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Minimally invasive treatment of dental caries, an update

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Abstract
The importance of this research lies in the effectiveness of the different minimally invasive techniques for the management of carious lesions.
Objective: To analyze the minimally invasive treatment for the removal of carious lesions. The techniques evaluated were: conventional method, ART, papacarie, laser and abrasive air.
Methodology: A compilation of articles published in the last 5 years was carried out using the PubMed electronic database. Abstracts and full texts were identified that included information on the techniques for minimally invasive treatment of carious lesions: the conventional method, ART, papacarie, laser and abrasive air.
Results: The conventional technique is the most commonly used at present, but it is the most aggressive because it removes both healthy and infected tissue. ART is one of the most economical and least painful measures for caries management. Papacarie is a minimally invasive chemical removal method and does not require local anesthesia. Laser for caries removal is expensive, but it is one of the least abrasive ways to manage it, and the abrasive air does not irritate pulp or adjacent tissues.
Conclusions: Removal of dental caries with rotary instruments is frequently associated with thermal and pressure effects on the pulp, resulting in pain. Due to the shortcomings of the bur, alternatives such as chemo-mechanical caries removal with sharp instruments (ART), laser and abrasive air were developed, which have a disintegrating effect on the caries tissue, while leaving healthy dentin largely intact.

Keywords: Caries, minimally invasive, ART, papacarie, laser and air abrasion

1. Introduction
Resulting in a high economic and biological cost, the traditional therapeutic approach to the management of carious lesions remains largely restorative [1], they also have an impact on the quality of life in the individual related to oral health [2].
Dental caries is a sugar-dependent disease that damages tooth structure and, due to the loss of mineral components, can eventually lead to oral cavitation [3]. It is one of the most impactful diseases worldwide and after all, it is a preventable disorder [4].
Traditionally, cavitated carious lesions and those extending into the dentin have been treated by "complete" removal of carious tissue, i.e., non-selective removal [5]. There is no consensus on how much caries to remove before placing a restoration to achieve optimal results. The evidence for selective caries removal compared to complete or near-complete removal suggests that selective removal may have benefits in maintaining tooth vitality, thus preventing abscess formation and pain. This eliminates the need for more complex and costly treatment or eventual tooth loss [6]. To make a change in dentistry, they must move away from traditional "drill and fill" treatments and begin the practice of minimally invasive (MI) treatment, as this is an attractive alternative to treat carious lesions in a more conservative and effective manner, resulting in better preservation of tooth structure [4].
To aid the clinical approach, several excavation protocols are available, including atraumatic restorative treatment (ART), which has been considered an innovative, painless and minimally

invasive procedure for the treatment of caries [7]. Another method of carious tissue removal is the use of chemomechanical agents (papacaries), which act on the denatured collagen fibers within the necrotic dentin layer, preserving the demineralized dentin [8]. One way of removing carious tissue nowadays is the use of laser, which is more costly but less uncomfortable for the patient [9,10].

Dentistry being a medical branch, requires the attention of the professionals who practice it to find methods that can improve the quality of life of patients through less invasive and effective treatments that are decisive in the solution of the problem that afflicts the patient. In this work, the literature on minimally invasive treatment for the removal of carious lesions was analyzed. The techniques evaluated were the conventional method, ART, papacarie, laser and abrasive air.

2. Materials and Methods

Articles on the subject published through the PubMed, SCOPUS and Google Scholar databases were analyzed, with emphasis on the last 5 years. The quality of the articles was evaluated using PRISMA guidelines, i.e., identification, review, choice and inclusion. The quality of the reviews was assessed using the measurement tool for evaluating systematic reviews (AMSTAR-2). The search was performed using Boolean logical operators AND, OR and NOT. It was realized with the words "caries", "minimally invasive", "ART", "papacarie", "laser" and "air abrasion". The keywords were used individually, as well as each of them related to each other.

3. Results and Discussion

3.1 Conventional Method

Caries excavation has traditionally been performed with drills and sharp-edged hand instruments [11]. Despite its advantages, such as simplicity, speed and efficiency [12], it is frequently associated with thermal effects and pressure on the pulp, which causes pain [13]. Removal may also involve the extraction of healthy tooth tissue adjacent to the affected carious area [14]. Although often effective [10], they have some important disadvantages [3]. Firstly, it is often difficult to establish the amount of dentin to be removed due to the possibility of unnecessary removal of healthy tooth structure in addition to carious tissue [14]. Secondly, local anesthesia is needed to alleviate the pain and discomfort caused by mechanical methods [15].

One of the most commonly used techniques for the removal of carious tissue is the use of rotators, but it causes damage to the tooth as it removes healthy tissue, which also makes it one of the most uncomfortable methods for the patient.

3.2 Atraumatic Restorative Treatment (ART)

ART avoids the unnecessary use of rotary instruments and local anesthesia, which reduces patient distress, anxiety and fear [16]. It is performed using a sharp hand instrument to remove the decayed tooth structure, followed by restoration with ionomer [7].

This method is intended to address the etiological factors of dental caries as part of its protocol. This technique eliminates only the infected dentin, which cannot be remineralized due to the high degree of disorganization of the collagen fibers, while maintaining the affected dentin, which can be remineralized, thus preserving a greater amount of tissue [17].

