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CASE SERIES

Management of seven external cervical resorptions

ABSTRACT

Aim: *External cervical resorption (ECR) assessment and its management planning are often difficult. This work proposes a standardized workflow for ECR treatment considering the 3D-classification of the lesion by Patel and assesses its clinical applicability to seven preliminary clinical cases.*

Summary: *ECR cases were detected from medical and dental history, clinical data and a conventional radiography; a Cone Beam Computed Tomography (CBCT) with a small field of view (FOV) was performed too. A both 2D and 3D-classification was applied on each resorption. After studying better the clinical aspect, especially the accessibility of the lesion, the restorability of the tooth was assessed and the approach was decided between external repair, with or without endodontic treatment, or internal repair. Reparative tissue was removed and the defect was managed through new generation composite resins, mineral trioxide aggregate (MTA) or other cements. A pulp capping was performed in one case and a canal treatment in the others. Clinical and radiographic checks assessed both quality and adequacy of the treatments immediately and over time.*

Key learning points:

- *A standardized workflow could be useful for ECR treatment.*
- *CBCT is essential for determination of ECR extension and an appropriate treatment planning.*
- *ECR management should be conservative, but should also remove the reparative tissue.*
- *ECR management could be performed within one or two appointments.*
- *A follow-up is required to evaluate the treatment over time. The main outcome is the survival of the element, the secondary outcomes are the absence of resorption progression, no symptoms and healthy periodontal values.*

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Introduction

Tooth resorption is a condition associated with a process resulting in a loss of dentin, cementum and/or bone (1). It is physiologic and desirable in primary teeth as it aids exfoliation of the deciduous tooth and thus facilitates eruption of the permanent successor (2), whereas it is pathologic and undesirable in adult teeth as it leads to irreversible damage (3).
A preliminary classification of tooth resorption considers its localization: it could be an internal or external resorption. External resorption may be further subclassified in external inflammatory resorption, external replacement resorption, external cervical resorption (ECR) and external surface resorption (4).
ECR is known also as invasive cervical resorption or cervical root resorption (5). It is a relatively uncommon and highly aggressive form of external tooth resorption that starts from the cervical region, below the epithelial attachment, and progressively destroys the tooth structure (4). It is assumed that there must be damage to the periodontal ligament and cementum in combination with a stimulating factor, that can induce and maintain the activity of clastic cells. The histopathogenesis consists of three main stages: resorptive (initiation), resorptive (propagation) and reparative (remodelling), that can occur in parallel in different areas of the same lesion, while it extends deeper towards the pulp and the middle and apical thirds of the root (3, 6).
Epidemiology shows no difference in sex or age: also young people have been found to be involved (7, 8). Maxillary anterior teeth are usually the most affected (8).
Aetiology is rather unclear. Some potential predisposing factors have been already proposed by Heithersay at the end of the last century: orthodontic treatment, dental trauma, internal bleaching, intraoral surgical and restorative treatments (9). Mavridou investigated also other factors, among which: viruses, systemic diseases, poor oral health, parafunctional habits, orthognathic surgery, music wind instruments, malocclusion, frenulum tension, extraction of a neighboring tooth, eruption disorders and cracks. In the majority of clinical cases, more than one potential predisposing factor was identified, indicating that ECR is multifactorial, not idiopathic. Furthermore, in 99% of the examined cases, almost one potential predisposing factor was recognized (7). Nevertheless, a sure causal relationship has not yet been found for any factors and a minority of cases is still without a plausible explanation.
Clinical features vary from nothing to a small defect at the gingival margin, which is directly detectable through a visual inspection, to a pink coronal discoloration of the crown, as a result of soft tissue color shining through the thin tooth tissue overlying the resorptive cavity, resulting in ultimate cavitation of the enamel. The process is usually painless because the pulp remains protected by a thin layer of predentin and dentin until late, when a pulpal or periodontal infection supervenes (9, 10). As the resorption is usually without symptoms through a very long period or even never become symptomatic, the lesion could proceed without anyone becoming aware of it, until the tooth could not be longer saved. So, due to the nature of this lesion, early detection is essential and difficult at the same time. It is very often discovered thanks to a routine conventional radiography during a visit as an incidental radiographic finding or, alternatively, because the clinic is rather advanced (5).
Until a few years ago, the only way to assess the extent of the lesion was the conventional X-ray. Here the lesion appears as radiolucency; a radiopaque line demarcates the root canal from the adjacent irregular radiolucency when the latter is close to the canal (11). The first classification by Heithersay was two-dimensional: it categorized ECR according to its extension into the root and its proximity to the root canal, as follows.
Class 1: a small invasive resorptive lesion near the cervical area with shallow penetration into dentine.
Class 2: a well-defined invasive resorptive

lesion that has penetrated close to the coronal pulp chamber, but shows little or no extension into the radicular dentine. Class 3: a deeper invasion of dentine by resorbing tissue, not only involving the coronal dentine, but also extending at least to the coronal third of the root. Class 4: a large invasive resorptive process that has extended beyond the coronal third of the root canal and may involve almost the entire root (12).

However, the classification above has got limitations, as it does not describe the true nature of ECR (resorptive and reparative) and, above all, it does not read the third dimension; furthermore when there is only a small starting lesion, especially if on the buccal or lingual aspect of the tooth, it may not completely be seen in conventional X-ray (13, 3). Therefore the periodontal radiography can result in inadequate assessment or even misdiagnosis and also poor management of root resorption (14).

Fortunately, the Cone Beam Computed Tomography (CBCT) has become available in Endodontics thanks to a reduced field of view (FOV) with a reasonable exposure dosage and good quality, optimizing exposure parameters on an individual basis: the principle as low as reasonably achievable (ALARA) is therefore followed (15). Several specialist societies published position statements, among which the European Society of Endodontology (ESE): they recommended the CBCT to assess and/or manage root resorption, which clinically appears to be potentially amenable to treatment (16, 17).

Patel suggested a new three-dimensional classification for ECR based on additional information available from CBCT. It takes into account three parameters thanks to three-dimensional analysis, as follows.

Height (coronal-apical extent) of the lesion: the lesion
1) is at cement-enamel junction level or coronal to the bone crest (supracrestal);
2) extends into coronal third of the root and apical to the bone crest (subcrestal);
3) extends into mid third of the root;
4) extends into apical third of the root.

Circumferential spread, which is graded according to the lesion maximum spread within the root:
A) ≤90°
B) >90° to ≤180°
C) >180° to ≤270°
D) >270°

Proximity to the root canal, which can be best assessed using axial CBCT views: d) lesion confined to dentine; p) probable pulpal involvement (18).

The combination of each of the three parameters (e.g. 1Ad) provides to the clinician a more accurate determination of the whole extension of ECR and can lead to a more appropriate treatment planning. The same author proposed different strategies for the management of ECR: external repair with or without endodontic treatment, internal repair, intentional reimplantation and periodic review until extraction. He suggested materials and he tried to connect each strategy with both the Heithersay and the three-dimensional classification, as far as possible (19).

Some case reports have already been published about ECR and its treatment (20-27), but without following a specific workflow. We arranged a preliminary workflow since 2015, then we upgraded it according the ECR classification by Patel (18) and the last ECR review (19). Here we suggest the last version of the workflow for a standardized approach in the anterior as well as in the posterior mouth, as schematized in the diagram of Figure 1. We have also already applied this workflow to new seven cases of ECR, as described below.

We found the cases of ECR thanks to medical and dental anamnesis, clinical data - including probing - and a conventional radiography or directly thanks to conventional radiography. We asked the patient about any symptoms, if not directly referred. Then we performed a CBCT with a small FOV, giving a relatively low effective dose and obtaining specific and clear information that made us know the real three-dimensional extension of the lesion. Only in one case we directly chose a larger CBCT FOV, as the patient needed also a cysts removal in the right half-jaw, and

