MANAGEMENT OF THE YOUNG PERMANENT TEETH WITH PULP DISEASES – A THERAPEUTIC GUIDE OF TEETH WITH OPEN APEX

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Abstract: *The treatment of the young permanent teeth with pulp diseases or necrosis is still a therapeutic challenge for any specialist. During the last 10-15 years, the specific therapeutic methods for immature teeth have evolved from conventional endodontic techniques to new concepts for regenerative endodontic treatment belonging to tissue engineering field. Knowledge and choosing the most effective therapeutic methods depends largely on determining the degree of pulp injury and the stage of root development. This article presents a systematic review of young permanent teeth features and the most used therapeutic methods and specific materials for immature teeth which are based on two different approaches respectively, apexogenesis (maturogenesis) and apexification. A big challenge was launched by a new concept regarding immature teeth clinically diagnosed with necrosis and apical periodontitis which are able to initiate, even under these conditions, apexogenesis process that will generate a normal thickness of dentine walls and an adequate root length.*

Cuvinte cheie: *dinți imaturi, maturogeneza, MTA, apexificare, revascularizatie*

Rezumat: *Tratamentul dinților permanenți tineri cu afecțiuni pulpare inflamatorii sau necroză reprezintă încă o provocare terapeutică pentru orice medic pedodont.De-a lungul ultimilor 10-15 ani, metodele terapeutice specifice dinților imaturi au evoluat de la tehnicile endodontice convenționale până la concepte noi de tratament endodontic regenerativ având la bază ingineria tisulară.Cunoaşterea şi alegerea celei mai eficiente metode terapeutice depinde în mare măsură de stabilirea gradului de afectare pulpară şi de stadiul de dezvoltare radiculară. Acest articol reprezintă o revizuire sistematică a celor mai utilizate metode terapeutice şi materiale specifice dinților imaturi care au la bază două modalități de abordare diferite respectiv, apexogeneza (maturogeneza) şi apexificarea. O nouă provocare a fost lansată odată cu apariția unui nou concept terapeutic privitor la dinții imaturi cu necroză pulpară şi complicații periapicale care sunt capabili să inițieze, chiar în aceste condiții, apexogeneza prin care va rezulta o grosime normală a pereților dentinari şi o lungime corespunzătoare a rădăcinii.*

INTRODUCTION

Pulp diseases of permanent teeth during growth have some specific particularities depending on the degree of root development and the structural features of young pulp.These influence both the evolution of inflammatory process and therapeutic response.Conditions that immature teeth offers do not allow a classic endodontic treatment but favorable biological features offered by the apical area of this teeth enable further development of root even in conditions that treatment resumes to a complete desinfection of the canal root using a mixture of antibiotics paste without applying other biostimulative endodontic materials [1]. Young pulp tissue is provided with opportunities to recover more than adult tissue and healing is possible in many symptomatic clinical forms.

Basic therapeutic principles of the teeth with wide open apex involves performing a three dimensional mechanical and antiseptic correctly treatment, without apical region trauma [2], followed by application of specific endodontic materials depending on the selected method.

Particular aspects of immature teeth

Causes of open apex

1. Immature teeth caught in one of the five stages of root development (after Cvek) by an acute or chronic inflammatory process.
2. Incomplete development when the pulp undergoes necrosis determined by untreated progressive cavity
3. Extensive apical resorption due to an incorrect orthodontic treatment
4. Surgery root end resection consequent to a chronic inflammation
5. Dento-alveolar traumatic injuries affecting immature teeth, especially maxillary teeth from incisal region which in condition to inappropriate treatment lead finally to necrosis

Common problems associated with open apex

- wide apical area in various stages of evolution with divergent, parallel or convergent walls
- thin dentinal walls which are susceptible to fracture during or after treatment
- short roots thus compromising crown-root ratio [2].

Favorable conditions for the success of immature teeth treatment

- integrity of biological potential makes great defensive capacity
- immune reactions well-represented in young permanent teeth guarantee well-organized response able to stop the development of acute processes

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- anatomy and autonomy of pulp apical area
- greater resources of circulatory recovery provided by a rich vascularity and a large apex [3].

Methods of specific treatment in young permanent teeth

The criteria for selection of immature teeth treatment methods should consider:

- the need to maintain pulp vitality at least in a limited area to ensure further development of root
- treatment method is selected in relation to the degree of the pulp injury
- use of a biological activator able to stimulate autonomous apical area

Depending on condition and degree of damaged pulp tissue, there are two possibilities of therapeutic approach, that *apexogenesis* and *apexification.*

Apexogenesis is the natural process by which the root continues to grow and the apical closure occurs.It is considered the procedure of choice for immature teeth with open apex because it generates a normal thickness of dentin and root length [4]. *Maturogenesis* is a new concept that aims not only teeth with wide open apex, but the teeth with root having thin and weak walls prone to fractures. Several authors prefer the term « *maturogenesis* » *to* describe continued root development and the term « *apexogenesis* » for apical closure [5].

