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ARTICLE REVIEW

Techniques to stimulate apexogenesis in dentistry

Técnicas para estimular apexogénesis en odontología

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ABSTRACT

Introduction: apexogenesis is currently used by health professionals to maintain young permanent teeth with exposed but infected vital pulp, which have not yet completed root development, in order to promote natural apical closure.
Objective: to describe crucial definitions of apexogenesis, characteristics and treatment objectives.
Methods: a bibliographic research was carried out, through a search of the following databases in certain articles such as: PubMed, ScienceDirect, Scielo, Redalyc. As a first step, we proceeded to enter a base of articles where we used keywords such as "techniques" "apexogenesis."
Development: apexogenesis is very useful for maintaining young permanent teeth with exposed but infected vital pulp, which has not yet finished its root development, all with the purpose of promoting apical closure in a natural way. Among the materials most commonly used in apexogenesis procedures are calcium hydroxide Ca $(OH)^2$ and mineral trioxide aggregate (MTA). To start with the apexogenesis technique, the approach area should be anesthetized, absolute isolation with a rubber dam should be used, the inflamed pulp tissue should be removed, bleeding should be controlled, and the exposed pulp should be rinsed with 2,5 % hypochlorite.
Conclusions: professionals can use materials such as calcium hydroxide or added trioxide mineral, and it is necessary for the dentist to previously establish a protocol that clearly defines the technique to be used.

Keywords: Apexogenesis; Pulpotomy; Treatment.

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RESUMEN

Introducción: la apexogenésis es utilizada actualmente por los profesionales de la salud con la finalidad de mantener dientes permanentes jóvenes con pulpa vital expuesta pero infectada, que aún no han terminado su desarrollo radicular, con el fin de promover de forma natural el cierre apical.
Objetivo: describir definiciones cruciales sobre la apexogenésis, características y objetivos del tratamiento.
Métodos: se realizó una investigación de tipo bibliográfica, a través de una búsqueda de las siguientes bases de datos en ciertos artículos como: *PubMed, ScienceDirect, Scielo, Redalyc*. Como primer paso, se procedió a ingresar a una base de artículos en donde se utilizaron palabras clave como "techniques" "apexogenésis."
Desarrollo: la apexogénesis es muy útil para mantener dientes permanentes jóvenes con pulpa vital expuesta pero infectada, que aún no ha terminado su desarrollo radicular, todo ello con la finalidad de promover de forma natural el cierre apical. Entre los materiales más utilizados en los procedimientos de apexogenésis aparecen el hidróxido de calcio Ca $(OH)^2$ y el mineral trióxido agregado (MTA). Para iniciar con la técnica de apexogenésis se debe anestesiar el área de abordaje, utilizar aislamiento absoluto con dique de goma, eliminar el tejido pulpar inflamado, hacer un control de la hemorragia, enjuagar la pulpa expuesta con hipoclorito al 2,5 %
Conclusiones: los profesionales pueden utilizar materiales como el hidróxido de calcio o el mineral trióxido agregado, además es necesario que el odontólogo establezca previamente un protocolo que defina claramente la técnica que será utilizada.

Palabras clave: Apexogénesis; Pulpotomía; Tratamiento.

INTRODUCTION

Apexogenesis

It is defined as that procedure that is performed on vital pulps, all with the purpose of promoting the physiological development of the roots of the teeth and also the closure of the apical portion in teeth with incomplete root development, which due to deep cavities pulp exposure occurs and because of this it is not possible to perform a conventional endodontic procedure since the apices are open.[1]

The vital pulp of an immature tooth may have little exposure after trauma by superficial pulpotomy allowing normal root dentin formation to continue.[1]

We must also note that the certain procedure is very useful to maintain young permanent teeth with exposed but infected vital pulp, which has not yet completed its root development, all with the purpose of naturally promoting apical closure. Its main objective is to maintain the vitality of the root pulp. Most immature teeth with crown fractures and exposed pulps have vital pulps in which inflammation is limited to the tissue surface.[1]