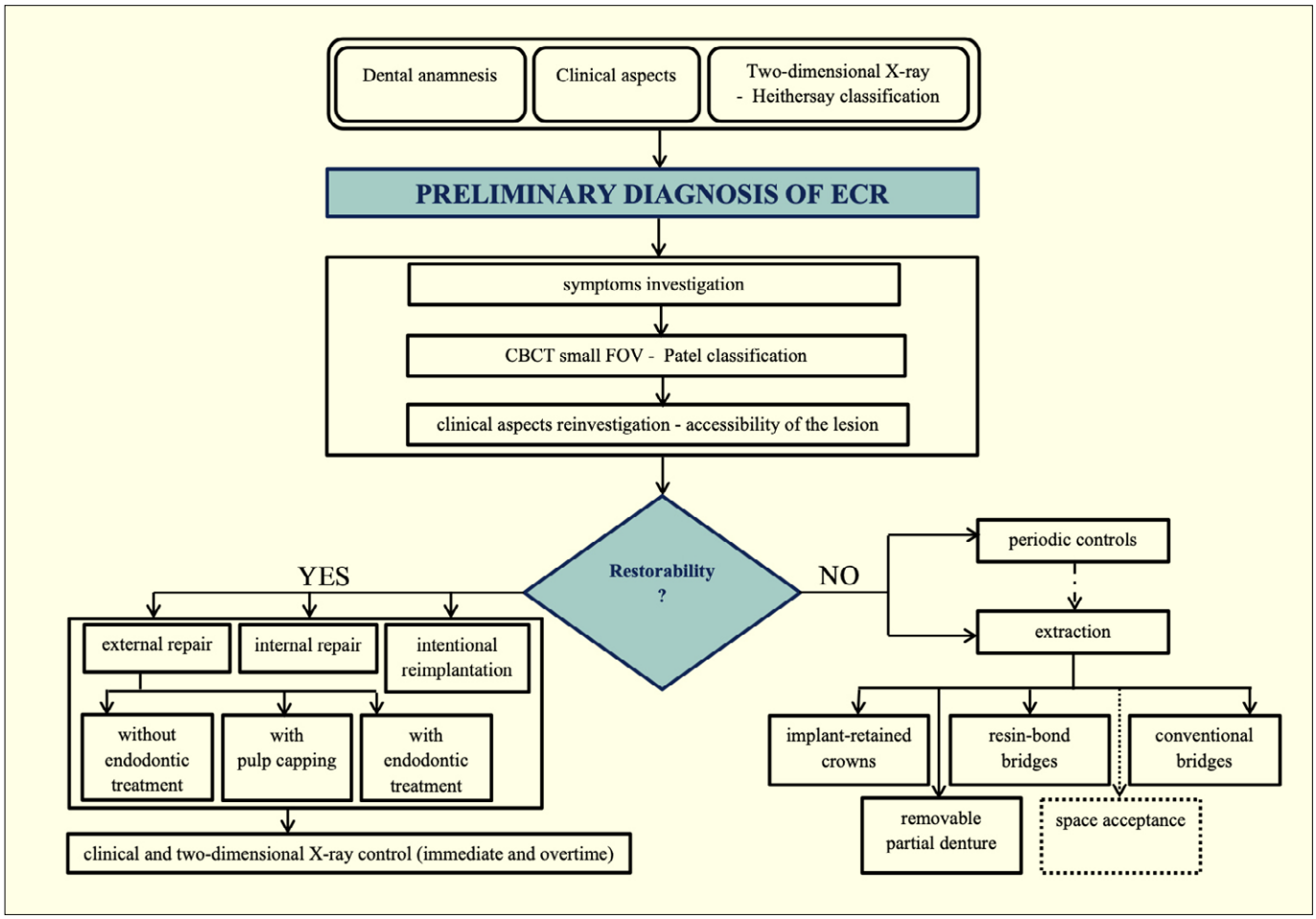

Figure 1.
Workflow diagram.

in another case an ECR was discovered in a CBCT for an implant plan. Consequently we applied a double classification, both by Heithersay and Patel.
We studied again and better the clinical aspect, especially the accessibility of the lesion, and subsequently we assessed the restorability of the tooth, that was fortunately always possible. Then we decided the approach between external repair, with or without endodontic treatment, or internal repair, following instructions and advices in the review by Patel (19). Especially, we tried to remove resorptive tissue when possible and managed the resorptive defect through new generation composite resins, MTA or other cements. We applied a calcium hydroxide cement for pulp capping in one case and used warm gutta-percha, endodontic cement and eventually mineral trioxide aggregate (MTA) for the canal treatment in the others.
Clinical and radiographic checks assessed both quality and adequacy of the treatments immediately and over time.

Report

#Case1
It was the first case in chronological order (year 2015).
A 17-years-old male presented requiring an orthodontic treatment. At the first visit, the oral health seemed good. Any soft oral tissues lesions, any caries or tooth abnormalities were directly detectable; some previous conservative and endodontic therapies were present. Periodontal pocket values were between 1 mm up to 3 mm, without bleeding or suppuration on probing. Instead, a malocclusion was assessed: therefore we prescribed an orthopantomography in order to plan the orthodontic treatment. Here we noticed a strange

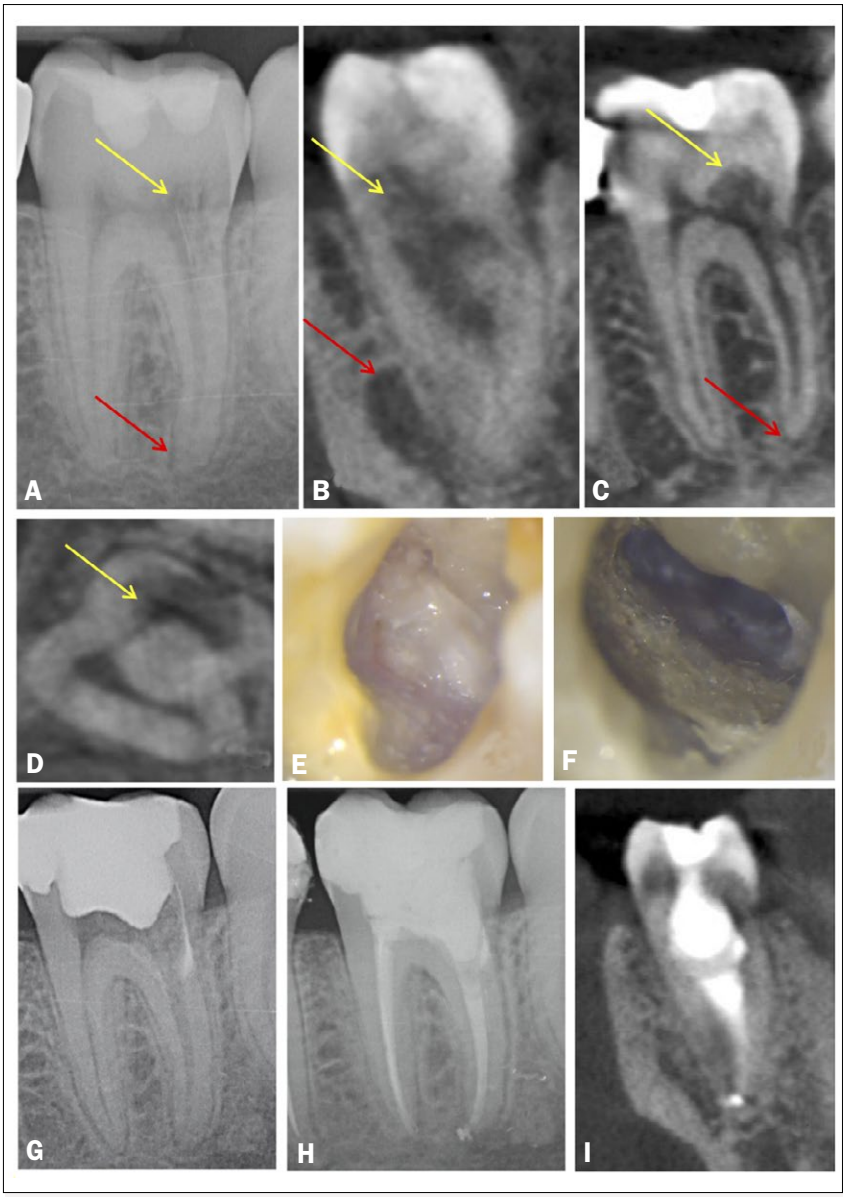

Figure 2 (video 1).
ECR case 1. **A)** Preoperative radiograph of a 3.7 showed ECR (yellow arrow) and preliminary signs of apical periodontitis (red arrow). **B)** Frontal, **C)** sagittal and **D)** axial CBCT slices confirmed the extensive nature of ECR which extends apically and completely around the distal canal (yellow arrows). **E)** Access cavity preparation revealed the partially reparative nature of ECR. **F, G)** MTA was located all around the access of the distal canal. **(H)** Immediate post-fill radiograph. **I)** Frontal.