The goals of apexogenesis described by *Webber* cited by [2] are as follows:

- to sustain a viable Hertwig's epithelial sheath which guides the maturation of root
- to maintain pulp vitality in apical region thus allowing the remaining odontoblasts to lay down secondary dentine producing a thicker root and decreasing the chance of root fracture
- to promote root end closure thus creating a natural apical constriction for root canal filling
- to generate a dentinal bridge at the side of pulpotomy that will isolate and protect the vitality of the remaining pulp tissue [6].

Therapeutic methods to achieve apexogenesis:

1. Indirect or direct pulp capping which preserves pulp vitality entirely, treating reversible pulpal injuries and sealing the pulp in order to prevent further microbial contamination [7]. Direct pulp capping is the method of choice for vital immature teeth for several reasons :

- wide open apex prevents increased intrapulpal pressure, provides a rich vascularity and allows healing of inflamed tissue
- the pulp has an increased reparative capacity being a young tissue

2. Total or partial pulpotomy preserves partially pulp vitality by removing the coronal injured pulp total or partial (Cvek technique) and by preserving pulp root segment

3. Partial pulpectomy keeps an apical pulp blunt to allow continued physiological root development

According to *Morse et al.* cited by [2] there are at least 5 methods of treating a tooth that has a *necrotic pulp and an open apex.*These methods are as follows:

1. A **reverse or blunt gutta-percha** cone and a sealing to fill the root canal
2. A **short or incomplete root canal filling** before the walls become divergent using gutta percha and a sealing or zinc oxide eugenol alone
3. Filling the root canal with gutta-percha and a sealer followed by a **periapical surgery** with or without a reverse seal
4. **One-visit apexification** by placing an apical biological barrier in the apical portion of root canal which will allow filling with gutta-percha in the same session
5. **Apexification** is defined as a method to induce a calcified barrier between periapical tissue and root canal in immature teeth with necrosis.To induce the formation of a calcified barrier at the open apex it is necessary to create appropriate conditions by cleaning and preparing the root canal to remove the toxic debris and bacteria followed by application of an endodontic biological materials.It is possible that these materials are not stimulating apexification but certainly correct debridement to remove the irritative elements is the main factor responsible for apical closure [8].

Therapeutic methods to achieve apexification:

1. Removal of infected necrotic pulp tissue. *Moller et al.* have shown that necrotic pulp tissue induces strong inflammatory reactions in the periapical tissue so it is absolutely necessary to remove it.Thus is possible to achieve the apical closure only by the simple sterilization of root canal, without application of any endodontic stimulative materials.

2. Combination of antibiotics and antiseptics pastes as temporarily filling after mechanical debridement. *Rule and Winter* cited by [2] have successfully tested this method using a combination of polyantibiotic after the canal debridement and in some cases described continued root development.

3. Calcium hydroxide was introduced by Hermann in 1920 for endodontic treatment and is considered in present the main endodontic material in treatment of necrotic immature teeth when kept at least 7 days because of its properties:

- *High alkaline pH* (9-11) which explains antimicrobial properties able to destroy in just 1-6 minutes 99,9% of bacteria in contact with calcium hydroxide

-*persistent* root-canal *secretions* are stopped; *Sjőgren* demonstrated that after 7 days root canals are complete sterilized

-*dissolve organic and infected necrotic* debris by mechanism of sodium hypochlorite

-*dentinogenetic effect* by stimulating apical odontoblasts to forme an apical barrier of calcified tissue and by releasing calcium-ions promotes its mineralization

- *Local haemostatic effect* due to calcium-ions which are coagulation factors [9]

- *low solvability* in water determine a gradual release of hydroxyl ions and although it has a high alkalinity is not harmful for pulp or periapical tissue even in direct pulp capping [10].

The major *disadvantage* of calcium hydroxide is higher resorbability which requires periodic replacement till the complete root formation but the long term calcium hydroxide therapy might alter the mechanical properties of dentine.

The time required for apical barrier formation after *Sheehy and Roberts* [12] is between 5-20 months and the rate of success is 74-96% [13].

