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CASE REPORT

3D Diagnosis and management of external cervical resorption

ABSTRACT

Aim: *This article reports the different clinical approaches of three external cervical resorptions (ECR) cases, based on a three-dimensional (3D) classification.*
Summary: *Treatment planning was based on a 3D diagnosis and the cone beam computed tomography (CBCT) was fundamental to do an accurate assessment of the extension of the lesions. The three cases presented different degrees of complexity, related to the extension of the resorption. In two cases, root canal treatment was performed and internal management of the resorptive lesion was accomplished. In a third case, with a more severe extension of ECR, surgical approach with flap elevation was done to access the resorptive defect. Minimum period of 6-months radiographic and clinical follow-up showed periapical and periodontal healing. This case report presents the importance of a correct 3D diagnosis and treatment planning in maintaining teeth with ECR.*
Key learning points:
- *ECR is a pathologic root resorptive process with an unclear aetiology. Beginning in a point of entry in the cervical area of the root, in later stages, the resorptive process can reach the pulpal space.*
- *Management of ECR lesions should be based on a 3D diagnosis, considering height, circumferential spread and proximity/involvement of the root canal.*
- *The use of CBCT enables the clinician to establish a proper diagnosis and evaluate the restorability of the tooth in question.*

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Introduction

Resorption of permanent teeth, unlike in the primary dentition, is pathologic and unwanted (1-3). Based on its location, root resorption can be classified as internal or external, and this latter may be further subclassified into surface resorption, external inflammatory resorption, external cervical resorption, external replacement resorption and transient apical resorption (4).
External cervical resorption (ECR) can be defined as a dynamic process arising from the periodontal root surface as a result of the activity of clastic cells. This process is characterized by the destruction of dental hard tissue which, in advanced stages, might involve pulpal tissues and the periapical area, leading to a complex restorative and endodontic management (4-7).
Even though the aetiology of ECR is not yet fully understood, it is assumed that there must be damage to the periodontal ligament (PDL) and cementum, that can either be related to an anomaly during development, resulting in a gap at the cemento-enamel junction, or to damage induced by trauma (6).
Concerning the ECR histopathogenesis, three main stages are present separately or coexist in the same areas of the lesion: resorption initiation, resorption progression and reparative (remodelling) (6, 8).
Some potential initiating factors could be involved, including previous orthodontic treatment, traumatic injury, internal bleaching, surgery and restorative treatment. More factors described in recent studies, have been associated to the initiation of this resorptive process, as extraction of a neighbouring tooth, malocclusion, playing wind instruments, periodontitis and autotransplantation (6). Moreover, a stimulating factor such as infection (bacteria), continuous mechanical force on the PDL (e.g. during orthodontic treatment), discontinuous mechanical unloading caused by chewing, parafunction or a combination, must be present to maintain the activity of the clastic cells (6).
The stage, degree of progression and location are important factors that define a highly variable clinical presentation of this type of lesion, making it a challenge to a proper diagnosis. Most ECR are incidental findings, eliciting no symptoms. Radiographic presentation may become a challenge too, as this lesion might present themselves as symmetrical or asymmetrical, with margins varying from being well defined to poorly defined with no clear delineation between ECR and healthy root structure (4). The existence of distinct patterns with respect to resorptive activity and formation of mineralized substitution tissue can affect the radiographic diagnosis (5).
Heithersay's classification (9), which is based on two dimensional (2D) imaging, does not describe the resorptive and reparative pattern of the ECR, especially concerning the circumferential spread of the lesion (4). Consequently, a three-dimensional (3D) classification based on periapical radiographs and cone beam computed tomography (CBCT), ensuring a more accurate diagnosis and aid communication between clinicians has been proposed (4).
The literature is replete with case (series) reports confirming that periapical radiographs do not consistently reveal the true nature of ECR compared to CBCT, but only a limited number adopts the newest 3D classification since its publication, hence, presenting complex multidisciplinary approaches (4, 10).
The objective of this article is to describe three case reports of advanced stages of ECR with pulpal involvement based on a 3D classification and management.