radiolucency at the distal cervical area of his second lower left molar 3.7.
We suspected an ECR. The tooth was a normal responder to both the vitally test (we used the cold test) and the percussion test. The general medical anamnesis was negative; the patient could not recall a history of dental trauma, another previous orthodontic treatment or any of the other possible predisposing factors and he did not report any symptoms. The clinic aspect of the tooth confirmed to be silent: any pink spots, any gingival irregularities, any strange small cavitations in the crown third part and any deeper periodontal probing values could be detected.
However, we decided to investigate better taking a periodontal radiography with a paralleling technique (Figure 2A): it revealed a more widespread radiolucent area in the distal side of the crown starting from cervical area and extending to the coronal third of the root. Besides, a small suffering area could be seen around the last third of the distal root, whereas it was not detectable in the orthopantomography. According to this further information the resorption was really present and was classified as a class 3 of ECR, following Heithersay classification.
We took a CBCT (Figure 2B-D, M) to understand its real extension. A 3D classification was not available in 2015, however now we could further classify the lesion as a 3Dp stage following Patel classification. The CBCT showed also a more important radiolucency into the wave bone around the distal root, therefore the positive answer to vitality test could be due to the mesial part of the teeth. These findings could be explained by CBCT high sensitivity: CBCT imaging was demonstrated to have twice the odds of detecting a periapical lesion than traditional periapical radiography (28).
We investigated again the clinical aspects, we decided for the restorability of the element 3.7, but, because the direct accessibility was limited, we concluded that an external repair of the root (the first choice in our workflow for restorable teeth) may have been really difficult. Therefore we chose an internal repair with MTA thanks to its biocompatibility and sealing ability (29), followed by a conventional canal treatment with warm gutta-percha.
Therefore, at the first appointment, we applied a stamp technique: we impress the occlusal anatomy and then we performed a classical cavity access (30, 31) with diamond burs before and ultrasonic (US) tips

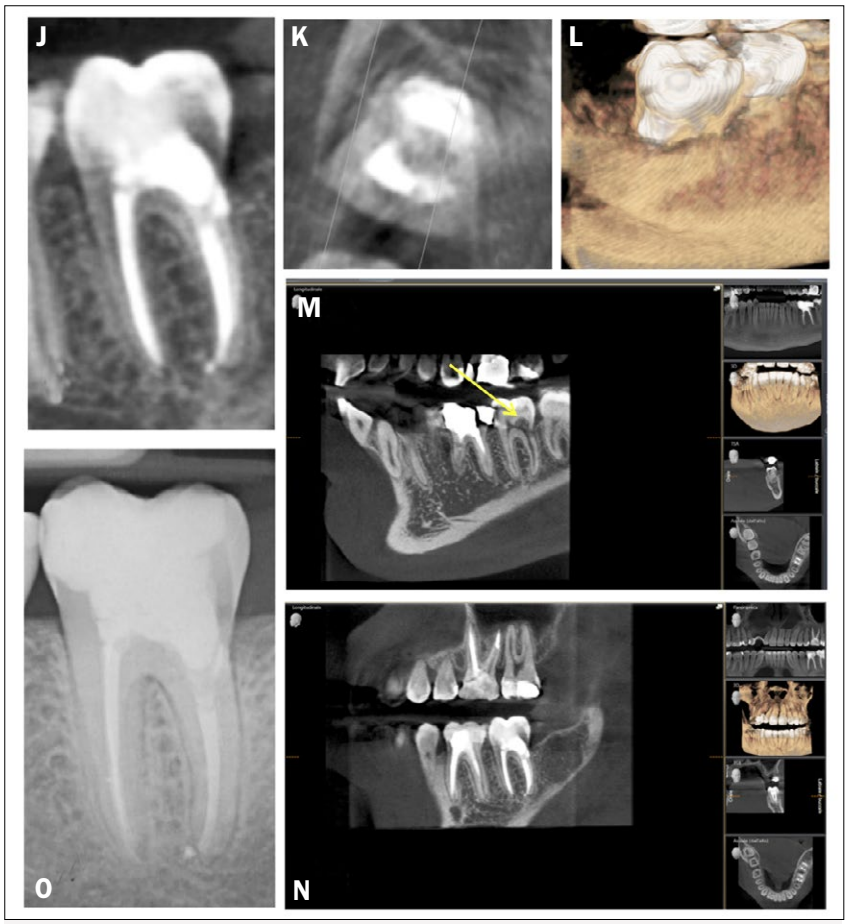

Figure 2.
ECR case 1. **J)** sagittal, **K)** axial CBCT slices and **L)** 3D rendering of two years recall. Comparison between **(M)** pre-operative and **(N)** two years recall CBCT. **O)** Four years recall periapical X-ray.

later (Figure 2E). Thanks to the microscope, we directly saw the reparative tissue and we removed it with an endodontic dedicated US tip, also to have access to the coronal third of the canal into the distal root. We located MTA both to the mesial and to the distal aspect of the canal access and we compacted with a micro-brush (Figure 2F). A periodontal X-ray was taken to make us sure that the MTA was correctly located (Figure 2G, video 1) and we waited 7 days to allow the complete hardening of the material under a temporary restoration. After a week the patient underwent the second appointment: we checked the MTA seal, we completed the root canal treatment and performed a direct restoration. An immediate post-operative periapical radiography (Figure 2H) was taken. After 2 years another CBCT was prescribed in order to plan an implant guided surgery of 1.3 and the imaging was extended to the lower jaw, according with the patient: it confirmed a good seal of the previous resorptive lesion and the radiolucent periapical area was no longer detectable (Figure 2I-N). Meanwhile, clinical controls and periapical X-rays have been taken until 2019 (4 years recall): the tooth has always been clinically asymptomatic, the periapical radiographs confirmed the healing bone process and the absence of new areas of resorption (Figure 2O).

#Case 2
The second case began in 2017.
A 17-years-old female was seen in urgency because of a poorly located strong spontaneous pain. Her lower left canine 3.3 showed a pink discoloration – therefore we supposed a resorption (11, 10, 3) – and the vitality test led to the following diagnosis: pulpitis (32). Any caries could be detected. A periodontal radiography was taken using a paralleling technique (Figure 3A): it revealed a radiolucent lesion with irregular and poorly defined borders in the cervical aspect of tooth extending to the coronal third of the root. Besides, a radiolucency could already be seen into the alveolar bone around the distal aspect of the first third of the root. The diagnosis of ECR was confirmed. According to this preliminary information the resorption was classified as class 3 following Heithersay classification. The patient confirmed that her general medical anamnesis was negative; her main predisposing factor was a previous fixed orthodontic treatment (9, 7, 33), followed by a post-orthodontic splinting and periodical recalls. She highlighted that she did not experienced any symptoms before, but this finding is not strange as ECR becomes symptomatic (if it happens) at its last stages (11). We opened immediately the access cavity in urgency, we put a temporary restoration and we planned a CBCT to further confirm the diagnosis of ECR and assess the true position and extension of the radiolucency. We took a CBCT (Figure 2B-E, video 2) some days later. A 3D classification was not yet available, however now we could classify

