Surgical Endodontic Management of External Root Resorption and Apexification Using New Calcium Silicate-Based Materials

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***Abstract*–External resorption and open apex are pathological conditions which can occur due to chronic inflammation after a dental trauma. In order to stop the pathological conditions, surgical correction and apexification is performed. New calcium silicate-based materials are used as new variety of Mineral Trioxide Aggregate (MTA) to increase the setting time and easier manipulation. This report presents external root resorption arrest and formation of an apical barrier by surgical perforation repair due to external resorption and apexification of post-traumatic necrosis tooth. A 22-year-old male patient was presented to Conservative Dentistry Department based on referral of Prosthodontics for upper left lateral incisor examination. The patient had a history of trauma 10 years ago and no symptoms had been noted since then. Percussion test was positive. Palpation, thermal and electrical test were negative. Periapical radiograph and Cone Beam Computed Tomography (CBCT) examination revealed radiolucency lesions in central and lateral middle third of root with blunt apex and periapical lesion. Surgical correction of external resorption and apexification was done using new calcium silicate-based materials. Tooth was restored using resin composite with prefabricated fiber post as intracanal reinforcement. Radiographs of treatment after 1 month and 6 months showed well-covered resorption area, less periapical lesions and good result for apical barrier formation. The new calcium silicate-based materials can be used in perforation repair due to external resorption and apexification treatments.**

Keywords*–*apexification, CBCT, endodontic surgery, external resorption, new calcium silicate-based materials

I. INTRODUCTION

Resorption of tooth structure happens in primary and permanent dentitions. Physiologic tooth resorption involves primary teeth, preceding their shedding. In permanent dentition, tooth resorption is a pathologic phenomenon that can lead to tooth extraction [1].

Tooth resorption results from injuries to or irritation of the periodontal ligament and or tooth pulp. It may arise as sequel of traumatic luxation injuries, orthodontic tooth movement, or chronic infections of pulp or periodontal structures, intracoronal bleaching, surgical procedures neoplastic process, associated with systemic diseases and lesions of idiopathic origin. The treatment goal in the external apical root resorption is to remove or destroy bacteria to allow healing to take place in the periradicular space [2,3].

A radiographic interpretation is decisive for the diagnosis of external resorption and the difficulty in distinguishing from internal resorption has been reported. An accurate diagnosis is essential for both tooth treatment and prognosis, while misdiagnosis can result in inappropriate treatment and tooth loss. Intraoral radiographs do not indicate the true dimensions of such lesions. The resorption defect may spread within the root in all directions and this may not be reflected in the size or position of the radiolucency detected in the radiograph. There is no doubt that recent improvements in digital imaging systems have brought numerous benefits to endodontic practice [4]. The advent of three dimensional imaging like cone beam computed tomography (CBCT) has provided the endodontist with previously unavailable tools which facilitate interactive image manipulation and enhancement [5].

According to Andreasen, traumatic injuries to young permanent teeth are not uncommon and are said to affect 30% of children. The majority of these incidents occurs before root formation is complete and may result in pulpal inflammation or necrosis. The root sheath of Hertwig is usually sensitive to trauma but because of the degree of vascularity and cellularity in the apical region, root formation can continue even in the presence of pulpal inflammation and necrosis. The completion of root development and closure of the apex occurs up to 3 years after eruption of the tooth. Complete destruction of Hertwig’s epithelial root sheath results in cessation of normal root development [6]. Inducing a calcified barrier in a root with an open apex or the continued apical development of an incompletely formed root in teeth with necrotic pulp was performed with apexification [7].

Traditionally, calcium hydroxide Ca $(OH)_2$ was the material of choice to induce formation of apical hard tissue [8]. Although the success rate of apical barrier formation using Ca $(OH)_2$ is 74−100%, there are still some disadvantages with this treatment choice. Poor patient compliance resulted in a lengthy course of treatment and multiple appointments, and the risk of reinfection and tooth fracture made this treatment unfavorable [9,10].

Different materials available for management of external tooth resorption are, a)mineral trioxide aggregate (MTA), b) Glass ionomer cement, c) Super EBA (a reinforced zinc oxide cement; its liquid contains 32% eugenol and 68% ethoxy benzoic acid), d) Hydrophilic plastic polymer (2-hydroxyethyl methacrylate with barium salts), e) Zinc oxide eugenol and zinc acetate cement, f) Amalgam alloy and g) Thermoplasticized gutta-percha administered either by injection or condensation techniques[9]. MTA is recommended as an alternative material to CH for the induction of apical barrier of immature teeth. MTA contains tricalcium aluminate, dicalcium silicate, tricalcium silicate, tetracalcium aluminoferrite, and bismuth oxide. MTA is a biocompatible material and has low solubility capacity, ability to set in a wet environment and presence of blood [11].

