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PERIAPICAL RESORPTIVE PROCESSES IN CHRONIC APICAL PERIODONTITIS: AN OVERVIEW AND DISCUSSION OF THE LITERATURE

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ABSTRACT

Introduction: Root resorption is a biological phenomenon, characterized by processes of cement and/or dentine depletion, resulting from the physiological or pathological activity of resorptive cells.

Purpose: The aim of this article is to review of the literature on the peculiarities of the periapical resorptive processes.

Conclusion: The absence of a physiological narrowing is challenging to the achievement of satisfactory early and late therapeutic results. It makes probable either the overpressing of necrotic, infected material when preparing the endodontic space or the overpressing of the sealer when sealing the root canal.

Key words: chronic apical periodontitis, external apical resorption, periapical resorption,

INTRODUCTION

Chronic apical periodontitis (CAP) is characterized by changes in the adjacent bone structure and periodontal ligament, as well as the cement and dentine. In a large percentage of the cases with CAP, the anatomically separated physiological narrowing is ether absent or expanded. On examinations of the apical zone, intra-and extraforaminal resorption has been found that is associated with inflammatory processes. A rarer clinical finding is the inflammatory internal root resorption with CAP, resulting from a trauma to the tooth [1].

The first report of dental tissue resorption, published in 1530, was made by Michael Blum and this is probably the first scientific report on this process, insufficiently studied even to the present [2].

Root resorption is a biological phenomenon, characterized by processes of cement and/or dentine depletion, resulting from the physiological or pathological activity of resorptive cells, called dentoclasts (a subclass of the osteoclasts) [3, 4]. Studies have suggested that the permanent dentition is protected against physiological resorptive processes, but pathological resorption has been found in cases of trauma, orthodontic treatment, expansion of tumor or cystic formations, or has been largely the result of inflammatory processes in the pulp tissue, etc. [5]. In internal root resorption, normal or necrotic pulp tissue, transformed into granulation tissue with giant multinuclear cells resorbing the dentinal wall in the absence of the odontoblast layer and predentine, has been histologically demonstrated [6, 7].

Nature of apical resorption processes

In the process of resorption, two stages, the traumatic and the stimulating stage, are primarily distinguished. In the first stage of resorption, non-mineralized structures on the outer surface of the tooth (precement) and on the inner surface of the root canal (predentine) are affected [8]. The exposed structures are colonized by multinuclear cells involved in the process of resorption. In the absence of activation of these resorptive cells, the process of resorption discontinues spontaneously [8]. In the presence of activation of these resorptive cells, the process of resorption enters in its second stage. For example, in the presence of infected dentinal canals and upon the development of inflammation, stimulation of osteoclast activity in the pulp or periradicular tissues occurs, initiating an internal and/or external resorption. Discontinuation of internal resorption is likely to occur upon removal of the pulp and granulation tissue, as well as interference with the blood supply to these tissues, necessary for the development of resorbing cells. An already existing external apical root resorption can be managed through canal dressing with calcium hydroxide ($Ca(OH)_2$) [1, 9, 10, 11]. The key stages of CAP treatment include an assessment of the apical zone, decontamination and subsequent sealing.

3-Dimensional apical sealing in teeth with apical resorption

One of the main principles of endodontic science is the 3-dimensional root canal filling, with a focus on filling the apical third of the root. Obturation becomes a more predictable stage, when the walls of the root canal form a physiological narrowing apically, suggesting the preparation of an apical stop that facilitates the proper application of the chosen filling method (paste and gutta-percha) – a central cone technique, hot and cold condensation or injection methods [Gutman JL, 1981; Leonardo ML, 1993; Maroto, 2003; Webber, 1984].

The absence of a physiological narrowing is challenging to the achievement of satisfactory early and late therapeutic results. It makes probable either the overpressing of necrotic, infected material when preparing the endodontic space or the overpressing of the sealer when sealing the root canal.

The apical level of root canal preparation and the border of obturation are still discussed in the literature of later decades. Sealers for sealing the root canal space in cases with advanced resorption are also examined thoroughly. In the most favorable cases with vital extirpation, the healing process that occurs in the apical zone is related with mineralization in the apical zone, after isolation of the root canal space from the periapical space with a suitable sealer and gutta-percha [12, 13]. Clinical studies have shown that the observance of aseptic preparation of the endodontic space and the availability of a distance from the apical pulp tissue stimulate the natural healing process. If an appropriate sealer is chosen, the healing occurs with the formation of cement-like tissue [1, 14].