Case report

#Case 1
A 21-year-old male patient was referred to the Endodontics Postgraduation clinic at University of Lisbon School of Dentistry (FMDUL) for assessment of tooth 46 (mandibular right first molar). The referring dentist had detected an apparent carious lesion on a bitewing radiography, and started excavation with high speed burs,

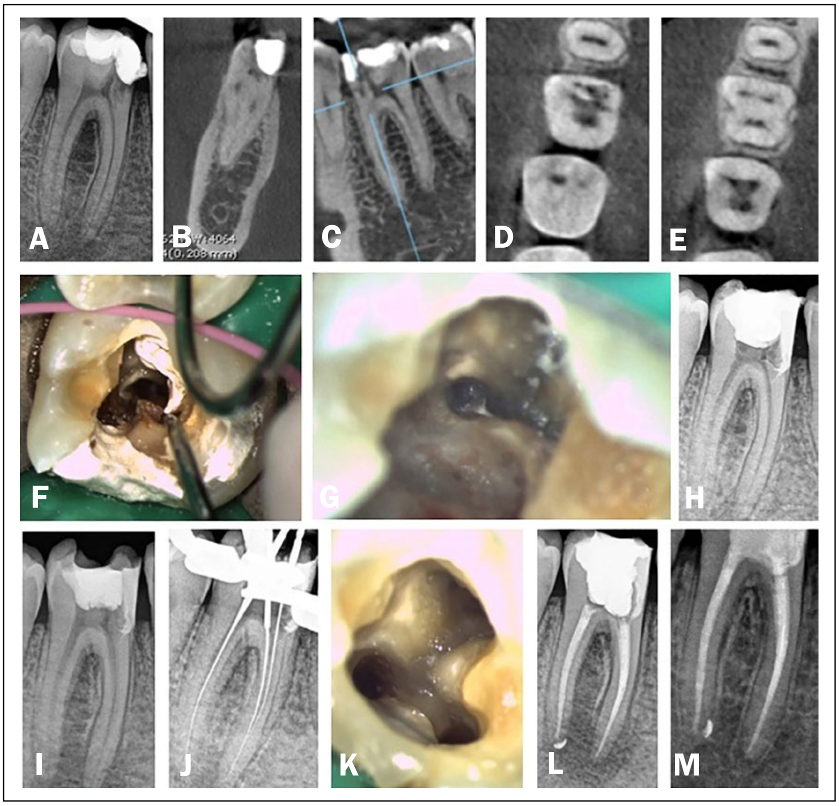

Figure 1.
A) Initial periapical radiograph; **B)** CBCT Sagittal view; **C)** CBCT Coronal view **D)** and **E)** CBCT Axial views; **F)** Removal of granulation tissue. Root canals orifices were covered with Teflon; **G)** Cleaned resorptive lesion; **H)** Periapical radiograph showing the adaptation of the pre-endodontic restoration; **I)** Periapical radiograph taken two months after initial session showing extensive periapical rarefaction; **J)** Working length determination radiograph; **K)** Root canals after the cleaning and shaping; **L)** Final periapical radiograph; **M)** 20-months radiograph follow-up.