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Materials used in apexogenesis procedures
Among the most used materials in apexogenesis procedures is calcium hydroxide Ca (OH) ², it was introduced by Hermann, however this material has been questioned because it can generate superficial necrosis of the pulp tissue when it has direct contact with it in its pure state, also mentioning that calcium hydroxide is very strong for cells, since it can even have a tissue dissolving effect, in the practice of apexogenesis another material has been used which is the added mineral trioxide (MTA), this material achieves the seal of the vital pulp.[2]

Mineral Trioxide Aggregate (MTA)
The mineral trioxide aggregate (MTA), was introduced in 1993 by Torabinejad, the material was patented in 1995 and approved in 1998 for application in endodontic procedures, the aforementioned material is a kind of powder composed of tricalcium silicate dicalcium silicate, dicalcium aluminate, calcium sulfate dehydrate and bismuth oxide, according to studies, MTA is a material with osteogenic capacity, biocompatibility, inductive and conductive functions for the formation of hard tissue, it has low solubility and is highly radiopaque, it has a superior sealing capacity to amalgam, zoe (zinc oxide and eugenol), can cause protein denaturation, destruction of bacteria in the area where the material is placed, cellular damage, however this material achieves the formation of similar hard tissue to cement, allows osteoblastic adhesion and bone regeneration among others.[3]

Apexogenesis technique
Apexogenesis is defined as the final physiological root development and formation and is indicated when the vital pulp of a tooth is exposed and two special conditions exist: the pulp is not irreversibly inflamed, apical development and closure is incomplete.[4]

To begin the apexogenesis technique, we begin by anesthetizing the area and placing a rubber dam, eliminating the inflamed pulp tissue, then controlling the hemorrhage, rinsing the exposed pulp with 2,5 % hypochlorite, and applying the material.[4]

Contraindications of apexogenesis
- Not in older permanent teeth.
- Avulsed, reimplanted or severely dislocated teeth.
- Severe root crown fracture requiring intraradicular retention for restoration.
- Tooth with unfavorable horizontal root fracture.
- Very decayed tooth that cannot be restored.
- Adult teeth with narrow canals and qualified apices.
- All pulp inflammatory processes, such as irreversible pulpitis and pulp necrosis.

pulpotomy
We will define pulpotomy as that treatment in which we manage to eliminate the part of the pulp, that is, the internal part of the tooth made up of nerves, tissues and blood vessels, which has suffered damage due to trauma or even reversible inflammation or deep caries, pulpotomy in a child, we will indicate that this procedure is performed on baby teeth that have caries but in a very advanced state, which has managed to cause damage to the root of the patient's tooth, the pulpotomy usually lasts between 10 to 15 minutes.[5]

Pulp
The pulp is a loose connective tissue richly vascularized and innervated, which is located in the central space of the tooth and surrounded by dentin, specifically it has four vital functions which are the formation and nutrition of the dentin as well as performing innervation and is responsible for defending the tooth.[6]

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Open apex
It is usually normal to find an open apex on the developing root of an immature mature tooth and in the absence of pulp disease, if the pulp dies before root growth is completed, root growth stops and formation of dentin, so the canal remains with a wide and open apex, the root may also be shorter. Sometimes there is an open apex as a result of extensive resorption of a mature one after endodontic treatment, due to periradicular inflammation, or as part of healing after trauma. Apical closure usually occurs three years after eruption; the normal mature permanent tooth has an apical canal constriction of 0.5 to 1.0 of the anatomical apex.[7]

METHODS

A bibliographic, documentary, exploratory and non-experimental research was carried out through a search of the following databases in certain articles such as: PubMed, ScienceDirect, Scielo, Redalyc. As a first step, we proceeded to enter a base of articles where keywords such as "techniques" "apexogenesis" were used. During the search process we tried to take studies published in English or Spanish, carried out in the last 10 years, that is, from the year 2013 – 2023.

Inclusion and exclusion criteria: All literature that does not contain a scientific basis and is within the established time period was excluded from the search.

Data extraction: After the initial search, 60 articles were found that contained information on the topic raised; however, 40 of them were analyzed, since they supported the objective of the proposed research.