However, it has some disadvantages such as difficulty of handling, long setting time. A variety of new calcium silicate-based materials have been developed recently to overcome the shortcomings of MTA. These materials contain tricalcium silicate, calcium carbonate, zirconium oxide and accelerator [13,14].

Therefore, the present case report was about describing the management of maxillary left central incisor with external resorption using CBCT for radiolucency detected and new calcium silicate-based materials for correction.

II. CASE REPORT

A 22-year-old male patient was presented to Conservative Dentistry Department, Faculty of Dentistry Gadjah Mada University based on referral of Prosthodontics for upper left lateral incisor examination. The patient had a history of trauma 10 years ago and no symptoms had been noted since then. There were no pain symptoms. The palatal gingival tissue was inflamed and slightly tender to palpation Percussion test was positive. Thermal and electrical test were negative. Translumination test showed crack lines at the labial section of the crown.

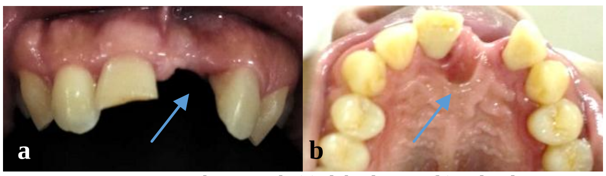

Figure1. Preoperative photograph (a), labial view (b) palatal view.

Computed radiograph examination revealed radiolucency lesions in central and lateral middle third of root with blunt apex and periapical lesion. In order to evaluate the real extent and degree of impairment in the condition detected radiographically, CBCT was done, which showed a possible root canal communication with the outside by lateral perforation and loss of bone.

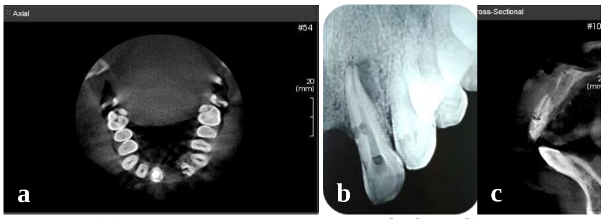

Figure 2. (a). CBCT scan: cross sectional slice (b) Preoperative compute radiograph labial view (c) CBCT scan: axial slice.

III. CASE MANAGEMENT

On the first appointment a clinical examination, a periapical radiograph, diagnosis and discussed treatment plans with patient was done. Patient agrees to a treatment plan that is offered, patient was asked to sign an informed consent. On the second appointment, access opening was done, working length was determined to be 23 mm by radiograph and confirm with apex locator (Root ZX II, Morita). Debridement root canal was done with conventional technique with K-file #60. Intracanal medicament of calcium hydroxide (Ultracal XS, Ultradent) was given for 2 weeks.

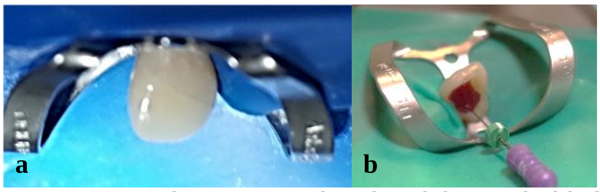

Figure 3. (a) Translumination test showed crack lines at the labial section of the crown, (b) Bleeding from granulation tissue when canal explored by K-file.

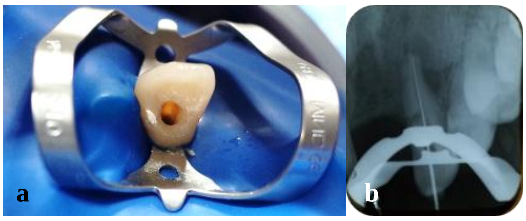

Figure 3. (c) Isolation with rubber dam and access opening, (d) working length was determined

On next recall, as the lesion was clinically reduced, surgical approach was done to repair the resorptive defect. Temporary filling was opened, circumferential filling techniques using K-file #60 and irrigate with a low concentration of NaOCl (0.5%) EDTA and chlorhexidine. The canal was dried, master cone was selected, and canal filled with gutta percha without sealer by lateral condensation technique till the gutta percha blocked canal from the resorptive area.