stopping when detecting "odd looking dentin". Clinically, a mesio-occlusal provisional filling was present, and probing was within normal depths in all surfaces. The patient reported a dull and constant pain that irradiated over the angle of the mandible and upwards, which he had been managing with over-the-counter non-steroidal anti-inflammatory medication. A discrete facial edema was also noted. Tooth 46 was tender to vertical percussion, with no increase in mobility. There was no response to the ice sensibility test (Endo cold spray, Henry Schein, Langen, Germany), and periapical radiography showed apical bone rarefaction, and a mesial lesion compatible with ECR (Figure 1A). A diagnosis of necrotic pulp and symptomatic apical periodontitis was made. A CBCT was requested to further assess the extension of the ECR lesion and for treatment planning (Figures 1B-E). The lesion was classified as 2Ap (2 [height], subcrestal; A [circunferencial spread], ≤90º; p [proximity to the root canal], probable pulp involvement) and the proposed treatment was root canal treatment with non-surgical management of the resorptive lesion, which was suggested and accepted. The treatment was performed under a Leica M320 dental operating microscope (M320, Leica, Wetzlar, Germany), in three appointments. In the first appointment, after proper anesthesia using 4% articaine with 1:200.000 epinephrine (Artinibsa, Inibsa, Barcelona, Spain) and rubber dam isolation, the access cavity was established with round burs and improved with Start-X ultrasonic tips (Start-X, Dentsply Tulsa Dental, Tulsa, USA). The orifices of the root canals were covered with teflon, and the granulation tissue associated with the resorptive lesion was removed with high speed round burs, and with dentin excavators (Figure 1F). After removal of all the resorptive tissue, visually confirmed under the dental operating microscope (Figure 1G), a universal matrix band was adapted to the tooth with an Ivory retainer and a pre-endodontic restoration was made with composite resin (Tetric EvoCeram, Ivoclar Vivadent, Schaan, Liechtenstein) to restore the mesial margin and allow absolute isolation with rubber dam (Figure 1H). A calcium hydroxide paste was applied over the mesial margin of the tooth, and the tooth was provisionally restored with Cavit (Ultracal, Ultradent, South Jordan, USA). In the following appointment, two months after the initial session, the patient had developed an acute abscess and had been prescribed systemic antibiotics by the referring dentist. A periapical radiograph showed extensive periapical rarefaction (Figure 1I). After achieving anesthesia and absolute isolation with rubber dam, access was re-established and a purulent discharge from the canals provided immediate relieve of symptoms. The root canals were negotiated with 0.10 and 0.15 stainless-steel K-files (K-File, Dentsply, Ballaigues, Switzerland) and the determination of the working length was performed with a Root ZX electronic apex locator (Root Zx, Morita, Komuro, Japan) and confirmed radiographically (Figure 1J). All root canals were shaped with WaveOne Gold reciprocating files (WaveOne Gold, Dentsply Maillefer, Ballaigues, Switzerland)