The instrument used in ART is a sharp spoon excavator with a diameter of 1 or 1.5 mm to remove soft caries [18]. In addition, a dental axe can be used to widen the cavity [19]. The ART procedure does not require the use of local anesthesia, as it is painless and well accepted [20]. Indications for the use of ART include young [10] and uncooperative patients, patients with special needs and cases in which traditional dental treatment cannot be performed and must be postponed [21].

The advantages of ART are that it costs less, is easily available, restoration can be performed using only hand instruments instead of power instruments, reduces damage to healthy tooth tissue, less noise compared to motorized instruments, less sensitivity and pain which minimizes the use of local anesthesia and reduces patient anxiety.

3.3 Papacarie

The chemomechanical caries extraction technique is another non-invasive manual excavation method that removes only the infected dentin while keeping the demineralized part for repair and remineralization [22] and prevents pulp irritation and patient discomfort [23]. This technique was developed in 1975 [24]. The technique consists of removing the decomposed tissue by applying natural or synthetic agents to dissolve and facilitate the removal of the infected tissue [23]. Papain promotes proteolysis of the collagen fibrils exposed in the decayed tissue, which further softens the decayed tissue, facilitating its removal with hand instruments [16]. After use, the gel often changes color and becomes cloudy or produces bubbles, making it easier to identify the reaction, completion or absence (i.e., no decomposed tissue remains) [25]. The softened tissue is then removed with non-cutting tip instruments. Enzyme-based materials may be associated with anti-inflammatory properties, which may lead to better treatment experiences and less induced pain. Hypochlorite agents are also associated with less necessary anesthesia, as sodium hypochlorite has its action within already damaged collagen fibrils [20].

Papacarie stands out among the chemical-mechanical techniques. This agent is a gel containing papain and chloramine that is used in combination with hand tools for minimally invasive removal of carious tissue [23].

The effectiveness of this method has given satisfactory results in terms of clinical follow-up, anxiety, comfort, pain, patient acceptance and cost. Papacarie gel can be successfully used in patients with special needs, pediatric dentistry and adults with phobias. Its implementation is an important alternative in public health care because it combines practicality, ease of use, low cost and does not require the use of local anesthesia.

3.4 Er: YAG Laser

It is a solid-state laser, which has as its active medium a yttrium-aluminum-garnet crystal contaminated with erbium metal molecules. It is one of the most recent methods introduced in the field of dentistry [26]. Its radiation, which is within the range of infrared light, has a wavelength of 2940 nanometers [27], which is characterized by being absorbed by water, and is therefore particularly suitable for precise and localized ablation of biological tissues containing it, which helps to prevent thermal damage [28].

It gives pulsed shots, each of which is in the nano-second range, such laser radiation, when fired on a tissue, causes evaporation of the water at the irradiated point resulting in a micro explosion of the surrounding hard tissue [29]. The excitation wavelength induces a fluorescence signal that has been assigned to protoporphyrin, a bacterial degradation product [30]. This process is known as ablation. It produces little heat generation within the underlying tissues and minimal temperature elevation in the pulp of the pulp

chamber [31]. Therefore, the tissue destruction caused by the Er:YAG laser is probably not related to the thermal effects produced by other types of lasers, but the microbursts are associated with the evaporation of water in the cementum and other dental hard tissues [29]. Caries in dentin is easily eliminated and sterilized by the Er:YAG laser, since the microorganisms causing the disease provoke proteolysis of organic matter and decalcification of inorganic matter, generating substances rich in water [28].

Carious tissue contains even more water compared to healthy dental hard tissues and therefore the high absorption of the Er:YAG laser provides selective and conservative caries removal without extending the preparation to healthy tooth structure.

3.5 Abrasive Air

Air abrasion as a caries removal technique is less aggressive than conventional techniques and is compatible for use with adhesive restorative materials [10]. Alumina, although currently the most commonly used abrasive for cutting, has controversial health and safety issues and has no remineralization properties [32]. This form of treatment uses the kinetic energy of abrasive grains in a stream of compressed gas (usually air) [33]. Its action consists of launching abrasive particles of aluminum oxide at high velocity, having a de-galling effect on the hard structures of the tooth and producing a temperature rise [34]. It is a technique used for small cavities [35]. The pressure range is between 40-160 psi and the particle size ranges from 27 to 50 um. The larger the particle size, the more abrasive [34]. Aluminum oxide is characterized by being chemically stable, non-toxic, and water-coupled [36].

The innovative aspect of this system is that it does not produce pressure, vibration or overheating of the tooth being prepared. As a consequence, it reduces fear and anxiety in the patient [37]. Stains can be cleaned and removed from the tooth surface, allowing the diagnosis of caries lesions in pits and fissures. It also enables the ultra-conservative preparation of margins of restorations that present areas of infiltration [38].

It is an innovative technique since it is only limited to the selective removal of carious tissue and does not irritate the pulp or adjacent tissues.

4. Conclusions

The removal of dental caries with rotary instruments is frequently associated with thermal and pressure effects on the pulp, resulting in pain. In addition, drilling may also involve the removal of healthy tooth tissue adjacent to the affected caries area. Due to the shortcomings of the bur, alternative techniques such as chemomechanical caries removal with sharp instruments (ART), lasers and abrasive air were developed, which have a disintegrating effect on the caries tissue while leaving healthy dentin largely intact.

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