Instrumentation in the apical zone

An important moment in the instrumentation of teeth with CAP is the patency of the apical zone. This parameter is measured by the diameter of the last instrument that can passively pass through the narrowing, and is called "working width"; together with the working length, it provides information on the three-dimensional characteristics of the apical zone. The determination of the working width to a specific number of 0.02 taper instruments is accepted as a conditional parameter of the narrowing. Since in majority of the cases this narrowing is irregular in shape, the working width provides information on the small diameter of the irregular oval shape of this type of apical constriction. In endodontics, this term was introduced by Dr. Jou from the University of Pennsylvania [15]. In his article, S. Senia cites Carl Hawris, who calls the working width "*the forgotten dimension*" [16].

In the radiographic assessment of the apical level of the root canal filling, the level of 0-2 mm coronary is accepted as the norm, which, according to the literature data, is associated with 94% success of the treatment [17, 18]. The success rate decreases to 68% at a level of canal obturation of more than 2 mm coronary, while upon overpressing, in 76% of the cases a delayed healing process occurs [19, 20].

The infected pulp tissue due to the presence of MO in the apical zone is challenging in the clinical practice [21, 22, 23]. Therefore, the determination of the correct working length is of essential importance. In the case of an intact apical foramen and an available intact physiological narrowing, there are no difficulties for the localization and preparation of an apical stop [24, 25], but in the case of an existing apical periodontitis and resorption, there are diverse variations, since the apical foramen is open.

Selection of an operative technique

The selection of an operative technique is a subject to biological and mechanical parameters that are critically analyzed when choosing the approach to individualize each clinical case. A known fact, based on numerous *in vitro* studies, is the problem of RC transporting, cleavage in the apical third, *via falsa*, steps and perforations. In a large percentage of the cases with orthograde endodontic treatment of teeth with CAP, the clinical protocol is complicated by the presence of radicular pins, old fillings, broken canal instruments and already existing RC transportation, resultant from the primary treatment, cleavage in the apical third, via falsa, steps and perforations. The instruments with an active cutting edge lead to more frequent cleavages and perforations than those with a non-cutting edge [26]. The direction of apical transportation affects the outer wall versus the root canal curvature by 0.01 to 0.15 mm [27, 28], which creates difficulties in sealing and increases the extent of leakage and percolation in this zone. The clinical philosophy outlining that the smallest possible apical file should be used for preparation of the apical stop, as opposed to the ideology on the last apical file, suitable to the apical narrowing and the degree of infection, ignores the existing scientific literature and is based entirely on the clinical experience [29]. The two main conceptions on the preparation of the apical third are "the apical seat" and "the apical stop". According to the first conception, the instrument works actively to the radiographic apex. The adjustment of a gutta-percha point is 1 mm coronary. The problem with this technique is the absence of an apical limit. Goldberg and Massone (2002) conducted *in vitro* study on the problem of apical transportation [30]. In 33.3% of the cases, they found the onset of transportation when using hand files (steel or nickel-titanium) of ISO #10 - 30, to maintain the apical purity. The analysis of these data has shown that # 25 cannot be used safely in this zone without leading to a lack of apical limit. Because of this fact, a typical radiographic finding in RCs, instrumented on the basis of this conception, is the over-pressed sealer in the periapical zone [31].

Nature of the periapical resorptive processes

There are biological mediators that are involved in the initiation and progression of the apical resorption in CAP. Matrix metal proteinases (MMPs), which are endogenous Zn-dependent catabolic enzymes, are responsible for the degradation of collagen and proteoglycans. Their influence and importance to the pathogenesis of CAP are thoroughly studied and clearly defined. Furthermore, the concentration of IgG antibodies has been shown to be almost five times higher for the diseases of the periapical zone than in the non-inflamed oral mucosa. Cytokines IL-1á, IL-1â, TNF-á, prostaglandins, mainly PGE2 and PGI2, and endotoxins are key mediators of the inflammatory process, and also enhance the resorptive processes in the radicular hard dental tissues. Neutrophils are the major source of PGE2 and are present in the initial stage of CAP [32].

