. The source of these stem cells is believed to be the apical papilla, which exists apical to the immature tooth[9][. RCR via blood clotting is a safe approach that has no risk of immune rejection or pathogen

***Corresponding author:**Saaid AlShehadat, Preventation Restorative Dentistry,College of Dental Medicine,University of Sharjah,United Arab Emirates Tel: 561939396; E-mail: salshehadat@sharjah.ac.ae

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transmission. However, the ability to produce an ideal blood clot with constant content is not warranted for every case[10]. Therefore, limited tissue regeneration might be encountered in some cases[11]. Incomplete bleeding into the root canal, which may inhibit suitable clot formation, was also reported[12,13].

The RCR of immature teeth using bio-scaffolds was also suggested[10,14]. Cell migration can be encouraged by having suitable bioactive molecules in the root canal. Platelet concentrates, such as platelet-rich plasma (PRP) and platelet-rich fibrin (PRF), have been used for RCR because of their high content of growth factors and cytokines. Bioactive molecules in both concentrates are able to recruit stem cells from the apical papilla [15,16] and provide a suitable environment for cell migration, proliferation, and differentiation[17].

Concentrated growth factor (CGF) is relatively a new generation of platelet concentrate product that can be prepared following an altered centrifugation technique. CGF contains more cytokines and growth factors compared with PRP and PRF[18,19]. Some of these bioactive molecules are platelet-derived growth factor-BB, transforming growth factor β-1, insulin-like growth factor-1, vascular endothelial growth factor, and basic fibroblast growth factor. CGF increases bone formation when applied onto a bone wound [20] Thus, CGF can be applied in implant surgery to accelerate osseointegration [21] and manage sinus grafting and elevation more conservatively[22]. At a cellular level, CGF promotes the proliferation, migration, and differentiation of stem cells[19,23]. Therefore, CGF is a promising alternative in regenerative endodontics[19,24]. However, we believe that the use of CGF in regenerative endodontic procedures has not existing clinical reports. The present report aimed to present the RCR of a maxillary incisor tooth with an open apex using CGF.

CASE REPORT

A 46-year-old female patient presented to the University Dental Hospital Sharjah to seek for the management of a discolored maxillary anterior left tooth. Tooth #9 was discolored and had a fracture in the incisal edge. The patient ensured that she got a very old trauma on the tooth at childhood. Electrical pulp and cold tests were negative for tooth #9 and positive for adjacent teeth (#8 and #10). All teeth were not tender upon percussion or palpation. No signs of infection or inflammation were observed in the surrounding soft tissues. The periodontal tissues looked healthy, and periodontal probing was within normal limits. Preoperative periapical radiograph (Figure 1A) revealed that tooth #9 has a relatively short root, wide canal, and abnormally flat-shaped apex compared with its adjacent teeth. A lateral radiolucency was also observed along the mesial surface of the root. The tooth was diagnosed as chronic apical periodontitis. Three treatment options were discussed with the patient. The first was conventional RCT followed by a ceramic veneer. The second option was apexification procedure using mineral trioxide aggregate (MTA) apical plug followed by root canal filling and a ceramic veneer. The third option was to revascularize the tooth using an auto platelet concentrate product followed by a ceramic veneer. The patient opted for the third option of treatment and signed a consent letter. The patient was medically fit for the treatment.

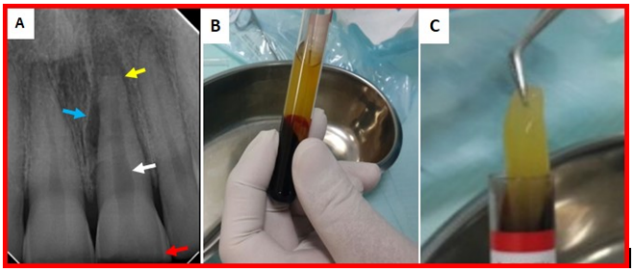
No local anesthesia was administered. A rubber dam was placed, and access cavity preparation was started using a small round bur. The pulp chamber was then de-roofed. Non-vital tissue was initially extirpated, and the working length was determined using an apex locator (J Morita Root ZX II, USA) and confirmed by a periapical radiographic view. The initial size of the apical foramen was determined (0.8-mm stainless steel K-file, size 80; Colorinox, Dentsply Maillefer, Switzerland). The root canal was disinfected using EndoVac (Discus Dental, Culver City, CA) irrigation protocol with 3% sodium hypochlorite. However, a very soft dentinal layer was observed on all canal walls; thus, a peripheral mechanical preparation of the root canal was achieved using a size 70 H-file (Colorinox, Dentsply Maillefer, Switzerland). Final irrigation was performed using 20 ml of saline followed by drying and the placement of a mixture of antibiotics (equal proportions of ciprofloxacin, metronidazole, and tetracycline)[25]. A glass ionomer cement (GIC) temporary filling was used to seal the coronal cavity (Fuji IX Extra Capsule, Japan).