Mucosa in relation to 21 and 22 was anesthetized using local infiltration with local anesthetic containing epinephrine 2% (Lidocaine compositum, Indofarma). A full thickness mucoperiosteal triangular flap was raised using periosteal elevator (EpBuser, Osung) in relation to 22 to expose the defect and granulation tissue present was curetted. The resorptive defect was then repaired with new calcium silicate-based materials (Biodentine, Septodont) that were mixed according to the manufacturer's instructions. 1 doses of liquid and 1 capsule powder of Biodentine was supplied for 30 s with a mixed amalgamator and carried to the defect with microapical placement system (MAP One, Produits Dentaires). The material was left for fifteen minutes to achieve the initial setting and relative hardness. Gutta percha then removed. Apical plug of 5 mm of MTA was placed with microapical placement system (MAP One, Produits Dentaires) and confirmed radiographically. A sterile paper point moistened with sterile water was placed over the canal orifice and the access cavity was sealed with temporary restoration (Cavit, 3M ESPE). The flap was repositioned after pressure is applied carefully with a cotton swab and tampon for a few minutes and sutured using interrupted sutures (Silk non-absorbable suture 3-0).

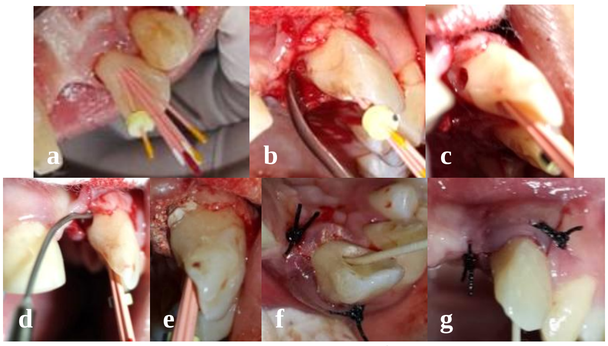

Figure 4. (a) Gutta percha blocking canal from seal material, (b, c) expose the defect and granulation tissue present was curetted (d, e), fill the defect and apical plug using MAP system, (f) A sterile paper point moistened with sterile water was placed over the canal orifice, (g) suturing and place moist paper point sterile over the canal orifice.

Patients were given postoperative instructions; patients are prescribed antibiotics amoxycillin and analgesics. A radiograph was then taken to confirm the materials placement.

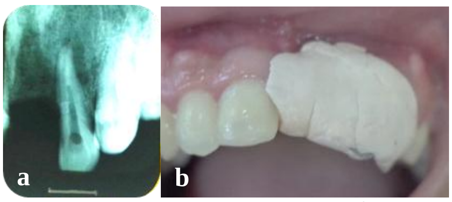

Figure 5. (a) Radiograph examination to confirm the materials placement, (b) periodontal pack dressing at postsurgical area.

Patient was recalled after a week; suture removal was done. No symptoms and signs were noted. Tooth then were prepared for fiber post. The selection of shapes and sizes was depending on precision drill tracing at radiograph. Cementation of fiber post was performed with self adhesive resin cement (Rely X U100, 3M ESPE). The remaining space of the canal was filled with light-cured composite resin (Filtek Z250, 3M ESPE).

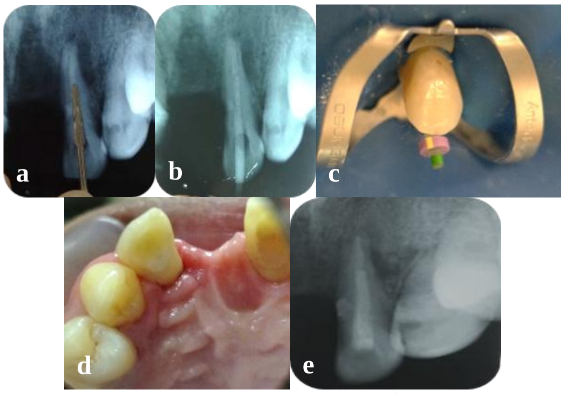

Figure 6. (a) Precision drill tracing, (b, c) fiber post try in, (d) Restoration was completed by composite resin, (e) Radiograph after 6 months tooth 22 showed well-covered resorption area and less periapical lesions.