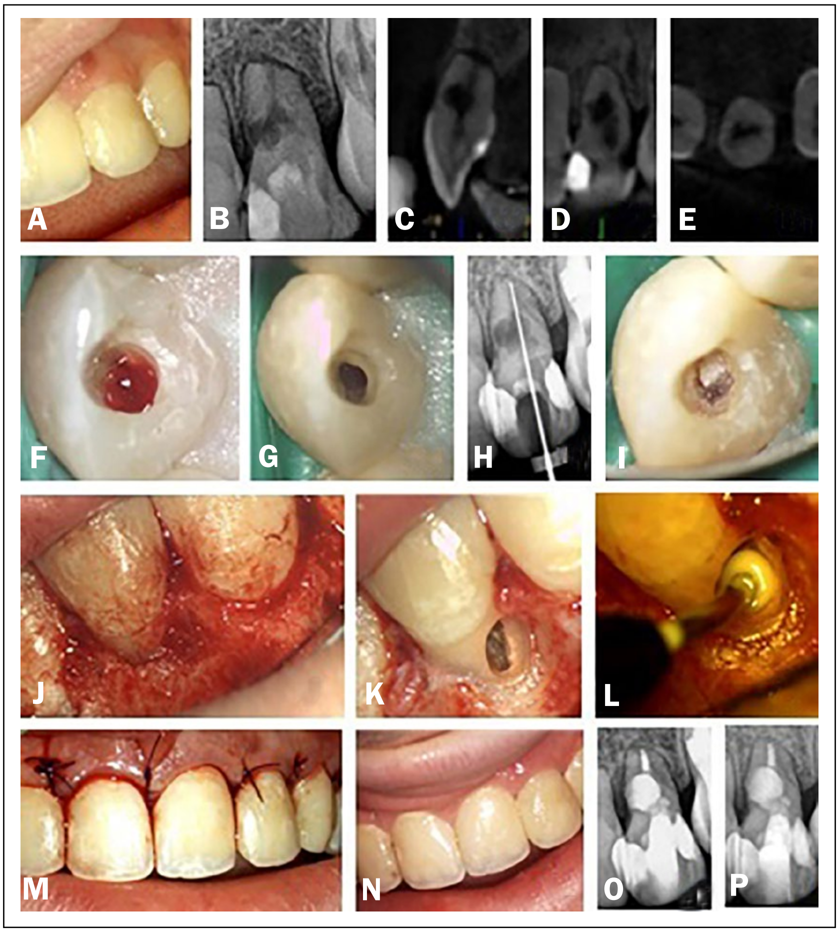

Figure 2.
A) Extraoral photograph- sinus tract associated with tooth 22; **B)** Initial periapical radiograph; **C)** CBCT Sagittal view; **D)** CBCT Coronal view; **E)** CBCT Axial view; **F)** Granulation tissue; **G)** Cleaned resorptive lesion; **H)** Working length determination radiograph; **I)** Reparation of the defect with MTA; **J)** Full thickness flap **K)** Cleaned resorptive lesion; **L)** Sealing root defect with glass ionomer; **M)** Repositioning of the flap with sutures; **N)** Extraoral photograph - complete healing of the sinus tract; **O)** Final radiograph; **P)** 7-months follow-up radiograph.

according to the manufacturer's instructions, with Medium file in the distal canal and Primary in both mesial canals (Figure 1K). Copious irrigation with 5.25% sodium hypochlorite (Denta Flux, J. Ripoll SL, Murcia, Spain) using a 5 ml syringe and a 27G notched needle (CanalPro Slotted-End Tips, Coltene, Lezzenes, France) was performed throughout all the root canal treatment. In the last appointment the patient was free of symptoms. A final irrigation protocol included one-minute irrigation with 10% citric acid prior to a final 5.25% sodium hypochlorite rinse under manual dynamic agitation with pre-fitted 4% tapered gutta-percha points (Zipperer, VDW, Munich, Germany), after which the root canals were dried with 4% tapered paper points (Zipperer, VDW, Munich, Germany) and filled with gutta-percha and an epoxy resin-based sealer (AH Plus, Dentsply Tulsa Dental, Tulsa, USA) with a continuous wave of obturation technique with the B&L system (Biotech, Seoul, Republic of Korea) (Figure 1L). The canals were sealed with Ionoseal (VOCO GmbH, Cuxhaven, Germany) and the tooth provisionally restored with Cavit (Ultracal, Ultradent, South Jordan, USA) before the prosthodontics department makes the direct composite resin restoration. At 20 months follow-up appointment, the patient maintained absence of symptoms, and normal bone trabeculation could be seen (Figure 1M).

#Cases 2 and 3

A 24-year-old male patient was referred to the Endodontics Postgraduation clinic at FMDUL for assessment of teeth 22 (Figure 2) and 23 (Figure 3, maxillary left lateral incisor and canine). Medical history was non-contributory and there was no previous trauma but the patient had undergone orthodontic treatment as a child. There were no symptoms, and no pain on percussion nor palpation. Tooth 22 had a mesiopalatal restoration in composite resin, with no apparent secondary caries, and tooth 23 presented neither carious lesion nor previous restoration. Probing was within normal values in all surfaces of both teeth, which also maintained normal mobility. There was a fistula associated with tooth 22 (Figure 2A). There was no response to the ice sensibility test (Endo cold spray, Henry Schein, Langen, Germany) in either teeth. Periapical radiography showed apical bone rarefaction associated with tooth 22, with considerable loss of root length, in a pattern consistent with orthodontic forces, and a mid-root alteration compatible with ECR (Figure 2B). ECR compatible lesion was also identifiable in tooth 23, with maintenance of periapical tissues health (Figure 3A). Both teeth were diagnosed as necrotic, with chronic periapical abscess and normal periapical tissues for teeth 22 and 23, respectively. A CBCT was requested to further assess the extension of the ECR lesions and for treatment planning. The ECR lesion of tooth 22 was classified as 3Bp (3 [height], extends into mid 1/3; B [circunferencial spread], >90° to≤180°; p [proximity to the root canal], probable pulp involvement)

