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Nano-Hydroxyapatite Clinical Applications in Dentistry

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Abstract

Because of its osteogenic properties and biocompatibility, nano-hydroxyapatite is becoming more popular in dentistry. The current study's goal is to review the clinical applications of nano-HAp in dentistry. PubMeD and Scopus were used to conduct a literature search. A total of 154 articles were found. Following a review of the titles and abstracts, 122 articles were eliminated. Full-text analysis ruled out another six articles. The systematic review included 26 articles. Nano-HAp was used in three studies for tissue remineralization, eight studies for the treatment of dentin hypersensitivity, two studies for orthodontics, nine studies for graft material, and four studies for periodontology and implantology.

Keywords: Nano-hydroxyapatite • Hydroxyapatites • Dentistry • Operative dentistry

Introduction

Calcium phosphate salts are important constituents of bone and teeth. Calcium apatite makes up 50% of the volume and 70% of the weight of human bone. Hydroxyapatite is a calcium phosphate compound with hexagonal structure and a stoichiometric Ca/P ratio of 1.67, similar to bone apatite. The main mineral that makes up dental enamel and dentin is carbonated calcium-deficient HAp. The inorganic matrix accounts for 96% of the weight in dental enamel, with HAp crystallites ranging in size from 48 to 78 nm. The inorganic matrix accounts for 70% of the weight in mature dentin, with HAp crystallites ranging in size from 60 to 70 nm. When compared to other calcium phosphates, HAp has a high thermodynamic stability under physiological conditions. The ability to chemically synthesise HAp has broadened its clinical applications in a variety of medical fields, particularly due to its osteogenic properties and biocompatibility. HAp synthesis can be accomplished using a variety of techniques, such as dry methods, wet chemical reactions, or mechanochemical reactions, to produce a variety of compounds with varying particle size, shape, and chemical composition. Nano-sized HAp (nano-hydroxyapatite, nano-HAp) is a biomaterial of particular interest due to its size, crystallography, and chemical composition similarities with human hard tissues. While synthesised HAp has a crystal size of 25.40 nm, nano-HAp crystal sizes range from 20 to 80 nm. Because of its biocompatibility and bioactivity, nano-HAp has several applications in dentistry.

Literature Review

Clinical applications of nano-HAp in dentistry have increased in recent years, albeit with mixed results. It has been proposed that various nano-HAp formulations be used to promote enamel remineralization and prevent caries reversal. However, the outcome for nano-HAp toothpaste was comparable to that of fluoride-based toothpaste. However, it should be noted that using a fluoride-free toothpaste may be beneficial in reinforcing tooth structure while lowering the risk of fluorosis. According to a Cochrane systematic review on fluoride toothpaste use in children, tooth decay prevention is proportional to the fluoride concentration used, though the choice of fluoride toothpaste for young children should be balanced against the risk of fluorosis.

Although there is no precise cut-off for fluorosis development, a fluoride intake of 0.05 to 0.07 mg of fluoride per kg of body weight has been suggested. As a result, it is possible to conclude that nano-HAp-based toothpastes can be used safely as an adjunctive means of caries prevention in the absence of fluorosis development risks. The combination with other bioactive materials, such as composites releasing remineralizing substances for secondary caries prevention, should also be investigated. Grocholewicz et al. used nano-HAp in tandem with ozone therapy. Ozone therapy has been reported for the treatment of early caries, but there is currently no reliable evidence that applying ozone gas to the surface of decayed teeth stops or reverses the decay process.

Discussion

Dentin hypersensitivity is the condition where the use of nano-HAp has received the most attention. Hu et al. conducted a comprehensive systematic review on various desensitising toothpastes and identified potassium, stannous fluoride, potassium and strontium, potassium and stannous fluoride, calcium sodium phosphosilicate, arginine, and nano-hydroxyapatite toothpastes as effective agents in relieving dentin hypersensitivity symptoms. de Melo Alencar et al. focused on the use of nano-HAp for the treatment of dentin hypersensitivity, concluding that nano-HAp at-home and in-office treatments effectively reduced hypersensitivity when compared to other desensitising agents or placebo/negative controls. Two studies (reported more favourable outcomes in the nano-HAp treatment groups, two studies highlighted a superiority of nano-HAp especially in the immediate post-treatment) were included in the current review reporting on dentin hypersensitivity.

The remaining five studies did not show that nano-HAp treatment was superior to other desensitising agents. Based on the available evidence, it is possible that nano-HAp could be effective in reducing dentin hypersensitivity, with non-superior efficacy when compared to other desensitising agents. Two studies reported the use of nano-HAp in orthodontics. Nano-HAp was found to be effective in reducing micro-leakage under orthodontic bands26, but no additional effect in reducing tooth discoloration after debonding was observed. The current evidence appears to be extremely limited, making it difficult to draw firm conclusions about the use of nano-HAp in orthodontics. RCTs should be used to conduct additional research.

The use of nano-HAp as a bone graft material and its incorporation with drugs or bioactive molecules has received a lot of attention. The use of nano-HAp to enhance the regeneration process has been reported for

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a variety of purposes. Two studies used nano-HAp for ridge augmentation, and the authors reported overall dimensional stability of the grafted material as well as implant placement success. Another use for nano-HAp is as a filling material for sinus lift. Even with early loading, there was limited bone resorption with high bone density and implant stability. Despite its limitations, the current evidence suggests that nano-HAp may play a role in sinus lift procedures.

Finally, in post-extractive alveolar sockets, nano-HAp was used as a graft material. According to the current literature, de Tullio et al. found that in the absence of graft material, the percentage of vital bone at 5 months was higher than in cases of nano-HAp or calcium sulphate application. In contrast, two studies found that using nano-HAp improved alveolar socket healing, with a higher percentage of mineralized bone and faster healing. Because the evidence is insufficient, additional research on nano-HAp in postextractive alveolar sockets is recommended. Two studies used nano-HAp to treat intrabony defects and found consistent improvements in PPD and CAL after three months. One study looked at nano-HAp retention after root surface treatment with EDTA and concluded that root preparation is necessary before applying nanomaterials.

However, a systematic review by Bral et al. suggested that nano-HAp particles could improve the bio-functionality of the implant by increasing osteoblast proliferation, adhesion, and calcium deposition. Nonetheless, the effectiveness of implant coating with nano-HAp requires additional research. There are some limitations to the current study. Due to the extreme variability in the studies included, no meta-analysis could be performed. Quality analysis revealed a moderate to high risk of bias, with the majority of studies judging operator experience and missing data reporting to be unclear. All of these limitations work together to reduce the reliability of the analysis. Nonetheless, there is a growing interest in the applications of nano-HAp, highlighting the need for additional RCTs on the various applications of this nanomaterial [1-5].

Conclusion

In conclusion, nano-HAp appears to have a great potential in dentistry, with a wide range of applications. The biocompatibility and versatility of nano-HAp encourage the performance of further clinical research to assess the potential of this nanomaterial.

Acknowledgement

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Conflict of Interest

There are no conflicts of interest by author.

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