Understanding External Cervical Resorption in Vital Teeth

Athina M. Mavridou, DDS, MSc,[*†] *Esther Hauben, MD, PhD,*[‡] *Martine Wevers, PhD,*[§] *Evert Schepers, DDS, PhD,*[*] *Lars Bergmans, DDS, MSc, PhD,*[*] *and Paul Lambrechts, DDS, PhD*[*]

Abstract

Introduction: The aim of this study was to investigate the 3-dimensional (3D) structure and the cellular and tissue characteristics of external cervical resorption (ECR) in vital teeth and to understand the phenomenon of ECR by combining histomorphological and radiographic findings. **Methods:** Twenty-seven cases of vital permanent teeth displaying ECR were investigated. ECR diagnosis was based on clinical and radiographic examination with cone-beam computed tomographic imaging. The extracted teeth were further analyzed by using nanofocus computed tomographic imaging, hard tissue histology, and scanning electron microscopy. **Results:** All examined teeth showed some common characteristics. Based on the clinical and experimental findings, a 3-stage mechanism of ECR was proposed. At the first stage (ie, the initiation stage), ECR was initiated at the cementum below the gingival epithelial attachment. At the second stage (ie, the resorption stage), the resorption invaded the tooth structure 3-dimensionally toward the pulp space. However, it did not penetrate the pulp space because of the presence of a pericanalar resorption-resistant sheet. This layer was observed to consist of predentin, dentin, and occasionally reparative mineralized (bonelike) tissue, having a fluctuating thickness averaging 210 μm. At the last advanced stage (ie, the repair stage), repair took place by an ingrowth and apposition of bonelike tissue into the resorption cavity. During the reparative stage, repair and remodeling phenomena evolve simultaneously, whereas both resorption and reparative stages progress in parallel at different areas of the tooth. **Conclusions:** ECR is a dynamic and complex condition that involves periodontal and endodontic tissues. Using clinical, histologic, radiographic, and scanning microscopic analysis, a better understanding of the evolution of ECR is possible. Based on the experimental findings, a 3-stage mechanism for the initiation and growth of ECR is proposed. *(J Endod 2016;■:1–15)*

Key Words

Cone-beam computed tomography, external cervical resorption, hypoxia, nanofocus computed tomography, reparative mineralized tissue

Significance

This work helps in exploring the evolving phenomena of ECR in vital teeth. By understanding the 3D nature and repair mechanisms, which are underestimated because of radiographic limitations and lack of know-how, a more adequate treatment decision will be achieved.

External cervical resorption (ECR) has attracted the interest of endodontists and dental clinicians because of its complex and invasive pattern (1, 2). This interest is confirmed by the amount of recently published articles in this field (3, 4). However, the majority of this research work focuses only on individual ECR case reports. Indeed, to date, only a few have attempted to thoroughly analyze the phenomena that occur during ECR (5–13). The first fundamental work was performed by Heithersay in which an extended report on ECR was introduced based on the combination of clinical, radiographic, epidemiological, and histopathological findings (6–10). This researcher observed that there are various degrees of ECR progression, indicating that this condition evolves in different stages. It should be mentioned that, in current clinical practice, the treatment and prognosis of ECR are still based on the classification proposed by Heithersay (14, 15). However, this classification has 2 main limitations:

1. This approach is only based on the 2-dimensional extent of the resorption. Indeed, the implementation of more recent *in vivo* and *ex vivo* techniques such as cone-beam computed tomographic scanning and nano–computed tomographic (CT) imaging, respectively, has provided new information on the 3-dimensional (3D) nature of this condition (16–18).
2. Heithersay's classification does not take into consideration the reparative nature of ECR. Recent reports revealed that ECR could be both destructive and reparative (16, 18).

The phenomena that occur during ECR are very complex (1). For example, during the initiation phase, the nature and structure of the portal(s) of entry (starting point of the resorption) can influence the progression of ECR (18). Furthermore, the pattern and types of cells involved during ECR progression and repair are still unclear (1). In addition, it is believed that the pulp tissue is not involved in ECR (1) and that resorption does not penetrate the pulp because of the presence of a resistant

From the *Department of Oral Health Sciences, BIOMAT Research Cluster, KU Leuven and University Hospitals Leuven, Leuven, Belgium; †Private Practice, Endo Rotterdam, Rotterdam, The Netherlands; ‡Department of Imaging and Pathology, KU Leuven and University Hospitals Leuven, Leuven, Belgium; and §Department of Materials Engineering (MTM), KU Leuven, Leuven, Belgium.