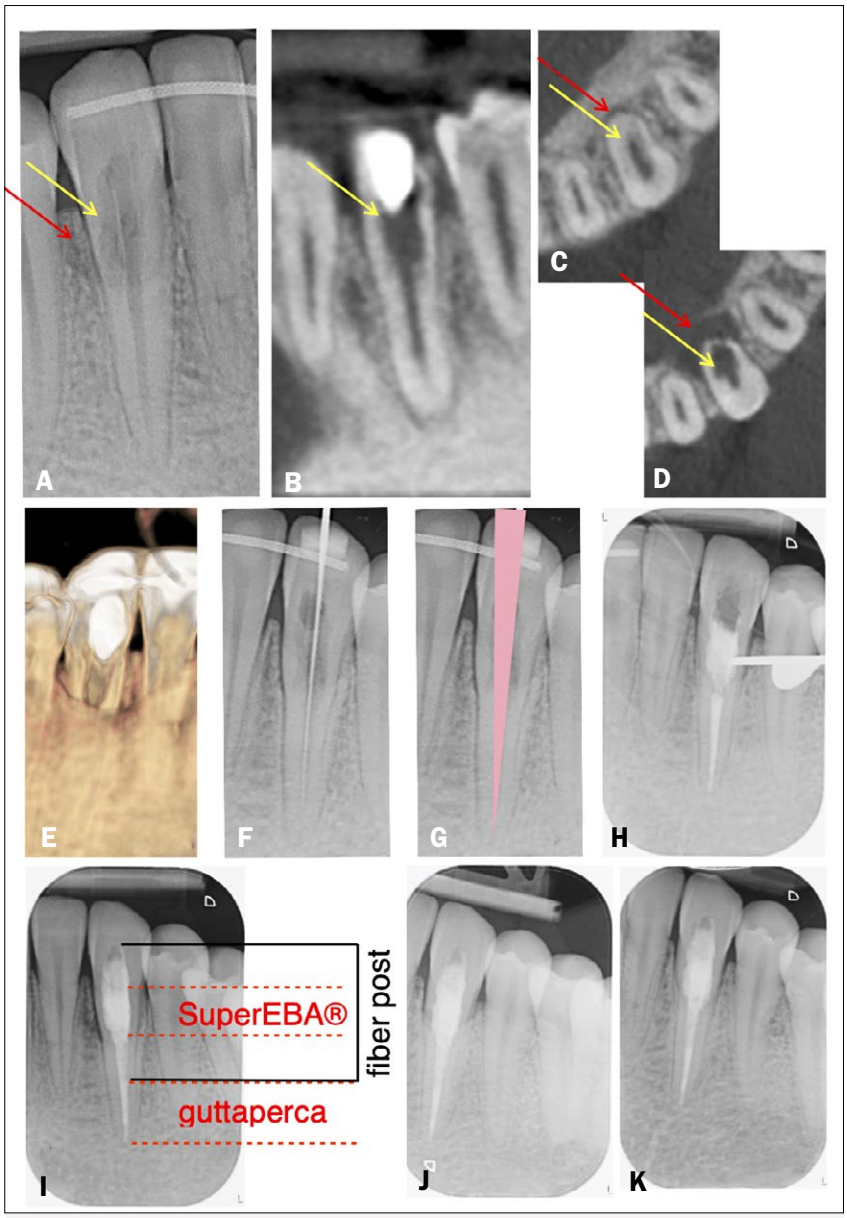

Figure 3 (video 2).
ECR case 2. **A)** Preoperative radiograph of a 3.3 showed ECR (yellow arrow) and signs of lateral periodontitis (red arrows). **B)** Frontal and **C, D)** axial CBCT slices confirmed both the extensive nature of ECR (yellow arrows) which extends apically the bone crest and a lingual bone lesion (red arrows). **E)** 3D rendering of the tooth. **F)** Radiographic working length. **G)** A gutta-percha cone was temporarily put into the canal. **H)** Defect restoration using SuperEBA® Cement and gutta-percha apical seal. **I)** Schematic view of the fully restored tooth: a fiber post was put into the middle and coronal third of the root. **J)** One year recall. **K)** Two years recall.

the lesion as a 2Bp stage following Patel classification. The CBCT showed also an important lingual radiolucency into the wave bone, that broke off the neighboring cortical bone (28).
We reinvestigated the clinical aspects, we decided for the restorability of the element 3.3 thanks to external repair and endodontic treatment. Therefore we removed the temporary restoration and we recorded the working length through a periapical X-ray (Figure 3F) as electronic apex detector did not work correctly because of the periodontal tissues interference. We shaped the canal and put a temporary gutta-percha point in it (Figure 3G). We opened a surgical flap and we removed both granulomatous tissue that was profusely bleeding and the resorbing tissue thanks to US inserts and operative microscope. Before filling the resorptive defect with SuperEBA® Cement, we controlled the integrity of gutta-percha point inserted into the canal to prevent cement from sliding downward. We put SuperEBA® Cement in the defect and closed the flap. Another appointment followed: the apical third of the tooth was filled with endodontic cement and warm gutta-percha (Figure 3H), an hollow fiber post was located because of its favorable mechanical properties (34) and a direct composite restoration was performed. An immediate post-operative periapical radiography (Figure 3I) was carried out. Clinical and periapical X-ray has been taken until 2019 - 1 (Figure 3J) and 2 (Figure 3K) years recall: the tooth has been clinically asymptomatic; the periapical radiographs show a healing bone process around the coronal third of the root and no new areas of resorption.

#Case 3
The third case was discovered in November 2018.
A 12-years-old female showed a discoloration on her second upper right incisor tooth 1.2 during her fixed orthodontic treatment. We immediately thought that a resorption was happening, as in that case the resorbed structure is replaced by highly vascular tissue which could be seen through a thinner enamel, especially in anterior teeth (11, 10, 3). The element was not symptomatic; however endodontic tests were performed: it responded to cold like her neighboring teeth and it was non-tender to pressure and percussion.
The general medical anamnesis was nega-

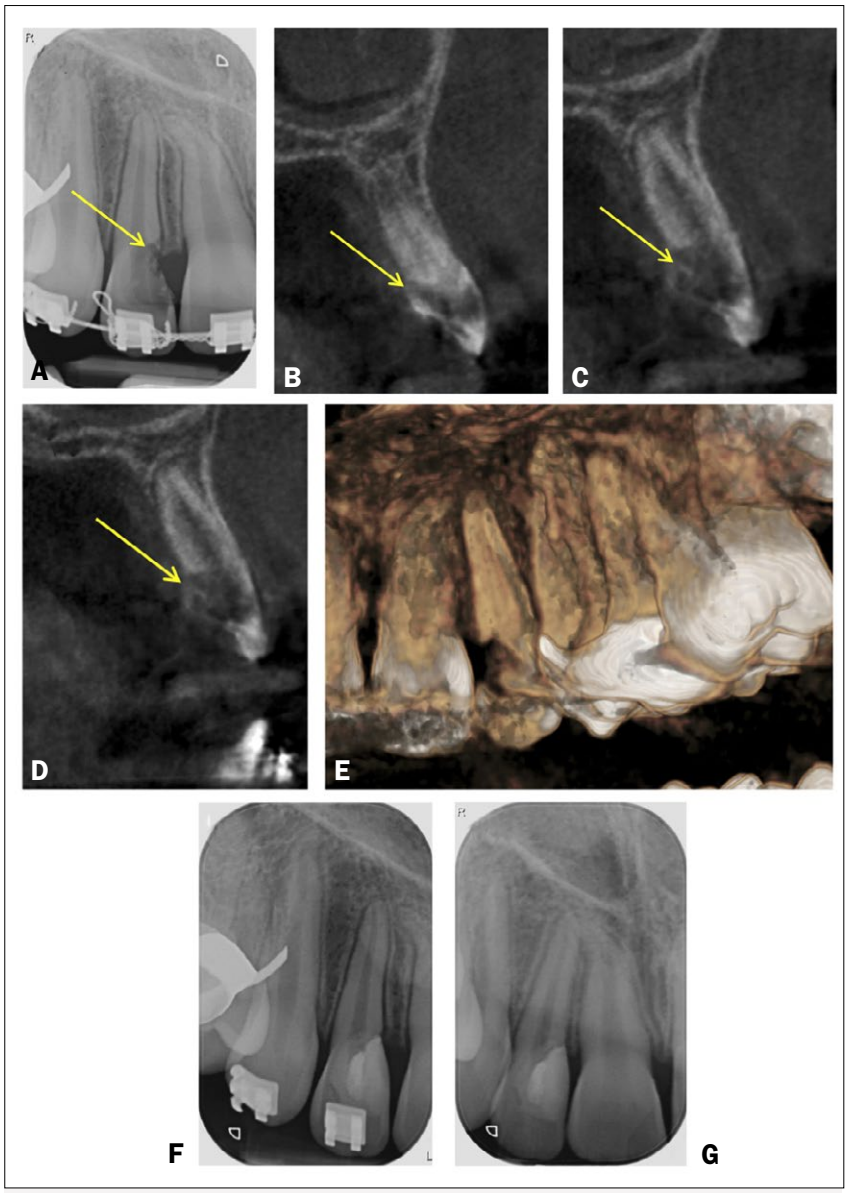

Figure 4 (video 3).
ECR case 3. **A)** Preoperative radiograph of a 1.2 showed ECR (yellow arrow). **B, C, D)** Sagittal CBCT slices let know the real extension of ECR (yellow arrows) that was mainly palatal and supracrestal. **E)** 3D rendering of the tooth. **F)** Immediate post-operative X-ray. **G)** One year recall.

tive; about her dental history, any other predisposing factors could be detected, except for the orthodontic treatment (9, 7, 33). A periodontal radiography was taken using a paralleling technique (Figure 4A): it revealed an irregular radiolucency in the mesial side of the crown just above the bone crest, not extending apically into the radicular dentine, but quite deeper through the coronal dentine, maybe touching the pulp chamber. According to this preliminary information, the lesion was classified as class 2 ECR, following Heithersay classification.

We took a CBCT (Figure 2B-E) to understand the real extension of the resorption: it was mainly palatal and supracrestal and fortunately did not reach the endodontic system. A 3D classification was recently available and we classified the lesion as a 1Bd stage following Patel classification.

We investigated again the clinical aspects, especially the palatal accessibility and we decided for the restorability of the element 1.2. We proposed a direct external repair, trying to maintain tooth vitality.