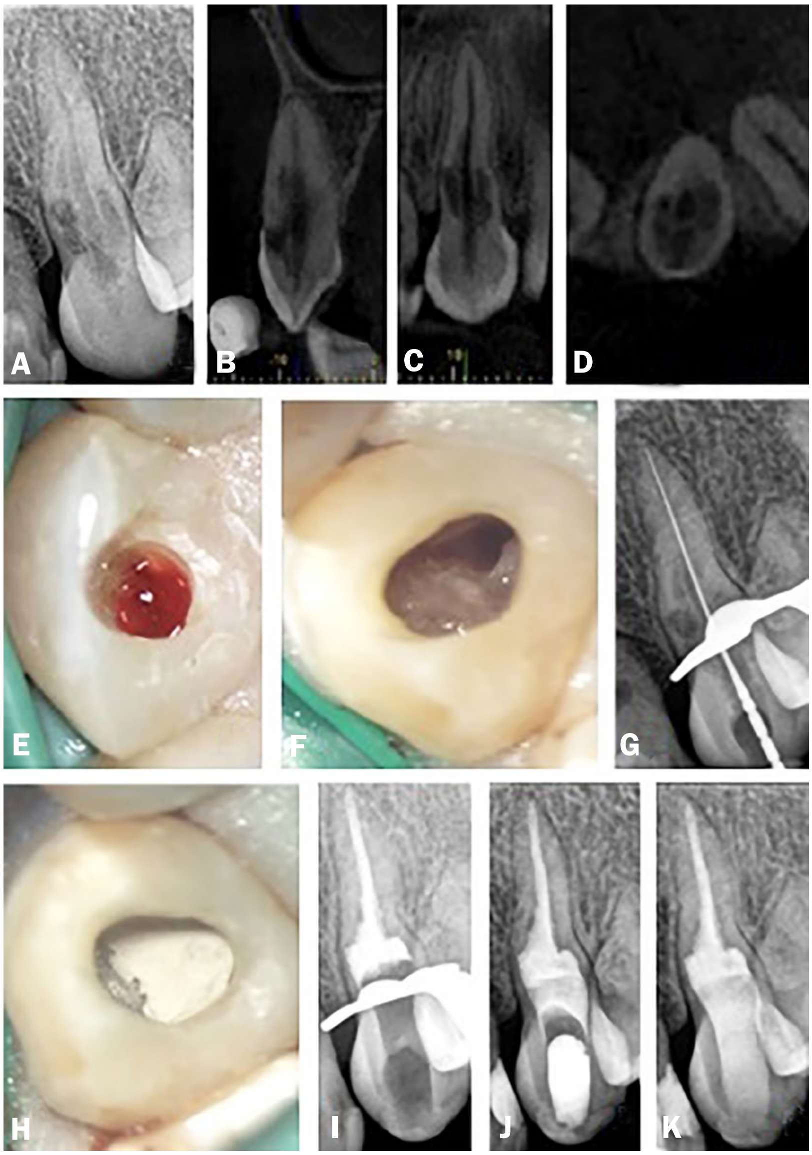

Figure 3.
A) Initial periapical radiograph; **B)** CBCT Sagittal view; **C)** CBCT Coronal view **D)** CBCT Axial view; **E)** Granulation tissue; **F)** Cleaned resorptive lesion; **G)** Working length determination radiograph; **H)** Reparation of the defect with MTA; **I)** Confirmation of defect reparation radiograph **J)** Final radiograph; **K)** 9-months follow-up radiograph.