4. **Artificial apical barrier** allows one-visit apexification (*one-step apexification*). It is an alternative technique proposed by *Koeings et al.* which consist of a compacted material applied in the apical 2-4 mm of root to forme an artificial barrier resistant to vertical forces developed during gutta-percha condensation on the root canal.The advantage of this technique is reducing treatment time for both patient and clinician.As materials for apical barriers can be used *tricalcium phosphate, resorbable ceramics, demineralized dry and frozen bone, mineral trioxide aggregate (MTA).*

Mineral trioxide aggregate was developed by dr.Torabinejad at Loma Linda University in 1990 and described in literature for the first time by *Lee et al.*in 1993 [14].There have been many articles published in dental journals which confirm the excellent biological and physical properties [15]. MTA consists in a mixture of hydrophilic mineral oxides [14] such as SiO2, K2O,

Al2O3, Na2O, Fe2O3, CaO, and MgO. Several studies have reported that MTA is similar to commercial Portland cement (PC) which represents 80 % and the rest of 20 % is bismuth oxide added for radio-opacity [16].On hydration both materials (PC and MTA) are forming a calcium silicate gel and calcium hydroxide in ratio 4:1, which can explain the similar mechanism of MTA and calcium hydroxide. Because the setting time is shorter than the HC, the time for treatment reduces and provides a good apical sealing, in the same time being biocompatible [17]. Besides its non-toxicity, has a good biological action by stimulating regenerative apical tissue [18], because allows cellular adhesion, growth and proliferation on its surface.

5. **Revascularization of immature teeth**

This new concept launched by Nygard-Østby is based on numerous studies which showed that induction of a blood clot in the third apical of root by periradicular tissue laceration might produce new vital vascularized tissue in the canal [19].Treatment protocol consist of copious irrigation with sodium hypochlorite 2,5% followed by a mixture of antibiotics (mixture of ciprofloxacin, metronidazole and minocycline pasta) developed by ***Hoshino et al.*** [20] without previous mechanical instrumentation. After the blood clot was produced to the level of the cement enamel junction (CEJ) a deep coronal restauration was performed with MTA, an ideal sealing material in wet conditions [21].

6. **Application of a collagen matrix** to apical level can induce apical tissue regeneration. ***Nevin and Crespi*** cited by [2] have studied the application of a collagen calcium phosphat gel (Zyplast) to an immature tooth with pulp necrosis that acts as a hard tissue inducer material and reported favorable outcomes.

7. The addition of **bone morphogenic proteins** to a collagen matrix allows for more tissue to growth by stimulating proliferation and differentiation of mesenchimal cells and that will ensure further root development.

Regenerative endodontic procedures

All these treatment methods that induce apexification in immature teeth with pulp necrosis are based on a new therapeutic concept: *regenerative endodontic treatment focusing* on the possibility of functional regeneration of pulp-dentine complex. Several recent studies have shown that biological endodontic therapy may result in further root development, increases thickness of dentin layer and apical closure, similar to apexogenesis even if are immature teeth with necrosis [22]. Biological basis of this concept is the field of tissue engineering that « exploded » during the last decade.Regenerative endodontic treatment is based on three main components of tissue engineering, selected to be available to clinicians when treating immature teeth with this method.

1) The first component of tissue engineering is a *cell source*.Odontoblasts have mesenchymal origin and under appropriate conditions, cells from dental pulp, from apical papilla and other apical tissues can forme odontoblast-like cells [23].

2) The second component of tissue engineering is a *physical scaffold* that will promote cell growth and differentiation.This scaffold must comply some conditions, for example, might selectively bind and localize cells and contain growth factors.From studies it was observed that platelet –rich plasma (PRP) satisfies many of these criteria [22].

3) The third components of tissue engineering to consider for regenerative endodontics is *signaling molecules*.Both growth factors and other compounds are capable of stimulating proliferation and differentiations of cells [22].Interestingly, ethylenediaminetetraacetic acid (EDTA) is effective in releasing growth factors from human dentin [24]. It is not yet known ,whether root canal irrigation with EDTA would promote the development of odontoblast proliferation in a regenerative endodontic procedures.Other studies showed that extracts of dentin provides cell proliferation because many growths factors are embedded into dentin matrix during dentinogenesis [25].

The next years of scientific research will deepen and sediment new concepts concerning the regenerative endodontic procedures which will expend the sphere of treatment options for immature teeth with pulp necrosis.

CONCLUSIONS

The pathology of young permanent teeth dresses varied aspects whose side effects are the disorders of apical development and maturation.Pulp vitality should be preserved whenever is possible because apexogenesis is superior to apexification and teeth after apexogenesis develop a normal thickness of dentine walls and root lenght.Progress achieved in recent years in the field of tissue engineering with application in treatment of young permanent teeth with necrosis showed that a series of regenerative endodontic procedures can induce further apical development and maturation similar to that generated by apexogenesis on vital teeth.

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