The patient presented with no complaint after 4 weeks. Clinical examination showed no signs of infection or any complication. About 10 ml of venous blood was drawn from the patient's arm using a 10-ml 21 G syringe (Lomar, Bristol Health Care, UK/China) and centrifuged for 14 min using a CGF pre-programmed machine (Silfradent Medifuge MF200, Italy). The CGF gel was separated from the red blood cells and serum using sterile scissors (Figures 1B and C). Meanwhile, the canal was irrigated with 30 ml of saline. The diameter of the apical foramen was enlarged to 1 mm by extruding a K-file (size 100, taper 2%) 1 mm beyond the apical foramen. The final irrigation protocol was performed using EDTA (3 times, 20 seconds for each administration by EndoVac) followed by saline. The canal was then dried using paper points, and the CGF gel was packed into the canal to the full working length using sterile pluggers. The coronal level of the CGF gel was near the cervical area (near the cemento-enamel junction). MTA (Pro Root MTA Kit, Dentsply Sirona, USA) was placed immediately after the CGF. The access cavity was then restored with GIC (Fuji IX Extra Capsule, Japan) and resin composite (3M ESPE Filtek Z350 XT, USA). The follow-up sessions were scheduled at 1 week, 1 month, then at 3-month interval, and once every year.

The patient experienced a little discomfort at the first 2 days after the placement of the CGF. Radiographically, an increase in radiolucency around the apical foramen was observed at 1 month with no accompanying clinical symptoms. This radiolucency was not observed in other follow-up sessions. Responses to cold and electrical tests were first observed after 6 months. Some changes in the apical shape were observed. The flat shape of the apex changed into a more rounded shape but with no real increase in the length of the root and in the size of the root canal. The tooth received a ceramic veneer after 3 months.

Figure 1: (A): A preoperative radiograph of mature tooth #21 showing old incisal fracture (red arrow), abnormally flat-shaped apex (yellow arrow), unusual radiolucency on the mesial surface

of the tooth (blue arrow), and a relatively short root and wide root canal (white arrow) compared with the adjacent teeth. (B): Three layers can be recognized in the tube immediately after blood centrifugation. (C): The upper layer is the concentrated growth factor (CGF) gel which can be easily obtained and separated from the other layer using scissors.



DISCUSSION

Regenerative procedures have received an increased interest in the management of non-vital teeth, which have been traditionally treated by RCT.

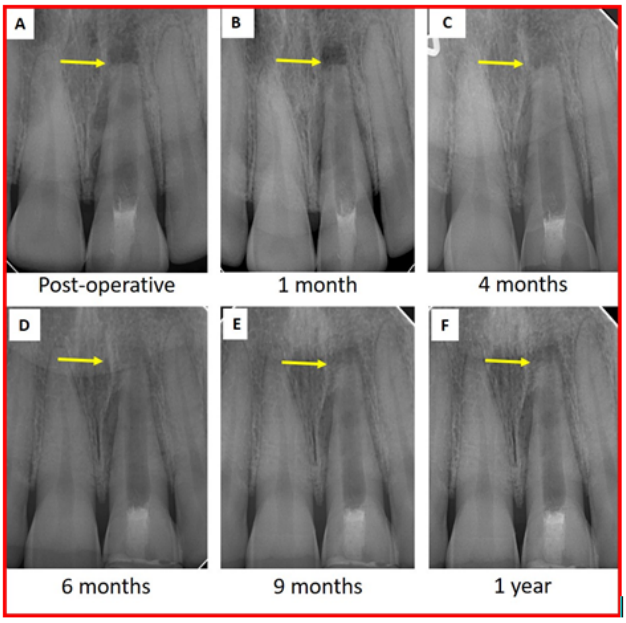
In the present case, tooth #9 was exposed to an old trauma (more than 30 years ago) that resulted in the devitalization of the pulp tissue and the discontinuation of tooth development.