(Figures 2C-E) and the lesion of tooth 23 as 3Cp (3 [height], extends into mid 1/3; C [circunferencial spread], >180º to≤270º; p [proximity to the root canal], probable pulp involvement) (figures 3B-D). The proposed treatment was root canal treatment with non-surgical management of the resorptive lesion, which was suggested and accepted. The treatments were performed under a Leica M320 dental operating microscope (M320, Leica, Wetzlar, Germany). After proper anesthesia using 4% articaine with 1:200.000 epinephrine (Artinibsa, Inibsa, Barcelona, Spain) and rubber dam isolation, the access cavities were established with round burs and improved with Start-X 1 ultrasonic tips (Start-X, Dentsply Tulsa Dental, Tulsa, USA). The granulation tissue associated with the resorptive lesions (Figures 2F, 3E) was removed with high speed round burs, and with dentin excavators. An aqueous solution of 90% tricloroacetic acid was also applied for 3 minutes to neutralize undetectable resorptive cells and clean the resorptive cavity (Figures 2G, 3F). The root canals were negotiated with 0.10 and 0.15 stainless-steel K-files (K-File, Dentsply, Ballaigues, Switzerland) and the determination of the working length was performed with a Root ZX electronic apex locator (Root Zx, Morita, Komuro, Japan) and confirmed radiographically (figures 2H, 3G). The canals were shaped with Protaper Next rotary files up to X5 (Protaper, Dentsply Maillefer, Ballaigues, Switzerland) according to the manufacturer's instructions. Copious irrigation with 5.25% sodium hypochlorite (Denta Flux, J. Ripoll SL, Murcia, Spain) using a 5 ml syringe and a 27G notched needle (CanalPro Slotted-End Tips, Coltene, Lezzenes, France) was performed throughout all the root canal treatment. In the last appointment the patient was free of symptoms. A final irrigation protocol included one-minute irrigation with 17% EDTA prior to a final 5.25% sodium hypochlorite rinse. After drying the canals with 4% tapered paper points (Zipperer, VDW, Munich, Germany), the canals were sealed with Mineral Trioxide Aggregate (MTA) (ProRoot MTA, Dentsply Tulsa Dental, Tulsa, USA). In both teeth, MTA was packed just short of the cemen-to-enamel junction (Figures 2I, 3H, 3I), sealed with glass ionomer Ionoseal (VOCO GmbH, Cuxhaven, Germany) and provisionally restored with Cavit (Ultracal, Ultradent, South Jordan, USA) (Figure 2J); in the lateral incisor, although a plug of MTA was applied, the extension of the resorption proved to be an obstacle for the correct sealing of the entire resorptive defect, and a surgical approach to correctly seal the space and margins was advised and accepted. Completion of the treatment of tooth 22 was done in a subsequent appointment, with elevation of a full thickness flap (Figure 2J), sealing of the entire root defect (Figure 2K) with Ionoseal (VOCO GmbH, Cuxhaven, Germany, Figure 2L) and the flap was repositioned with suture (Figure 2M). Two weeks after the surgical procedure, the fistula had disappeared (Figure 2N) and both teeth were sent for definitive restoration with composite resin (Figure 2O). At a follow-up appointment of teeth 22 and 23, 7 and 9 months after treatment, respectively, the patient maintained absence of symptoms, and normal bone trabeculation could be seen (Figures 2P, 3K).

Discussion

This article presents three cases of ECR in which classification and treatment plan was based on the most recently proposed 3D classification (4).

To properly classify and diagnose an ECR, the clinician must be aware of the different types of root resorption and their clinical findings. Depending on the location in relation to the root surface, a root resorption can be classified as internal or external (4). ECR lesions are included in the external resorption category.

The ECR can be challenging to diagnose, as it is usually asymptomatic in the early stages because pulpal and/or periodontal involvement may only appear at the later stage of disease progression (4). A previous histological and scanning electron microscopy (SEM) analysis and 3D nano focus CT imaging study allowed to understand why, in the progression phase, ECR has difficulty to progress into the pulpal space. A higher mineralized tissue composed by predentin, dentin, and reparative (bone-like) tissue, denominated pericanalar resorption-resistant sheet (PRRS), seems to be the pulp's response to this noxious stimulus. However, the structure of this sheet may not remain constant during the progression of the lesion, presenting loss of thickness in some areas and with occasional disruptions, associated with modification of the pulp tissue consistency in these regions (8). Moreover, ECR is capable of destroying PPRS layer and reach the pulp space, creating interconnections between the resorption cavity and the pulp, and pathways for opportunistic bacteria (8). These findings may explain the development of pulpal necrosis and symptomatic apical periodontitis associated with tooth 46 and chronic apical abscess associated with tooth 22.

The aetiology of ECR lesions remains unclear. According to previous studies, orthodontic forces have been established as one of the major etiological factors for ECR. Considering the potential predisposing factors for ECR presented in the literature, a study involving 337 teeth showed that orthodontic treatment was the factor most frequently associated (45.7%) with ECR cases (6). These forces may have been strongly implicated in the development of ECR in tooth 22 and 23, once the patient had a dental history of orthodontic treatment, which also resulted in loss of cortical bone in the vestibular plate as can be seen on the CBCT scan. Despite all the other listed predisposing factors in the literature, it is still not possible to establish a cause-effect relationship for the development of ECR in tooth 46.