Therefore we opened a surgical flap and we removed both granulomatous tissue that was profusely bleeding and the resorbing tissue thanks to US inserts and operative microscope. The pulp of the chamber was directly observable only under the microscope. So we decided to try a quick direct pulp capping through calcium hydroxide (Dycal, Dentsply Sirona) (35). Then we performed a direct composite restoration followed by many finishing and polishing steps to remove respectively main irregularities and minute scratches (36): we used diamond burs, flexible and semi-flexible abrasive instruments (cups, points and wheels), instruments coated with abrasives (abrasive disks and strips) and abrasive polishing paste compounds (37). The flap was closed. An immediate post-operative periapical radiography (Figure 4F) was taken. Clinical checks with annual periapical X-ray were planned: the tooth has been clinically asymptomatic, has kept its vitality and 1 year recall X-ray (Figure 4G) and probing (video 3) have been satisfactory.

#Case 4

The fourth case was discovered in November 2018 too.

A 52-years-old smoker female was referred by her oncologist. She suffered from lung cancer with multiple metastases, mainly localized to the spine, as well as hypertension and panic attacks. She needed to begin an intravenous bisphosphonate thera-

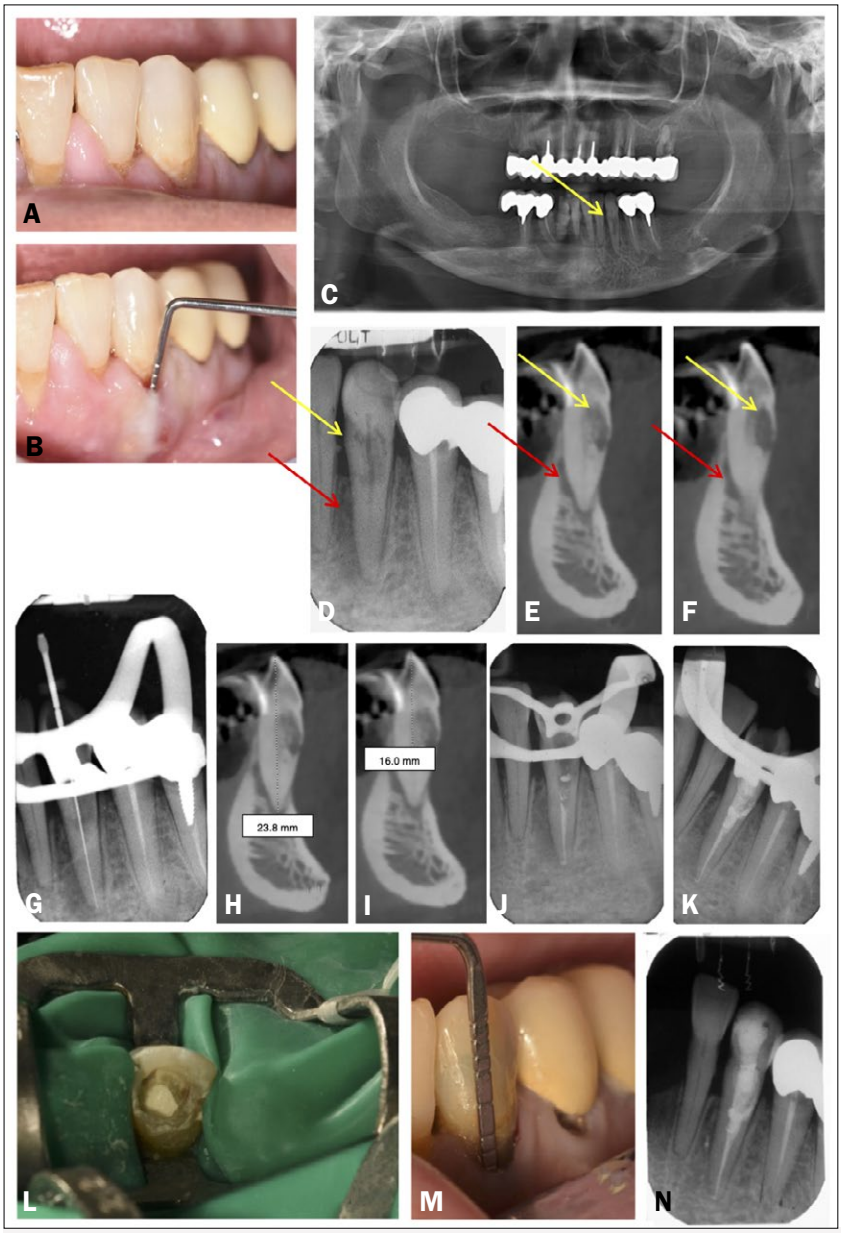

Figure 5 (video 4). ECR case 4. **A)** Preoperative aspect and **B)** probing of 3.3. **C)** Root of 3.3 showed a strange radiolucency in the orthopantomography (yellow arrow). **D)** Preoperative radiograph of a 1.2 highlighted an ECR (yellow arrow) and a bone lateral radiolucency along the mesial aspect of the root (red arrow). **E, F)** CBCT sagittal slices showed the exact extension of both the resorptive lesion in the coronal and, partially, middle third of the root (yellow arrows) and the periradicular lesion (red arrows). **G, H)** Radiographic working length was taken. **I)** Radiographic resorption level was recorded too. **J)** The apical third was filled with warm gutta-percha. **K)** The middle and coronal third were filled with MTA. **L)** Occlusal view before composite coronal restoration. **M)** One year probing and **N)** Two-dimensional X-ray.

py and the oncologist prescribed a previous dental control to prevent osteonecrosis of the jaws (ONJ). Our dental visit detected a very poor oral hygiene, a single metal-ceramic multiple-unit fixed dental prosthesis on the upper jaw and two conventional metal-ceramic bridges in the lower jaw. Some caries were evident apically to the metal-ceramic crowns and the loss of tooth-supporting structures around elements 4.2, 4.1 and 3.1 resulted in tooth mobility. There was a generalized loss of clinical attachment, mainly through recessions, with no periodontal pocket depths greater than 3 mm, except for the buccal aspect of element 3.3 (Figure 5A), where we recorded the value of 7.5 mm (Figure 5B) with an immediate suppuration on probing. The same element did not respond both to the vitality and percussion test. The patient did not report any symptoms here or elsewhere in the mouth; however, this data was relative as she was taking a high-dose morphine therapy because of her systemic condition.

The patient gave us her latest orthopantomography (Figure 5C) that showed some extremely decayed teeth behind the metal-ceramic crowns, a mandibular cyst behind the elements 4.3, 4.2 and 4.1 and 3.1 and a radiolucent area around the root of the element 3.3, as a sign of periodontitis. Besides tooth 3.3 had got a strange radiolucency also inside the root, just below the cervical area.

A periodontal radiography of 3.3 was immediately carried out using a paralleling technique (Figure 5D): it confirmed a mottled resorptive lesion into the coronal third of the root, and showed better the bone radiolucency, especially along the distal aspect of the tooth. According to this preliminary information, the lesion was classified as a class 3 of ECR, following Heithersay classification.

We supposed the occlusal trauma because of the metal-ceramic opposite prosthesis and the poor oral hygiene as ECR predisposing factors.

A CBCT scan (Figure 5E, F, video 4) was prescribed to assess the true nature, extension, and position of both the mandibular cist and the radiolucency inside 3.3. The slices confirmed the provisional diagnosis of ECR that had spread at the beginning of the middle third of the root and had reached the pulp; besides the bone radio-

lucency appeared to be in the lingual side above all. We used the new Patel classification: it was a 3Cp lesion. We investigated again the clinical aspects, and we initially proposed a direct external repair of the root: we would have begun with an endodontic access without removing the previous distal third class restoration, put a temporary gutta-percha point into the root canal, opened a flap, directly removed the resorptive tissue and repaired with MTA or SuperEBA® Cement, closed the flap and concluded the canal therapy. We also explained that this therapy might have been performed together with 4.3, 4.2, 4.1 and 3.1 extraction and mandibular cyst removal. But the patient refused any unnecessary oral surgery, so we decided for an internal reparation. We opened the endodontic access and we performed a preliminary shaping at the radiographic working length (Figure 5G, H), as the electronic apex detector did not work correctly because of the periodontal tissues interference, as well as in case 2. We performed canal and resorption filling through a sandwich technique, the same proposed in order to deal with root perforation (38): we closed the apical third (the last 8 mm: working length of 24 mm minus resorption length of 16 mm) (Figure 5H, I) with warm gutta-percha (Figure 5J), then we used MTA up to the cervical area. The MapSystem (Simit Dental) was very useful. As more than 5 mm of MTA were necessary, we put the material partially in a first appointment and partially in a second one (Figure 5K, L), so that the material was able to become completely hard. We ultimate the therapy with a common composite coronal restoration. Subsequently we removed elements 4.3, 4.2, 4.1 and 3.1 because of their advanced mobility, the mandibular cyst and the other teeth with deep caries in the upper jaw. After two months the patient started the intravenous bisphosphonate and we planned almost monthly dental visits. The tooth has always been asymptomatic until today and the buccal periodontal probing depth (PPD) has become shorter: it was 5 mm two months later, 4.5 mm three months later, 1 mm seven month later and 0.5 mm one year later (Figure 5M). At the same time, the two-dimensional radiographic aspect became better and no bone lesions could be seen at 1 year recall (Figure 5N).