Address requests for reprints to Dr Athina-Maria Mavridou, Department of Oral Health Sciences, BIOMAT Research Cluster, Kapucijnenvoer 33, 3000 Leuven, Belgium. E-mail address: athimavridou@gmail.com
0099-2399/$ - see front matter

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mineralized pericanalar layer (18). The importance of this layer, which is referred to as the pericanalar resorption-resistant sheet (PRRS) (18), and its relationship to the pulp tissue and ECR evolution should be investigated.

Therefore, this study aimed to provide a thorough overview on the initiation, progression, and especially the repair phase of ECR. In order to get a better understanding on the evolving mechanisms, the recently established multimodular approach proposed by Mavridou et al (18) was applied on 27 individual ECR clinical cases. This methodology combines clinical and epidemiological findings, *in vivo* CBCT imaging, *ex vivo* 3D nanofocus CT imaging, scanning electron microscopic analysis, and histologic analysis.

In this way, a consistent approach is applied in order to bridge the existing know-how and proposed theories of ECR. Indeed, most of the published work only presents individual and autonomous case studies, which makes it very difficult for clinicians to combine this information and draw conclusions on how to interpret and manage this complex condition (14, 19–21).

Materials and Methods

In this study, 27 patients who were referred to the University Hospital Leuven, Leuven, Belgium, for advice and possible treatment of teeth with evidence of ECR were included. The diagnosis of ECR was based on clinical and radiographic (digital periapical and CBCT imaging) examination. All ECR cases involved vital teeth as confirmed by the initial diagnosis. The analysis of ECR case was done in 2 steps: clinical examination and *ex vivo* analysis.

Clinical Examination

The patients were clinically examined by means of an optical microscope (Zeiss, Oberkochen, Germany). The aim was to observe the existence of tooth discoloration and cracks; examine the periodontal health and more specifically the existence of calculus and plaque and measure the pockets' depth; evaluate the probing feasibility of the ECR cavity and bleeding during probing; notice if there was any evident resorption of the tooth structure; and try to identify if the resorption cavity contained granulation tissue.

Apart from the clinical examination, an interview was conducted based on our clinical and research experience (17, 18, 2–24) and existing literature (1–3, 8, 25–31). The collected information was linked to the dental and medical history of the patient, which was provided by the referring dentists in an attempt to indirectly identify some potential predisposing factor(s) involved in ECR.

Ex Vivo Analysis

After clinical examination, a prescreening of selected case studies was made with the use of a CBCT scanner (3D Accuitomo 80; J Morita, Kyoto, Japan) in order to confirm the diagnosis, evaluate the extent of the resorption, and judge treatability (32–34). The exposure parameter settings were set at 90 kV, 5.0 mA, and 17.5 seconds. The resolution parameters included a field of view of 6 × 6, and the images were reconstructed with a slice interval of 0.125 mm and a slice thickness of 0.500 mm (17, 18). Based on the outcome of the CBCT analysis, the long-term prognosis of the examined cases was determined as poor, and, thus, extraction was indicated.

After extraction, the extracted teeth were fixed in a $CaCO_3$-buffered formalin solution as described by Duyck et al (35). Based on the experimental approach (multimodular approach) proposed by Mavridou et al (18), nano-CT imaging, hard tissue histology, and scanning electron microscopic (SEM) microscopic analysis were

TABLE 1. An Overview of the Techniques Used per Case

	ECR cases																										
Used techniques	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Clinical examination	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Digital x-ray	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
CBCT imaging	×	×	×	×	×	×	×	×	×	×			×	×	×	×	×		×	×	×	×	×	×	×	×	×
Nano-CT imaging			×	×	×	×	×	×	×	×	×	×	×	×	×	×	×		×	×	×	×	×	×			×
Histology	×	×	×	×	×	×							×						×			×					
SEM																	×	×							×	×	

CBCT, cone-beam computed tomographic; ECR, external cervical resorption; nano-CT, nano–computed tomographic; SEM, scanning electron microscopy.