Nowadays, 3D imaging, such as CBCT, brought to discussion the well-known shortcomings of 2D imaging that can result in a deficient evaluation and diagnosis of the resorption process and its true dimensions, consequently leading to a poor management of the ECR (7). CBCT is a very important tool to establish a good diagnosis and to assist the clinician to plan the management of several complex endodontic problems (1).

Therefore, clinicians with the aid of CBCT, are able to evaluate the extension of the resorptive lesion, and concerning its location in the root, circumferential spread and proximity to the root canal (4). In ECR lesions, the decision-making process is based on symptoms, dimension of the resorptive defect and tooth restorability (1). The proper approach depends on the severity and accessibility and restorability of the lesion, as it is of most importance to accomplish a complete removal of the resorptive tissue, to seal the resultant defect and portal of entry, thus preventing recurrence (10).

The most recent developed 3D classification considers the height of the lesion establishing four levels, being the number 1 at the cemento-enamel junction level or coronal to the bone crest (supracrestal), and number 2, 3 and 4 extending apical to the bone crest, within each third of the root, respectively. The circumferential spread is measured in degrees, being A≤90°, B>90° to≤180°, C>180° to≤270° and D>270°. The proximity to the root canal contemplates d: lesion confine to dentine and p, probable pulpal involvement (4). Considering the advantages stated, the approach of these cases was based in their 3D classification: tooth 46 2Ap; tooth 22 3Bp; tooth 23 3Cp. Tooth 46 lesion extends into coronal third of the root and apical to the bone crest (subcrestal), with a circumferential spread inferior to 90°, whilst both lesions on teeth 22 and 23 had an extension into mid-third of the spot, concerning height. Tooth 22 lesion had a circumferential spread between 90° and 180°, while tooth 23 lesion was classified having the biggest circumferential spread (between 180° and 270°). A probable pulp involvement was considered for every case.A complete diagnosis was accomplished with sensibility tests and clinical evaluation, as we should take in consideration that this 3D classification is to be applied to CBCT scans only and does not contemplate information regarding the pulpal vitality.

Considering the extent and accessibility of the resorptive lesion, various treatment options are presented in the literature: external repair of the resorptive defect; internal repair and root canal treatment; intentional replantation; periodic review; and extraction (7, 10). The main purpose when managing an ECR case, is to arrest the resorptive process by removing all the resorptive tissue, restore the defect with an aesthetic biocompatible material and prevent recurrence of the process (10).

After treatment plans were presented, patients were aware of the prognosis, especially for tooth 22, a borderline case with a questionable prognosis, concerning the loss of root length due to external inflammatory resorption. The absence of tooth mobility and probing depths played a major role in the decision-making. With the patient's informed consent and acceptance of treatment plan, root canal treatments were performed with internal repair of tooth 23, external repair of tooth 46 with a composite resin and external repair with surgical approach in tooth 22, and the defect sealed with glass ionomer. The literature suggests internal approach as a treatment option when ECR is close to or has invaded the pulp space, when it is difficult to access surgically the resorptive defect or when excessive removal of sound tooth structure is needed (10). Decision-making for the approach of tooth 23 was based on the literature, also considering that, from CBCT imaging evaluation, small points of entry were involved. Inaccessible and small entry points may expand circumferentially and apicocoronally and are best managed with an internal approach (10). On the contrary, a greater destruction of the root surface was evaluated on tooth 22, impossible to repair with an internal approach. A mucoperiosteal flap was needed to allow adequate access to the ECR for curettage of the granulomatous tissue from both root and periodontium. Despite the fact that tooth 46 already presented considerable tooth structure loss due to previous attempt of restauration after a misdiagnosed decay, a supraosseous portal of entry was identified, which, according to literature, is best managed by an external approach (10).