Data analysis: Once the information was found, the next step was to analyze it using the so-called adhesive technique, establishing a comparison between the total engraving and the selective engraving, observing certain details of each which allows us to determine which of the two techniques is more beneficial for patients.

DEVELOPMENT

Association between diabetes-apexogenesis
Dental caries is a process that destroys the hard tissues of the tooth, that is, the dentin, enamel and cementum, due to the action of acids produced by plaque bacteria from dietary carbohydrates. Therefore, if the caries lesion is not treated or prevented, the result will be a bacterial invasion of the dental pulp, that is, endodontic, in the same way, there will be a septic inflammatory development, that is, pulpitis, which will ultimately end up causing necrosis of the pulp connective tissue.[8]

Association between anemia-apexogenesis
People who have anemia generally do not have a sufficient amount of oxygen-rich blood in their body, that is, due to the lack of oxygen, an individual may feel tired or weak, having symptoms such as difficulty breathing, dizziness, headaches, etc. even irregular heartbeats, however, anemia in oral health highlights a higher incidence of periodontitis, oral infections, glossitis, that is, inflammation in the area of the tongue, also childhood caries, through scientific studies it has been possible to establish a direct relationship between what is anemia and periodontitis, this is caused by a lack of iron, which causes a risk of suffering from gum disease. The consequences that periodontitis can leave are the degradation of the tooth

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support that in the future can end in tooth loss, the teeth may have too much mobility and are no longer mechanically resistant and the patient may have many problems when chewing.[9]

The negative impact that the aforementioned disease causes on patients is tooth loss, sometimes the destruction of the bone can be rapid and in other cases it can be slow, it is necessary to be alert to these events since treatment in a timely manner will be great help.[9]

Association between hypertension-apexogenesis

Cardiovascular diseases currently constitute a cause that can cause premature death in humans. Generally, these conditions generate damage to organs and systems of the human body, which leads to systemic decompensation and decreased patient survival, relating this disease to branch of dentistry we must mention that it causes an effect on the oral mucosa, and this creates small petechial hemorrhages, which attributes the severe and sudden increase in blood pressure, also mentioning that patients with cardiovascular risk should be treated with prophylaxis antibiotics so that in this way the microorganisms found in the oral cavity can be prevented from being transferred to the bloodstream and causing infective endocarditis.[10]

In addition, it is necessary to mention that if sufficient care is not taken, periodontal and oral diseases can cause the person an alarming state of bacterial colonies in the heart, some diseases such as petechiae can occur in the oral cavity, adding also that if The patient uses antihypertensives, what can happen is that there is gingival enlargement, gingival bleeding, xerostomia.[10]

Association between obesity-apexogenesis

For a long time, adipose tissue was considered an inert system that stored triglycerides. However, today it is known that it is a complex organ that secretes numerous immunomodulatory factors and plays an important role in metabolic regulation and vascular biology. Adipose cells, which include adipocytes and macrophages, secrete more than 50 bioactive molecules, known as adipokines. Some of them act locally and others are released into the systemic circulation and function as signaling molecules in the liver, muscle and endothelium. Adipokines perform different functions such as hormones or proteins. Adiponectin modulates a number of metabolic processes such as glucose regulation, blood pressure, fatty acid catabolism and has inverse associations with serum markers of inflammation (anti-inflammatory).[5]

Association between osteoporosis-apexogenesis

Osteoporosis has been associated with an increase in tooth loss in several population groups. According to studies carried out in female groups with low skeletal bone density, they demonstrate a tendency to present greater periodontal attachment loss than control groups with normal skeletal bone density 5,6. In relation to the latter, osteoporosis is a progressive systemic disease that is characterized by a loss of bone mass and deterioration of the microarchitecture of the skeletal tissue, compromising the trabecular and cortical bone. It is described that more than 20 % of women over 50 years of age present it. Regarding the classification of systemic mineral bone loss, the World Health Organization is based on measurements of bone density by dual X-ray absorptiometry, through a "T" marker.[6]

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Association between alcoholics-apexogenesis