#Case 5

The fifth case was detected in January 2019.

The patient, a 40-years-old male, with good oral health, presented in urgency with the chief complaint of intermittent spontaneous pain related to his lower left side. Any tooth showed directly detectable caries or abnormalities. We performed the cold test on every element and we find that element 3.6 suffered from pulpitis.

A periodontal radiography was carried out using a paralleling technique (Figure 6A): it revealed a radiolucent lesion with irregular and poorly defined borders in the cervical mesial aspect of tooth crown extending to the coronal third of the root. An ECR was diagnosed. According to this preliminary information, the resorption was classified as class 3 following Heithersay classification.

The patient general medical history was negative; any ECR predisposing factor could be detected. He highlighted that he did not experienced any symptoms before, until this late stage (11).

We immediately took a CBCT (Figure 6B-D), which confirmed that the resorptive lesion was mainly in the cervical mesial aspect of the teeth and that it had developed deeper and deeper into the dentin until it had reached the pulp chamber. We classified the lesion as a 3Cp stage according with Patel classification.

We reinvestigated the clinical aspects, we decided for the restorability of the element 3.6 and we proposed an endodontic treatment with internal repair.

In the same appointment, we saved a copy of the occlusal anatomy in order to perform a stamp technique (30, 31) for the following coronal restoration, so that it could be quick and precise; then we opened a conservative access cavity and we removed both the pulp tissue and the reparative tissue. We performed a classical canal therapy with warm gutta-per-

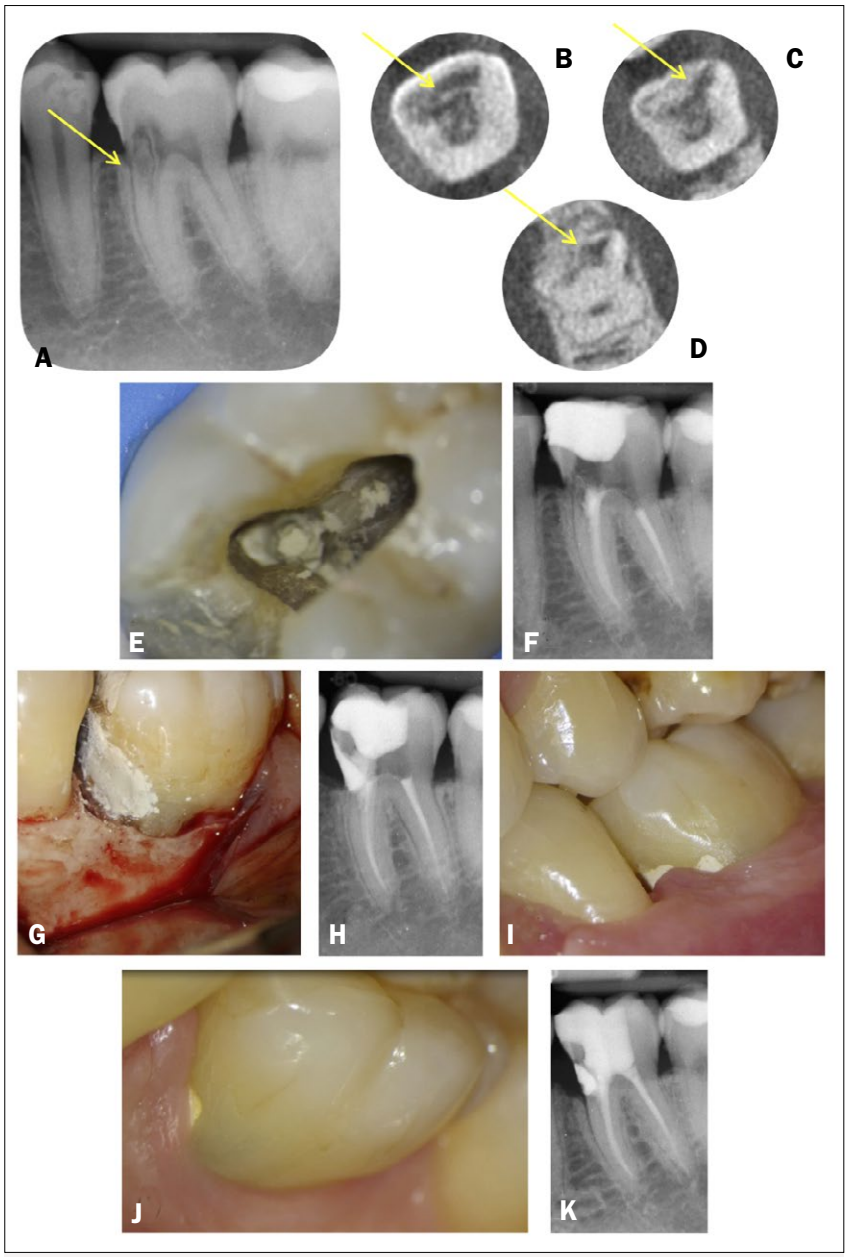

Figure 6 (video 5).
ECR case 5. **A)** Preoperative radiograph of a 3.6 showed ECR (yellow arrow) on the mesial aspect of the tooth. **B, C, D)** Axial CBCT slices let know the real extension of ECR (yellow arrows) that reached the endodontic system. **E, F)** Internal filling of the lesion with MTA. **G, H)** External filling of the lesion with SuperEBA® Cement. **I)** One week clinical control. **J)** Ten moths clinical and **K)** radiographic control.

cha, except for the lesion, which we tried to fill with MTA (Figure 6E), but we did not achieve the whole defect reparation. Therefore we put a moistened micro-brush head in order to allow MTA hardening and a temporary coronal restoration, we took an X-ray in order to understand how much material was located and exactly where (Figure 6F), and we planned also an external approach. In the following appointment we opened a flap, we located SuperEBA® Cement in the defect (Figure 6G) and closed the flap again. An X-ray confirmed that now the defect was completely filled (Figure 6H). We put the rubber dam and completed the case with direct composite restoration, using the stamp technique. 1 week later soft tissues were very good (Figure 6I). A 10 months recall showed a good clinical (Figure 6J) and radiographic healing (Figure 6K): especially, we noticed that interdental papilla was grown; only a small defect was produced on the mesial aspect of the SuperEBA® Cement filling because of an error during the professional oral hygiene. The patient has been asymptomatic until today.
All the steps until the last control are better reported in video 5.

#Case 6
The sixth ECR case was found in July 2019.
The patient, a 21-years-old female, presented in urgency complaining about a spontaneous pain in her left lower side. She had also noticed a small localized swelling between teeth in her lower jaw. At the clinical control, the patient was caries free and had never had a restoration before. All the teeth were pulp tested using refrigerant spray and electrical pulp test, and all responded within normal limits. Teeth were not tender to percussion and gave a normal sound on percussion, except for element 3.6. On its mesial buccal aspect there was the soft tissue swelling the girl was complaining about. Periodontal probing was consistently 3 mm or less and without bleeding or suppuration on probing, but when the periodontal probe reached the mesial buccal site of 3.6 the value became 7 mm with suppuration. We diagnosed a periodontal abscess in a healthy mouth.
A periodontal radiography was carried out using a paralleling technique (Figure 7A): an irregular radiolucent area was discernible on the mesial aspect of 3.6 crown, especially in the cervical area. An ECR was diagnosed. According to this preliminary informa-