There are several products in the literature recommended to accomplish the better removal of the resorptive tissue. Trichloracetic acid (TCA) at 90%, applied for a period of 3-4 minutes, calcium hydroxide and even sodium hypochlorite enable tissue within the resorption cavity to become progressively avascular due to a process of coagulation necrosis. TCA as also a proven action of infiltrating the small channels and recesses of ECR that are difficult to reach by mechanical preparation (11-13). Consequently, under magnification, the tissue is easily removed by curettage and a complete visualization of the resorption defect is accomplished, one of the most important steps to prevent ECR recurrence (11, 12, 14). For tooth 23, with internal and nonsurgical treatment, the difficulty in eliminating all the entry point of the lesion must be considered. This case relied in the action of TCA to cauterize any resorptive tissue that remained (14).

The same protocol with TCA was applied to the surgical management of tooth 22, but based on the knowledge that this aqueous solution severely demineralizes dentin, the clinician opted for the use of calcium hydroxide on tooth 46 not to compromise the bonding strength when restoring the tooth with composite resin (14). Calcium hydroxide is a strong alkaline substance, with a pH of approximately 12.5, which is widely known by its antimicrobial properties. Nonetheless, several authors have confirmed its use for several clinical situations according to its properties of dissolving tissues and inhibition of tooth resorption (15). To restore the root surface, the location of the root defect must be considered. Several materials such as amalgam, MTA, which may be used with adhesive bonding agents (16), and others bioactive cements, resin composite, glass ionomer cements have been proposed as resorptive lesion reparation materials (10, 17). As for the supracrestal lesions, communicating with the oral environment, as performed in tooth 46, composite resin or glass ionomer cements have been recommended (10). Chemical interaction is the primary bonding mechanism for resin modified glass ionomer cements (RMGICs), thus hybridizing the dentin (18). Therefore, these materials depend on the ionic bonding to the calcium present in hydroxyapatite (14). TCA is application will result in elimination the hydroxyapatite in the dentine surface, contributing to a severely demineralized tissue. On tooth 22, a round bur was used to eliminate the deprived dentin surface from hydroxyapatite and to refresh the surface, enabling the calcium to be present for glass ionomer ionic bonding (14). In case composite resin is used, a flowable resin may be advisable to be used between the adhesive layer and the composite resin in order to improve the cementum-restoration interface (19).

Bioactive materials have also been described in the literature as a good material choice for application in subgingival ECR cavities. Among their antimicrobial properties and biocompatibility, a good sealing ability and capacity to promote periodontal reattachment are the most important to consider in this subgingival cavities (10). A study aiming to compare the biological interaction of human osteoblasts and periodontal ligament cells with different materials (MTA, Biodentine, amalgam and composite) reported the highest survival and proliferation rate when the cells where in contact with Biodentine (Septodont, Lancaster, PA, USA) (20). Despite these findings, and even considering its lower setting time (10-12 minutes) when compared to other bioactive cements, and also its reasonable aesthetic appearance (21), a different material was chosen for the repair o tooth 22.

Because dentin bonding is extremely difficult due to its humidity and organic nature (22), a composite resin technique was not considered for the sealing of the defect of tooth 22. Ionoseal (VOCO GmbH, Germany), a light curable RMGIC, was chosen because of its adequate restorative mechanical properties and also its ability to provide a good sealing and remineralization (18). RMGIC cements were added hydrophilic monomers and photoinitiators to improve the mechanical and physical properties of conventional GI cements, and also to reduce its early moisture sensitivity (17). Thus, making these materials a great material option to seal resorptive defects.

Ideally the 12-months follow-up period should be performed (7). A total remission of symptoms was observed before that period, and all teeth remained functional, even in the short term follow-up.

Overall, comprehending the course of this pathology and its aetiology is fundamental to allow timely diagnosis of this condition in routine treatments. Proper diagnosis and adequate treatment plan is only accomplished with a 3D evaluation of the resorptive defect.

Conclusions

The correct assessment and treatment planning of these three ECR cases resorting to a 3D classification and CBCT analysis, lead to successful approaches with remission of symptoms. Nonetheless, with the informed consent of patients, borderline cases should be followed with a long period of time to ensure the maintenance of normal periapical tissues and function.

Clinical Relevance

Management of external cervical resorption lesions should be based on a 3D diagnosis, considering height, circumferential spread and proximity/involvement of the root canal. The use of CBCT enables the clinician to establish the proper 3D diagnosis maximizing the outcomes of the treatments under way.

Conflict of Interest

None.

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None.

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