As we well know, the use or excessive consumption of alcohol can be harmful to our health, relating it to oral health we have that in the long term it can cause a number of problems in oral health, that is, diseases such as the formation of cavities, dry mouth, gum disease, referring to how alcohol affects the gums, we must mention that it can cause redness, bleeding, inflammation, and that alcohol can cause epithelial atrophy of the oral mucosa, which produces an increase in solubility. of toxic substances and making the oral cavity a more vulnerable area at the time of the appearance of diseases. Excess alcohol can cause periodontal diseases, which increases probing depth, increases clinical attachment loss and increases infections, and also stimulates bleeding and makes the healing process more difficult.[7]

Association between smokers-apexogenesis

Periodontitis is an inflammatory disease, it appears due to microorganisms present in the dentogingival biofilm, which causes a destruction of the periodontal insertion apparatus, one of the main factors of the aforementioned condition being the habit of smoking, adding that excessive consumption of Tobacco produces multiple diseases and the highest number of deaths in the world, being one of the biggest problems for public health, one of the first periodontal alterations is gingival recession and epithelial hyperplasia, that is, around 25 to 30 % of People who have smoking habits present the aforementioned recession.

According to a study carried out by Grossi, it can be observed that in light smokers there is a risk of bone loss of 3,25 and in heavy smokers it is 7,28 times, therefore it could be observed that smoking is strongly related to bone loss in patients, some research has proposed that smoking negatively influences the healing process after surgical and non-surgical therapies. Additionally, clinical results have been lower in smoking patients after root planning and polishing, adjunctive antimicrobial therapy, periodontal surgeries, and periodontal maintenance therapy.[11]

DISCUSSION

Table 1 evidence of the clinical cases used in the comparison of the study, the case, Treatment, Methodology, Result obtained and Bibliography are described. Source: Santiago Logroño, Stephanie Parra and Génesis Albán "Own elaboration"

Table 1: Clinical evidence of Apexogenesis

Case Description	Treatment Used	Methodology Used	Result Obtained	Literature
Twelve-year-old patient referred to the endodontics postgraduate program at the CES University for follow-up and evaluation of the right lateral incisor, who has a history of intrusive dislocation due to trauma of five years of evolution and pulp revascularization	Apexogenesis in children	A chamber opening of 12 was made, the root canal of the tooth was accessed, observing the exit of oxidized organic material, an apical barrier was detected at 17 mm, confirming this length by radiographic means, it was established as the definitive working length, no information was obtained through of the use of the apical locator. Copious irrigation was performed	In the second appointment, an apical plug is made with MTA AngelusTM ensuring 3 mm of filling material, a cotton swab moistened with distilled water is left for eight days, Coltosol® (Coltène Whaldent) is left as a temporary material for coronal seal. In the third	Ruiz A. 2012. [12]

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procedure performed by the postgraduate of endodontics from CES University. The patient's medical history includes a control x-ray two years after the procedure. At the time of consultation, the patient did not report any signs or symptoms.		with 5% NaOCL (Zonident®, Proquident), Ca(OH)2 was left as intracanal medication for eight days.	appointment, the setting of the MTA is verified and the canal is filled with thermo-softened gutta-percha and Top Seal® cement, Dentsply-Maillefer, an endodontic seal is made with glass ionomer (VitrebondTM-3M), the cavity is temporarily filled with Coltosol® Coltène Whaldent. At each appointment, a rubber dam was used to guarantee the greatest possible asepsis and reduce the chances of bacterial contamination.	
A 9-year-old patient with irrelevant medical history presented to an emergency consultation exhibiting a dentinoenamel fracture with pulp exposure in tooth 11, as a result of a bicycle collision in the 24 hours prior to the consultation. The clinical examination revealed that facial tissues were within normal limits. The tooth presented a slight gyroversion and pulp exposure surrounded by healthy dentin.	Apexogenesis in children	They applied local anesthesia with 4% caticaine hydrochloride, combined with L-Adrenaline, 1% NaOCl was sprayed on the fracture area, managing to remove a superficial layer of the pulp, the bleeding was stopped with cotton and physiological saline, and finally it was restored. l cavity with a glass ionomer, the first days of the intervention the patient did not present symptoms.	After 18 months of the intervention, a clinical and radiological control was carried out, in which root development and the neoformation of an incipient alveolar cortex were observed, the vitreous ionomer was replaced by composite resin with two additional retentions, the last control was carried out at 25 months, and the result was that the tooth was asymptomatic and responded normally to sensitivity tests. Through the x-ray it was possible to observe that the root completed its development and no pulp calcifications were observed.	Zmener O, Boetto A. 2022. [10]
A 27-year-old man, who consulted due to the upper left central incisor (21) with a change in color and angular fracture, the reason for the consultation was primarily	Apexogenesis in adults	The diagnosis was that the adult patient had pulp necrosis in the upper left central incisor tooth with incomplete rhizogenesis. Periodic treatments with calcium hydroxide paste were started.	Every three months the medication was renewed, after removing the previous calcium hydroxide paste with Hedstrom files. Irrigation, drying and obturation with	Berasteguí E. 1992. [9]