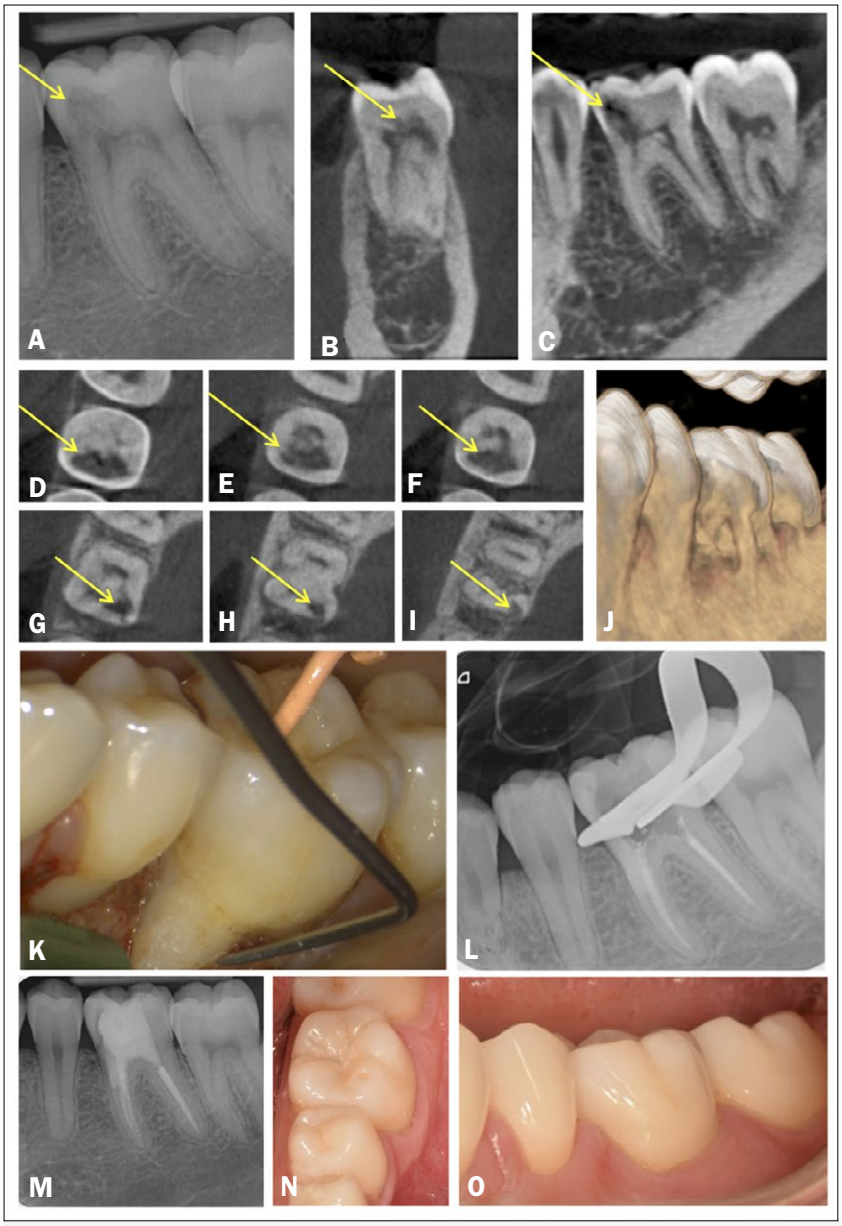

Figure 7 (video 6).
ECR case 6. **A)** Preoperative radiograph of a 3.6 showed ECR (yellow arrow) on the mesial aspect of the tooth. **B)** Frontal, **C)** sagittal and **D, E, F, G, H, I)** axial CBCT slices let know the real extension of ECR (yellow arrows) that reached the endodontic system.**J)** 3D rendering of the tooth. **K)** External repair of the defect with a bulk-fill composite. **L)** Intraoperative radiographic control. **M)** Postoperative radiographic control. **N, O)** Conservative restoration.

tion, the resorption was classified as class 2 following Heithersay classification.
The medical anamnesis was negative; the patient reported no history of trauma, orthodontic treatment or any other predisposing factor.
An antibiotic therapy was prescribed and a small FOV CBCT was planned. Seven days later, the abscess had reduced itself and the patient was asymptomatic, so we performed both the CBCT and the tooth treatment. Sagittal (Figure 7B), frontal (Figure 7C) and axial (Figure 7D-I) slices confirmed that the ECR coronal-apical extension had stopped just above the coronal third of the root, but it had developed mainly into the coronal dentine and it had reached the endodontic system, despite we had assessed the pulp vitality. The lesion is an 1Bp stage following Patel classification. The overall extension could be well understood with a 3D rendering image (Figure 7J), thanks to the volume rendering tool (39).
Considering the 3D rendering image, we performed a further clinical investigation and we proposed to the patient a root canal treatment, as the endodontic system was involved, combined with an external root repair in the same appointment.
We performed the first step of the stamp technique, saving the occlusal anatomy (30, 31). A conservative cavity access let us remove the pulp and carry out a preflaring. We temporary put a K-file into the buccal mesial canal in order to localize it also from an external view. We opened a surgical flap, we removed the reparative tissue with a bur, we put a gutta-percha point into the canal in order to maintain the patency during the subsequent excavation of ECR defect and we performed a composite resin restoration (19). A new generation bulk-fill composite (Beautifil-Bulk, Shofu) (Figure 7K) was chosen, as it has got a low polymerization shrinkage and let us reduce the time needed (36, 40). We underwent all the finishing and polishing steps under water: a starting diamond bur delivered a deeper and more aggressive cut; flexible abrasive points and coarse, medium, fine and super fine discs produced a smooth and glossy surface finish (37). Then we closed the flap, we put the rubber dam around the tooth and finished the endodontic treatment with warm gutta-percha (Figure 7L). We used the same bulk-fill composite for direct coronal reconstruction, except for a capping layer of conventional hybrid composite (40). 7 days later, a postoperative radi-

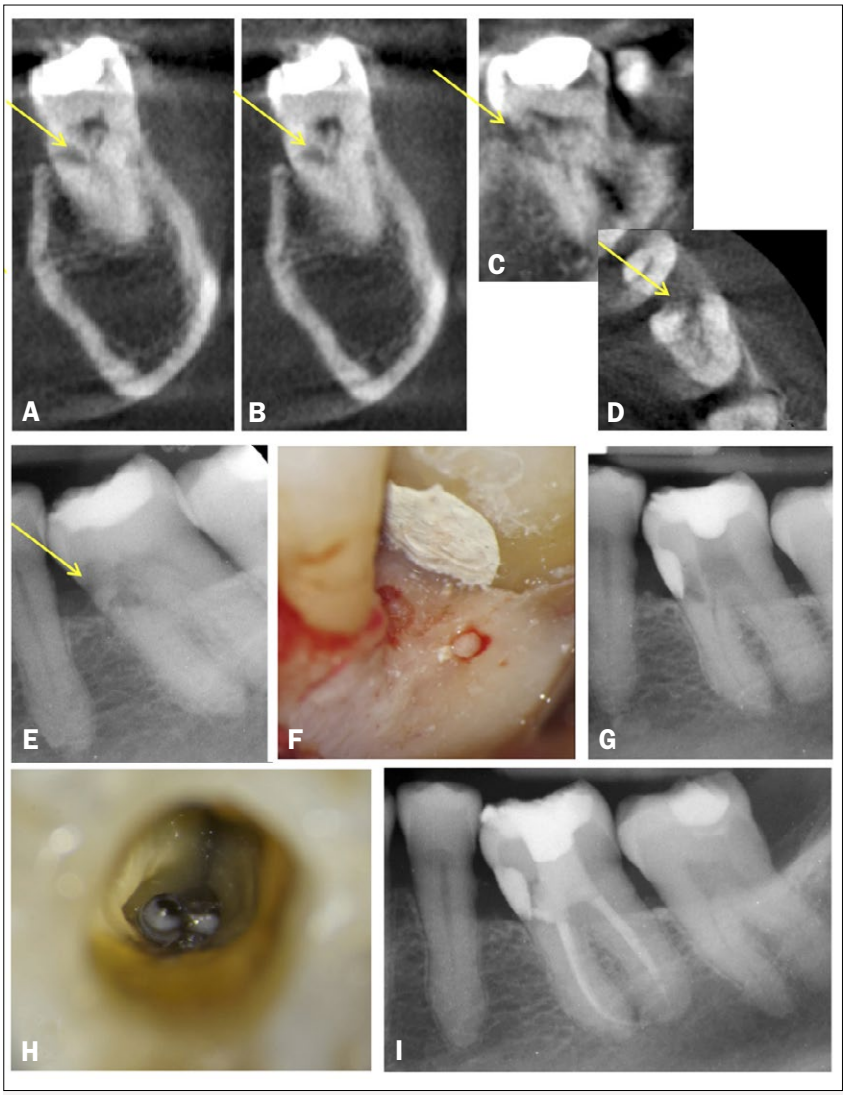

Figure 8 (video 7).
ECR case 7. **A, B)** Frontal, **C)** sagittal and **D)** axial CBCT slices let diagnose an ECR of 3.7 (yellow arrows). **E)** Two-dimensional X-ray radiograph of 3.7 showed the resorption (yellow arrow) on the mesial aspect of the tooth. **F)** External defect restoration using SuperEBA® Cement. **G)** Two-dimensional X-ray of external defect restoration. **H)** Internal defect restoration using MTA. **I)** Postoperative radiographic control.

ographic control was taken (Figure 7M), followed by a further polishing step of coronal restoration with abrasive polishing paste compounds, to reduce and smooth any roughness and surface scratch created by finishing instruments (Figure 7N, O). All the steps are shown in video 6. The patient has always been asymptomatic until today and the last mesial buccal periodontal probing depth is 3 mm, without bleeding and suppuration on probing.