This trauma explains the abnormal flat shape of the open apex of the tooth (Figure 1A). The chief complaint of the patient was tooth discoloration in the absence of pain and discomfort. The options to manage tooth discoloration included internal bleaching, ceramic veneer, or ceramic crown.

The three options cannot be performed without treating the root canal properly to avoid a possible development of infection later on.

The wide size of the canal and thin dentinal walls of the root canal, especially in the cervical area, encouraged the use of RCR, to avoid the mechanical preparation of the canal, which is usually needed in conventional RCT and increase the thickness of the dentinal walls as usually observed when RCR is applied in immature teeth[19]. However, the presence of a very soft dentin on the internal walls of the canal required mechanical preparation to exclude the risk of subsequent infection and failure of treatment.

Figure 2: A series of follow-up on tooth #21 after revascularization procedure using CGF. (A): A post-operative view. (B): A transient periapical radiolucency was observed after 1 month, but not in the following follow-up sessions. (C), (D), (E) & (F): After 4, 6, 9 and 12 months respectively, a minor change in the shape of the flat apex with no evidence of the formation of new mineralized tissues along the root canal walls.



Apical closure and root lengthening occur more frequently when PRF is used for RCR [19] because of its high content of growth factors compared with blood clot and PRP[1]. CGF is a relatively new generation of platelet concentrate with more cytokines and growth factors[8]. Primary experimental and animal studies found that CGF is promising for regenerative endodontics as it can promote pulp cell migration and proliferation and can induce the odontoblastic and endothelial differentiation of stem cells [19,23,24] Therefore, CGF was selected for the RCR procedure in the present case.

According to the clinical considerations of the American Association of Endodontists for regenerative endodontics, the main goal of regenerative procedure is to eliminate clinical symptoms and resolve apical periodontitis if present. The increase in the thickening of the root canal walls and continued root development are considered secondary goals[26,27]. Therefore, RCR using CGF to manage tooth #9 in the present case was considered successful. In the follow-up period, the tooth was free of pain and tenderness, had intact surrounding soft tissue, and had no sign of failure. The permanence of radiolucency on the external surface of the root can be interpreted as the presence of fibrous tissues that developed during the healing period after the old trauma (fibrous healing).

Successful RCR for immature teeth in young patients is usually accompanied by regaining tooth sensation, tooth lengthening, and dentinal wall thickening [19] which indicate the formation of new nervous and mineralized tissues[1]. In the current case, the tooth was responsive to sensibility tests after 6 months. However, the formation of new hard tissues was not observed except for a mild change in the shape of the most apical part of the root (Figures 2A–F). In young patients, immature tooth is usually accompanied by an "apical papilla," which is a rich source of dental stem cells known as stem cells from apical papilla (SCAP). SCAP develop into primary odontoblasts to produce primary dentin during tooth development[28]. The stunted development of the tooth after trauma can be attributed to the failure of the apical papilla to survive. However, the apical

papilla can survive after an endodontic infection. In addition, the infection may increase the osteogenic and angiogenesis potentials of SCAP[29,30]. In the current case, the failure to develop hard tissues after RCR can be attributed to the absence of SCAP. The presence of the apical papilla and SCAP is not expected after this long period after trauma. The failure of hard tissue formation cannot be imputed to the use of CGF. Primary studies on CGF concluded that CGF appear to be attractive and promising for regenerative endodontics[19]. However, this should be confirmed by utilizing CGF in more clinical cases particularly with non-vital immature teeth in young patients.

The suggested correlation between the survival of the apical papilla after trauma or infection and the development of mineralized tissues after RCR can also explain the cases where hard tissue fails to generate after RCR in some immature teeth. Therefore, cell-based approaches for pulp generation should be considered to treat teeth where the apical papilla fails to survive. However, cell-based therapy is currently not feasible in clinical practice because of the difficulty and excessive cost of harvesting and growing the stem cells. The restoration of tooth sensibility in this case also suggests that the nervous tissue regeneration of pulp tissue does not require the survival of the apical papilla.

CONCLUSION

RCR in old patient, where the apical papilla does not exist, may restore tooth sensation but cannot create new mineralized tissue along the root canal walls. Cell-based RCR should be developed to manage infected teeth with thin weak dentinal walls. CGF appears to be promising for revascularization and should be further evaluated in cases of immature teeth.

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