The patient was subsequently advised for regular follow ups. However the patient reported to the department only after 1 and 6 months and was completely asymptomatic on presentation. Clinical and radiographic examinations for treated tooth performed that resorption defect were successfully treated with new calcium silicate-based materials.

IV. DISCUSSION

Root resorption can be initiated by many factors acting alone or simultaneously. Commonly described stimulant include pulpal necrosis, trauma, tooth whitening agents, periodontal treatment and orthodontic treatment. Other possible etiologies may include systemic disturbances.

Classifications play an important role for the clinician in the process of diagnosis and treatment planning. Andresen has made a unique contribution to the understanding of tooth resorption following dental trauma and his original classification remains the most widely accepted i.e. tooth resorption into internal (inflammatory and replacement) and external (surface, inflammatory, replacement) [15].

Majorana et al reported an incidence of root resorption to be 17.24% after luxation/avulsion injury. Despite the wide range of etiologies the resorption process is largely considered to be inflammatory in nature. Biological mechanism involving osteoprotegerin, RANKL and RANK, as well as bioactive neuropeptide such as Substance P, NKA, NPY, VIP and CGRP play apart in this resorptive process trough their vasoactive, chemotactic and cellular effects. The pathophysiology behind resorption centers on osteoclast formation, recruitment and stimulation. The clastic cells adhere to mineralized surface and releases hydrogen ion and proteolytic enzymes creating a localized, acidic micro environment: this result in dissolution of mineralized tissue, precementum and cementoblasts from the root surface [16].

An alternative diagnostic tool for the early detection of root resorption is CBCT. It was used to detect root resorption in the present case report. Early detection can lead to timely intervention and better treatment outcomes. Root resorption extension is identified by analyzing all lesions dimensions; axial, transverse, and cross sectional slices can be obtained using CBCT. Root resorption measurements, as part of a longitudinal follow up, can determine whether the lesion is in a stage of arrest, repair, or progression. The most important advantage of this imaging modality is acquiring comparable image with much lower radiation doses than multiple detector CT but CBCT appears to involve 3-7 times the dose of a panoramic examination, depending on the area examined, the degree of collimation, and the acquisition software. Thus, the decision to select an imaging modality for diagnostic purposes should be based on the expected diagnostic yield and in accordance with the "as low as reasonably achievable" principle [17].

Andreason et al. suggested that a combination of short-term use of Ca(OH)2 followed by root filling with calcium silicate-based materials like MTA would prevent weakening of the dentin. The advantages are a reduction in treatment time, lower chance of tooth fracture, and fewer visits to the dental office [17].

MTA and Biodentine are two successful materials used for apexification procedures. Both of them have good biocompatibility and adequate sealing property. But Biodentine is superior in its handling properties and. fast setting time. Biodentine contains tricalcium silicate, calcium carbonate, zirconium oxide and accelerator ($CaCl^2$) [13].

The initial setting time of Biodentine was 9–12 min and final setting time was 45 min. However, the setting time of MTA was 165 ± 5 min, which is a major drawback for MTA. In addition, particles of Biodentine are smaller than MTA and this provides Biodentine a better penetration capacity to dentine tubules [18].

Its property to release calcium ion and enhancing the alkaline environment makes Biodentine more conducive for osteoblastic activity. Also, calcium and hydroxide ions stimulate the release of pyrophosphatase, alkaline phosphatase, and BMP-2, which favors the mineralization process. It also induced the repair of the periodontium and new cementum formation over the material [19].

Revascularization and repair of root anatomy is the ideal treatment of choice for necrotic nonvital teeth with wide open canals but it is not always feasible due to prolonged treatment time required. Apexification followed by reinforcement of weakened root structures with fiber post is viable option [20].

Brito-Júnior et al. evaluated the fracture resistance and stress distribution of simulated immature teeth after apexification with MTA and found that the teeth restored without fiber posts were more prone to root fracture in the cervical and middle thirds of the roots due to the stress concentration in these areas. They stated that fiber posts were able to improve fracture resistance and stress distribution of open apex teeth after apexification with MTA. In addition, according to the results of the recent study, using any of the calcium silicate-based material and restoring open apex teeth with fiber posts increased the fracture resistance [21].

From the case above, could be concluded that CBCT examination can enhanced radiographic diagnosis of external root resorption by analyzing all lesion dimensions.The new calcium silicate-based materials contains accelerator can be used due to external resorption by surgical perforation repair and apexification of post-traumatic necrosis tooth, and restoring weakened root structures with fiber post could increase the fracture resistance.

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