#Case 7
The seventh case was detected in October 2019.
A 52-year-old male patient in good general health and no oral symptoms had undergone some extractions some years ago because of carious processes. He presented again requiring an implant treatment.
Therefore we performed a new clinical analysis of the mouth without notice any pathological signs and took a CBCT in order to plan a guided surgery: here a radiolucent area was noticed in element 3.7 (Figure 8A-D). It was clearly a 3Bp stage of ECR by Patel classification.
In this case we directly had a definitive diagnosis of ECR, referring to the diagram in Figure 1. A clinical reinvestigation with a periapical X-ray (Figure 8E) followed. A normal response to both cold and percussion test was tested on element 3.7. The endodontic diagnosis was normal pulp and normal periapex. The tooth was mesially inclined as 3.6 was lost in youth and never replaced: the 3.6 extraction might have worked as predisposing factor. We proposed external debridement and restoration because of a direct mesial accessibility.
In the following appointment, a flap was opened and the bulk of reparative tissue was removed with a bur, exposing the pulp tissue, and replaced with SuperEBA® Cement (Figure 8F, G). As the initial debridement caused the pulp exposure, an orthograde endodontic treatment was initiated: we removed the pulp and put a temporary restoration with metacresylacetate. Subsequently, we performed also an internal reparation with MTA (Figure 8H), a classical canal therapy with warm gutta-percha and a composite restoration with a stamp technique (30, 31) (Figure 8I). All the main steps of clinical management are shown in video 7. Controls were planned and the patient has been asymptomatic until today.

Discussion

ECR is a relatively uncommon form of external tooth resorption, often undiagnosed or misdiagnosed (4, 5). It invades the tooth from the PDL, apical to the epithelial attach-

ment, and develops through both resorptive and reparative stages (3, 6).
Aetiology is still rather unclear: orthodontic treatment, iatrogenic or accidental dental trauma and poor oral health have been the most frequent predisposing factors detected until today and ECR itself has been proposed to be mainly multifactorial (7).
The lesion could be asymptomatic until later stages, therefore an early diagnosis is difficult and the process is often accidentally found with a radiographic control, where it appears as a barely up to a highly discernable radiolucency (11).
Heithersay developed the first classification system that divides the condition into 4 classes according to the extent of the lesion in periapical X-rays (12). But the true nature and real extension of an ECR defect cannot be assessed on conventional radiographs: a three-dimensional analysis is mandatory. CBCT scans clarify the exact location of the entry point of granulation tissue into the root, the dimension of the resorption and the presence of dentin surrounding the resorption tissue. Besides, it can diagnose also starting lesions undetectable with periapical X-rays (16, 17). Nowadays a three-dimensional classification by Patel is available: it considers height (coronal-apical extent) of the lesion, its circumferential spread and proximity to the root canal and it is easily applicable (18).
Different management approaches have been proposed too, also linked with the three-dimensional classification (19).
However, a common standardized workflow has not been published yet. Therefore we tried to developed it and test its clinical applicability: it start from a preliminary ECR diagnosis, but then a small FOV CBCT is mandatory to confirm it, to study the real extension of the lesion and to choose, with a clinical reinvestigation, the more appropriate treatment planning. When the restorability is assessed, external and internal repair are the most recommended clinical management options.
We used our protocol in 7 consecutive ECR cases (Table 1). Only in case 7 the ECR lesion was directly diagnosed on CBCT imaging, nevertheless the workflow has been applicable from that step: it has proven to be flexible.
Six of the seven cases of ECR were detected in the post-lateral lower jaw and only in case 3 an anterior element was affected, in contrast with previous findings (8). Both male and female patients presented to our attention: ECR does not seem to be linked to the sex of the patient, as already established (7). These patients were of different ages, even young people: case 3 was diagnosed in a 12-years-old female; which agrees with the new literature data (7). Predisposing factors have not always been found; when verified they were: a previous (case 2) or contextual (case 3) orthodontic treatment, occlusal trauma and poor oral health (case 4) or a previous surgery in the same oral area - extraction of a neighboring tooth - (case 7) (7). 3 cases were symptomatic on a late stage (case 2, 5, 6): as a matter of fact, these patients were seen in urgency; whereas the other 4 ECR (case 1, 3, 4, 7) were casually found (11).
Everyone accepted a CBCT study which turned out to be useful especially for pulp involvement investigation and management choice (19): fortunately, in all cases the elements were maintainable with an external or internal repair, associated with an endodontic treatment except for case 3, where an external approach associated with a pulp capping was mandatory, especially considering the age of the patient (35). Three main rules were followed: we tried to remove reparative tissue, as its incomplete removal is likely to result in the recurrence of ECR (19), we apply the most conservative approach for each case and we perform the management within one or two appointments. Stamp technique succeed in maintaining most of the coronal tissue and allowing a fast and anatomically precise restoration (case 1, 5, 6, 7) (30, 31). Different materials, such as MTA (case 1, 4, 5, 7), SuperEBA® Cement (case 2, 5, 7) and composite (case 3, 7), were already proposed for clinical ECR management because of their sealing ability and biocompatibility (19) and turned out to be useful in our clinical practice. In cases 5 and 7, a combination of techniques and of materials

Table 1

Overview of the 7 ECR clinical cases

CASE	TOOTH	PATIENT SEX	PATIENT AGE (years old)	PREDISPOSING FACTOR(S)	MANAGEMENT	HEALING	FIGURE	VIDEO
1	3.7	male	17	not revealed	Internal repair with MTA + root canal therapy	yes	2	1
2	3.3	female	17	previous orthodontic treatment	External repair with SuperEBA® Cement + root canal therapy	yes	3	2
3	1.2	female	12	contemporary orthodontic treatment	External repair with resin composite + pulp capping	yes	4	3
4	3.3	female	52	occlusal trauma and poor oral health	Internal repair with MTA + root canal therapy (sandwich technique)	yes	5	4
5	3.6	male	40	not revealed	Internal repair with MTA + external repair with SuperEBA® Cement + root canal therapy	yes	6	5
6	3.6	female	21	not revealed	External repair with bulk-fill composite + root canal therapy	yes	7	6
7	3.7	male	52	previous surgery in the same oral area: extraction of element 3.6	External repair with SuperEBA® Cement + internal repair with MTA + root canal therapy	yes	8	7

was even used, in order to fill the irregular form of the lesions.
All patients were extremely motivated to follow-up visits, with both clinical and radiographic checks in order to evaluate the treatment over time: it is an extremely important aspect. The main outcome is the survival of the element, the secondary outcomes are the absence of resorption progression, no symptoms and a healthy periodontal depth. All the seven cases described have reached both the primary and secondary outcomes until today, however their follow-up must continue.

Additional supporting information: Video Legends

Video 1. ECR case 1 – element 3.7. The main steps of the treatment under operating microscope are here reported: reparative tissue removal, MTA location, irrigation, root canal filling.
Video 2. ECR case 2 – element 3.3. The consecutive axial CBCT slices are compiled as a video.
Video 3. ECR case 3 – element 1.2. 1 year recall probing: a light bleeding on probing matched with healthy periodontal probing values.
Video 4. ECR case 4 – element 3.3. The consecutive sagittal CBCT slices are compiled as a video.
Video 5. ECR case 5 – element 3.6. The main steps of the treatment under operating microscope are here reported: access cavity, pulp removal, reparative tissue removal, irrigation, root canal filling with gutta-percha, internal MTA location, external SuperEBA® cement location, 10 months recall.
Video 6. ECR case 6 – element 3.6. The

main steps of the treatment under operating microscope are here reported: occlusal anatomy stamp, access cavity, pulp removal, preliminary shaping, surgical flap, reparative tissue removal, external defect repair with a bulk-fill composite, root canal treatment, adhesive restoration.
Video 7. ECR case 7 – element 3.7. The main steps of the treatment under operating microscope are here reported: reparative tissue removal, external SuperEBA® cement location and linked X-ray, internal MTA location, root canal therapy, adhesive restoration.

Conclusions

A correct and predictable management of ECR needs a standardized workflow (including a CBCT study), a quick and definitive conservative approach and a follow-up overtime. This case series has succeeded in applying the rules above for the treatment of 7 external cervical root resorptions. However, both long-term follow-up visits and other clinical cases are necessary to confirm the real usefulness of the method.

Clinical Relevance

The workflow above can help clinicians to have a correct diagnosis of ECR cases but also in the decision making process regarding their treatment plan.

Conflict of Interest

The authors deny any conflict of interest.

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