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THE TREATMENT OF REVERSIBLE PULPITIS USING CALCIUM HYDROXIDE FOR INDIRECT PULP CAPPING

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Annotation

Vital pulp therapy is a biologic and conservative treatment to preserve the vitality and function of the pulp tissue. Indirect pulp capping is one of the techniques which can be done with $Ca(OH)_2$. The success rate of using $Ca(OH)_2$ during treatment of reversible pulpitis isn't so high. And the reactivity of the vital pulp is reduced when exposed to an aggressive calcium hydroxide-based material. According to the international classification of diseases, reversible pulpitis is considered as K04.00 – initial pulpitis.

The purpose of this review article is to assess systematically the available scientific evidence about the clinical response of pulp-dentin complex after using $Ca(OH)_2$ for indirect pulp capping.

Materials and methods: The study of publications was produced in the electronic databases such as Google Scholar, PubMed during a systematic review of the literature. Included articles contain information about using $Ca(OH)_2$ during treatment of initial pulpitis and its side effects. The publication date criterion was selected from January 2011 to July 2021.

Results: 55 articles were viewed during the review. After analyzing the literature for inclusion criteria, the total number of publications has become 10.

Conclusions: According to literature data, the using calcium hydroxide for indirect pulp capping during treatment of the reversible (initial) pulpitis is decreasing due to the side effects and clinical response from dentin pulp complex.

Keywords: *$Ca(OH)_2$, indirect pulp capping, reversible (initial) pulpitis, vital pulp therapy, dentinal bridge formation*

The authors declare no conflict of interest.

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ЛЕЧЕНИЕ ОБРАТИМОГО ПУЛЬПИТА С ИСПОЛЬЗОВАНИЕМ ГИДРОКСИДА КАЛЬЦИЯ ДЛЯ НЕПРЯМОГО ПОКРЫТИЯ ПУЛЬПЫ

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Аннотация

Биологический метод лечения — это консервативное лечение для сохранения жизнеспособности и функции ткани пульпы. Непрямое покрытие пульпы — один из биологических методов, который может быть выполнен с помощью гидроксида кальция. Вероятность успеха при применении гидроксида кальция при лечении обратимого пульпита не очень высока. Реактивность витальной пульпы при воздействии агрессивного материала на основе гидроксида кальция снижается. По международной классификации болезней обратимый пульпит рассматривается как К04.00 — начальный пульпит.

Целью данной обзорной статьи является систематическая оценка имеющихся научных данных о клиническом ответе комплекса «пульпа-дентин» после использования гидроксида кальция для непрямого покрытия пульпы.

Материалы и методы. В ходе систематического обзора литературы производилось изучение публикаций в электронных базах данных, таких как Google Scholar, PubMed. Включенные статьи содержат информацию об использовании гидроксида кальция при лечении обратимого пульпита и его побочных действиях. В качестве критерия даты публикации был выбран период с января 2011 года по июль 2021 года.

Результаты: в ходе обзора было просмотрено 55 статей. После анализа литературы по критериям включения общее количество публикаций составило 10.

Выводы. Согласно литературным данным, использование гидроксида кальция для непрямого покрытия пульпы при лечении обратимого пульпита прекращается из-за побочных эффектов и неблагоприятного клинического ответа со стороны комплекса «дентин-пульпа».

Ключевые слова: *гидроксид кальция, непрямое покрытие пульпы, обратимый пульпит, биологический метод лечения пульпы, формирование дентинного мостика*

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Introduction

Vitality of the dentino-pulp complex is essential for the long term survival of the teeth. The purpose of vital pulp therapy is to maintain viability of pulp tissue by removing bacteria from the pulp-dentinal complex.

Vital pulp therapy (VPT) procedures involve removal of local irritants and placement of a protective material directly or indirectly over the pulp [2]. Indirect capping of the pulp, which is one of the techniques of VPT, can be done using MTA, Biodentine, Trioxident, adhesive system and $Ca(OH)_2$.

$Ca(OH)_2$ has been considered the gold standard, however, research has shown that it is not ideally suited for this procedure [6]. In long-term clinical studies of indirect pulp capping with calcium hydroxide, failure rates increase with the follow-up time [5].