The changes in the secretion of IL-4 and IL-10 are of particular importance for the development of CAP and the processes of healing, occurred as a result of the treatment applied. These interleukins are major inhibitory cytokines that influence the proinflammatory mediators. In a performed study it was found that the treatment leads to an increase in the average level of stimulated production of IL-4 and IL-10.

B. Andonovska et al. (2008) has concluded from the obtained results that MMPs -1, -8, -13 also actively participate in the destruction of tissues and the formation of granulation tissue in CAP [33]. This opens new opportunities for the diagnosis and monitoring of the inflammatory conditions, based on the destructive role of collagenases (MMP -1, -8, -13) in the inflammatory process, which are directly dependent on their concentrations in the pathologically changed tissues [33]. The hypothesis of immunological processes in the dentine is supported by the activation of autoimmune reactions that are directed to the dentine and potentiate the action of odontoclasts, the primary cell type, and characteristic for the resorptive processes. These cells belong to the line of macrophages - phagocytic cells derived from the monocytes, which play a key role in the immune response. It is well-studied and demonstrated that calcitonin directly inhibits the osteoclast activity and suppresses the inflammatory process [34, 35]. The inhibition of osteoclast activity is beneficial for the proliferation of periodontal and cements cells and facilitates the regeneration of the periodontium. Most probably, future results and achievements in the rapidly developing immunological field will clarify some still obscure problems in the endodontic practice.

Diagnosis of resorptive processes in the endodontium and on the outer root surface is the result of an in-depth analysis of the diagnostic imaging methods. In certain clinical cases, the differential diagnosis cannot be made on the basis of conventional imaging, which is two-dimensional (2-D), regardless of the technique used. The superimposition of some anatomical structures and mineralized tissues requires the use of modern non-invasive diagnostic techniques, such as the conical beam computed tomography (CBCT) capable of reproducing three-dimensional (3-D) images [5], thus raising the rate of diagnosed pathological changes in the hard dental tissues and in the bone structure.

Despite the development of technology, an accurate initial diagnosis of the changes in the periapical tissues can still only be done *ex vivo*. In the diagnosis of peripheral radiographic signs, we could make an assumption about the extent of the resorptive process. Based on a study of 104 apices, Vier and Figueiredo observed resorption around the apical foramen in 87.3% and resorption of the foramen in 83.2% of the cases, and found no correlation between the external apical resorption and the type of periapical lesion [36].

Calcium hydroxide in teeth with apical resorption

Calcium hydroxide has influence on the detoxification (inactivation) of the endotoxin in the root canal system and impairs the ability of lipopolysaccharides (LPs) to stimulate the production of antibodies by the B-lymphocytes. Sodium hypochlorite and chlorhexidine do not have the ability to detoxify the endotoxin [37]. Teeth, where calcium hydroxide has been used as a medicated dressing, show a low level of bacterial contamination, a low level of MMP expression, a more organized extracellular matrix in the periapical zone, compared to the teeth that have been treated in one visit [38, 39]. This suggests that calcium hydroxide is of importance for the regenerative processes in the tissues [40, 41, 42]. The long-acting medicinal dressing of $Ca(OH)_2$ can lead to microcracks or radicular fracture [43, 44]. To avoid these complications, recent studies have shown that the time of intracanal dressing with $Ca(OH)_2$ paste should be reduced to a single application, lasting 7 to maximum 30 days [45, 46, 47].

CONCLUSION

The prognosis in the process of healing after performed endodontic treatment is closely related to the degree of the resorption process, the extent of the apical lesion and the possibility of biological sealing of the apical zone. As a consequence of microbial contamination or a trauma in the apical zone, a process of demineralization and destruction of the periapical structures initiates. The healing process in CAP is a result of the decontamination of the endodontic and periapical space, and the creation of conditions for three-dimensional obturation of the root canal system, which is a key step in the cases of a lacking anatomical-physiological narrowing.

The absence of a physiological narrowing is challenging to the achievement of satisfactory early and late therapeutic results. It makes probable either the overpressing of necrotic, infected material when preparing the endodontic space or the overpressing of the sealer when sealing the root canal.

Calcium hydroxide is one of the most effective medications for the treatment of external resorption due to the high concentration of Ca^{2+} and high alkaline pH [15, 48]. The specific mechanism of action of calcium hydroxide is still discussed. Seltzer and Bender stress the importance of the available Ca^{2+} for the activation of adenosine triphosphatase, which induces the remineralization potential of dental tissues [24].

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