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aesthetic, since the dental staining was increasing as time went by and he also wanted for the fracture to be treated. Among the personal data, there was no data of interest regarding general illnesses, although there was a history of a traumatic accident on tooth 21 due to a fall to the ground at seven years of age, without subsequent painful symptoms, which is why he did not attend consultation. from a specialist and was not treated.			new calcium hydroxide were carried out in the same way and the provisional prosthesis was subsequently cemented. After two years of treatment it was decided to permanently obturate the canal. The main tip of gutta-percha was softened with heat to give it a three-dimensional shape. of the duct, the condition of the cone was checked and the duct was blocked using the lateral condensation technique. The patient showed no symptoms. One year after the treatment was completed, the x-ray indicated that everything was going well.	
Girl patient, 7 years old, admitted to the Pediatric Dentistry Clinic of the Faculty of Dentistry-UNNE for care. After obtaining informed consent from the parents, the Clinic protocol was carried out, taking a medical-dental history that included a radiographic clinical examination, in order to inquire about the patient's general health status. The reason for the consultation was the presence of multiple carious lesions with pain. The intraoral examination revealed the presence of carious lesions on teeth 55, 65, 84, 74, 75, 16, 46 and 24.	Apexogenesis in children	A preventive plan was started simultaneously with the treatments that consisted of motivation and teaching of the brushing technique according to their age and motor skills, the application of topical fluoride, and the sealing of the permanent teeth with deep remineralized grooves (2.6., 3.6) and non-penetrating open cavity inactivations. It was decided to carry out the extraction of tooth 6.5., due to its degree of destruction. The restorative treatment was carried out on pieces 1.6. and 4.6. using composite and in piece 5.5., amalgam was placed. Tooth 7.5 required the placement of a steel crown to correctly restore its anatomy, due to the extensive carious process distally, a pulpotomy treatment with MTA was performed on the permanent tooth (2.4.), which was vital. , in order to produce closure by apexogenesis.	The crown restoration was carried out through the placement of a polycarboxylate crown. As a marginal seal was achieved with the placement of said crown, successive controls allowed root formation in both length and thickness. Once the corresponding restorations were completed, the maintenance of the space was planned through a nance button type maintainer.	De CM, Vega L, Meza M, González C. 2018. [8]

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CONCLUSION

Apexogenesis is a very useful treatment to maintain young permanent teeth with exposed but infected vital pulp, which have not yet completed their root development, in order to naturally promote apical closure. In addition, it is necessary to mention that for this treatment dental Some materials are used, generally the most common are calcium hydroxide, as well as the added trioxide mineral. Likewise, this procedure is carried out as follows: as an initial step, we anesthetize the area and place a rubber dam, eliminate the inflamed pulp tissue, then the bleeding is controlled, we rinse the exposed pulp with 2,5 % hypochlorite, we apply the material, the aforementioned dental procedure before being carried out must follow a number of protocols, that is, the presence of an analysis doctor, evaluation through an x-ray, as well as the patient should be consulted if in previous times the affected area currently suffered any damage, among other factors that help determine an appropriate diagnosis.

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The authors declare that there are no conflicts of interest.

Author contributions
All authors participated in conceptualization, data curation, formal analysis, research, methodology, supervision, writing-original draft, writing-review and editing.

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