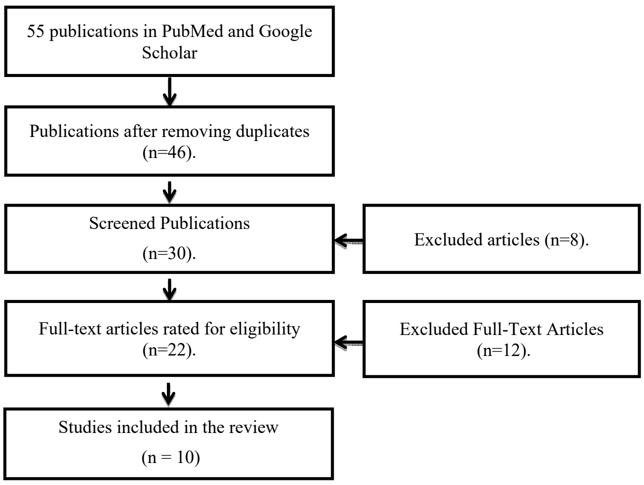

Fig. 1. Article selection process
Рис. 1. Процесс отбора статей

The purpose of this review article is to analyze the properties of $Ca(OH)_2$ for indirect pulp capping during the treatment of initial pulpitis.

Materials and methods

Publications that met the following selection criteria were included:

1) Publication year isn't earlier than 2011.

2) Availability of studies proving the properties of $Ca(OH)_2$ and clinical response of the pulp while using it.

3) Figuring the topic of the clinical evaluation of using $Ca(OH)_2$ as indirect pulp capping agent for treatment of initial pulpitis and the response of pulp-dentin complex.

The review didn't include publications, the title and abstract of which did not meet at least one of the presented inclusion criteria.

Up-to-date information in Russian and English from Google Scholar, PubMed electronic databases has been studied.

A search in Russian and English with no time limit was performed by one person. Search terms included "$Ca(OH)_2$", "reversible pulpitis", "indirect pulp capping", "гидроксид кальция", "обратимый пульпит", "непрямое покрытие пульпы". The studies were filtered and selected in several stages. Firstly, they were evaluated by titles. Secondly, individual documents at the first stage were additionally assessed by reading the abstracts and full-text articles. The first selection criterion was the selection of publications whose titles included at least one search term. Further, publications which are dated earlier than 2011 were excluded. At the last stage, the content of the full-text versions of the selected articles was examined (Figure 1).

Results

55 articles were reviewed, of which 30 were from the PubMed database, 25 were from Google Scholar.

Table 1

Characteristics of the studies included in the review

Таблица 1. **Характеристика исследований, включенных в обзор**

Author	*Publication year*	*Study*	*Number*	*The material*
Marina A. P. et al [4]	2014	patients	86	Calcium hydroxide, MTA
Fatou L. B. et al [5]	2012	teeth	60	Calcium hydroxide, MTA
Cenkhan B. et al [7]	2011	upper and lower first molar	72	Calcium hydroxide, MTA
Călin D. L. et al [10]	2019	patients	13	Calcium hydroxide, MTA
Monica M. et al [14]	2016	molars	23	Calcium hydroxide, MTA
Karim F. et al [21]	2020	teeth	40	Calcium hydroxide
Ana B. et al [23]	2011	rats	N	Calcium hydroxide, adhesive system
Maria A. et al [24]	2017	patients	98	Calcium hydroxide, GIC
T.N. Manak et al [27]	2019	teeth	33	Calcium hydroxide
Soares C.J. et al [29]	2011	teeth	40	Calcium hydroxide

After the selection according to the exclusion criteria, the total number of articles was 10. In the selected articles, the relevant data on the effectiveness, side effects and immunological reaction of using $Ca(OH)_2$ in treatment of initial inflammation of the pulp were analyzed (Table 1).

Discussion

Indirect pulp capping (IPC) is defined as a procedure in which carious dentin closest to the pulp, is preserved to prevent pulp irritation and is covered with a biologically compatible material. This treatment method is expected to protect primary structures – odontoblasts and promote initial dentin formation at the dentine and pulp junction [3].

Pulp capping materials should act as a barrier that protects the vitality of the entire pulp tissue by covering the minimal exposed tissue and by preventing further endodontic treatments. $Ca(OH)_2$ was used for indirect pulp capping while treating initial pulpitis.

At 3 months observation period, the clinical success rate was 68% with $Ca(OH)_2$. At 6 and 12 months the clinical success rate was 76% with $Ca(OH)_2$. It indicated that $Ca(OH)_2$ isn't effective in reducing pain and maintain the pulp viability as agent for IPC[11].

Antimicrobial and fungicidal effects

$Ca(OH)_2$ has a high pH (approximately 12.5-12.8). It has bacteriostatic properties which mean it keeps bacteria from actively spreading. Its mechanism of an actions are achieved through the ionic dissociation of $Ca^{(2+)}$ and $OH^{(-)}$ ions and their effect on intact and healthy tissues, the induction of hard-tissue deposition and the antibacterial properties. The lethal effects of $Ca(OH)_2$ on bacterial cells are certainly due to protein denaturation and injury to DNA and cytoplasmic membranes. Hydroxyl ions are highly oxidant free radicals that show extreme reactivity with several biomolecules, causing damaging of proteins and destroy to the bacterial cytoplasmic membrane. The reactivity of hydroxyl ions is high and indiscriminate, diffusing from the generation site [18].

$Ca(OH)_2$ has a wide range of antimicrobial activity against common endodontic pathogens. However, it was unable to kill Enterococcus faecalis in the dentine. $Ca(OH)_2$ continues to have a high pH after setting because material dissolves readily in aqueous solution, liberating hydroxyl ions. This high pH provides a stimulus for tooth to repair itself in absence of bacterial infection [17]. So, calcium hydroxide has excellent antibacterial properties. Some studies have found a 100% reduction in pulp infection associated microorganisms after one hour of contact with calcium hydroxide [10].

C. albicans cells are more resistant to $Ca(OH)_2$ than E. faecalis. $Ca(OH)_2$ provides Ca2+ ions that are essential for the growth of C. albicans which explained the limited or no effect of $Ca(OH)_2$ to fungal infection [28].

C. albicans cells are more resistant to $Ca(OH)_2$ than did E. faecalis.

Dentinal bridge formation

The property of Ca(OH)2 is the ability to induce reparative bridge formation when applied to pulp tissues. However, dentinal bridge contains multiple defects and porosities. The disintegration of CH under restorations associated with porosity in the dentinal bridge can provide a pathway for microleakage and the subsequent stimulation of circulating immune cells, inducing pulpal inflammation because of irritation and potential pulpal calcification and obliteration [3, 21]. The porosity of this dentinal bridge potentially allows recolonization of bacteria, thereby leading to failure of IPC procedures [6].

The mean thickness of the dentin bridge was evaluated on a x-ray at 3 and 6-month post-op. Average thicknesses was 0.121 mm for calcium hydroxide [10].

Solubility

A drawback of the $Ca(OH)_2$ is the high solubility that leads to the formation of tunnel defects due to the dissolution of the $CaOH_2$ underneath the restoration covering it, affecting the seal against bacterial invasion. Irritation, dystrophic calcification, and potential degenerative changes are induced inside the pulp due to these occurrences [12].

Immune response

Alkaline pH of Ca(OH)2 irritates the pulp cells and induces the release of bioactive molecules such as BMP and TGF-β1, which stimulate pulpal repair [2]. Some negative properties of using calcium hydroxide as indirect pulp capping material are lack of inherent adhesive qualities, dissolution over time, and inability to provide a long-term seal against microleakage may account for its inability to suppress inflammation.

In addition, an increased frequency of inflammatory cells and localized areas of pulp necrosis have been reported over time [5].

Also the process of new dentine deposition was delayed and diffuse calcification, with formation of pulp stones was noticed [14].

Calcium hydroxide is called gold standard because of its advantages. They are initially bactericidal then bacteriostatic, promoting healing and repair of the pulp, high pH stimulates fibroblasts, neutralizing low pH of acids, stopping internal resorption, inexpensive and easy to use.

There are some disadvantages which reduces the using of calcium hydroxide for indirect pulp capping during treatment of reversible pulpitis. They are degrading during acid etching, doesn't exclusively stimulate dentinogenesis, does exclusively stimulate reparative dentin, may dissolve after one year with cavosurface dissolution, does not adhere to dentin or resin restoration [16]. The decrease in the number of cells in the culture plate is sizable for calcium hydroxide. It demonstrates lower rates of vitality and a strong cytotoxic capability [13].

The conclusion

Preserving pulp vitality is the therapeutic choice in conservative odontology. Conservative dental pulp treatment reduces the need for more invasive treatment. The maintenance of pulp viability and conduction of reparative dentin can be possible by indirect pulp capping with $Ca(OH)_2$ as IPC agent.

$Ca(OH)_2$ is classified as a strong base with a high pH (approximately 12.8). Its main properties come from the ionic dissociation of Ca^{2+} and OH^- and their effect on intact tissues, generating the induction of hard-tissue deposition and being antibacterial.

There are 3 major causes of failure of $Ca(OH)_2$ as IPC agent:

1. The porosity of the dentin bridge that is produced
2. $Ca(OH)_2$ adhering poorly to dentin
3. Inability to provide a long term seal against microleakage

$Ca(OH)_2$ is widely used, less expensive and gold standard as an indirect pulp capping material, however, it has no anti-inflammatory action.

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