

Nanodentistry- An Overview

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Abstract:*Nanotechnology has rapidly made its way into various areas of science. Nano dentistry refers to the use of nanotechnology for diagnosing, treating and preventing oral and dental diseases. The field of nanotechnology has a great potential. Nano dentistry facilitates faster and to the point, accurate diagnosis. It enhances the properties of dental materials, which facilitates excellent handling properties and makes the material more durable. A systematic search strategy was employed and articles were found using keywords. Literature was taken from databases like PubMed and Google Scholar. Articles that discussed Nanotechnology and Nanodentistry were included. Other articles which had data regarding the applications were also included. A total of about 70 articles were collected initially. Multiple articles were added later from other sources. After eliminating articles that did not meet the inclusion criteria, more than 30 studies were finally obtained. This review summarized the use of Nanodentistry. The applications and future scope were also discussed in detail.*

Keywords:*Biomaterials;Dentistry;Nanodentistry;Nanomaterials;Nanoparticles; Nanotechnology.*

1. INTRODUCTION:

Nano dentistry refers to the use of nanotechnology for diagnosing, treating and preventing oral and dental diseases. This is done to preserve and improve oral/dental health using nanostructured materials. Nanotechnology is a new field that is developing very rapidly. (Mantri and Mantri, 2013) Nanotechnology has rapidly made its way into various areas of science. With the rate at which this concept is gaining popularity in the field of dentistry, it is sure to bring about a big positive shift in this field.(Abou Neel *et al.*, 2015) The field of nanotechnology has a great potential. If it is developed in an ideal manner and is done efficiently it will be of great use to the human population in terms of better treatment resulting in better health. (Chandkiet *al.*, 2012) Nano dentistry facilitates faster and to the point, accurate diagnosis. It provides enhanced properties to the dental materials, which facilitates excellent handling properties and makes the material more durable. It provides superior hardness and increased flexural strength.

A wide range of studies and reviews have been conducted to study Nanodentistry and its various aspects. A review done by Sasalwaad et al, stated that Nanodentistry is the next big thing but is small. (Shilpa S. Sasalawad , Sathyajith N. Naik , K. K. Shashibhushan , P. Poornima, Shivayogi M. Hugar , N. M. Roshan, 2014) Another article by Aeran et al, aimed to study about Nanodentistry and its applications..(Aeranet al., 2015) The clinical applications, benefits and hazards of Nanotechnology in dentistry were analysed in detail too. (Shashirekha, Jena and Mohapatra, 2017) The recent advances in Nanodentistry were also reviewed. (Izadiet al., 2020) As per a study done by Rao et al, it was stated that Nanodentistry created a new ‘buzz’ in dentistry. (Raoet al., 2013) There are many challenges that can be encountered while employing nanotechnology in fields such as dental, medical and engineering, biological and ethical challenges as well as feasibility. The biological challenges may include the risk of toxicity and incompatibility caused due to the materials. Public acceptance is a huge ethical challenge.(Bumb, Bhaskar and Punia, 2013)) This also portrays a significant potential for misuse.

This research is necessary because it reviews the application of nanotechnology in the field of dentistry. Nanodentistry is an emerging field that has a very great potential. It facilitates easy diagnosis. It improves the durable nature of the dental materials. In addition, it can also improve the durability of teeth because of enhanced dental materials. This review was done to understand in depth about Nanodentistry and its applications. This article reviews the concepts and future applications of Nanodentistry.

Foreword to Nanodentistry:

The medical as well as dental fields have seen a variety of changes in the technology used to provide excellent results. Nanodentistry employs the use of nanotechnology in the field of dentistry. In the year 2000, Nano medicine evolved. Alongside this, the field of Nanodentistry had also started evolving. Nanodentistry makes the maintenance of comprehensive oral health possible by using nanomaterials. (Freitas, 2000; Schleyer, 2000)Nanomaterials in dentistry have been studied extensively so that it helps in overcoming the downfalls of the existing dental materials. Nanotechnology has drawn the attention of many scientists and clinicians because of its significant developments. (Oh et al., 2015) There are 2 main approaches followed in the synthesis of nanoparticles which include top down approach and bottom up approach. The top down approach involves synthesising new substances from existing bigger entities which the bottom up approach involves building up from a molecular and atomic level, to form nanomaterials. (Subramaniet al., 2019) It was already predicted earlier that if nanotechnology is used efficiently it can reach its full potential and provide greater benefits than what are already available. (Panchbhai, 2019)

History:

In the year 1867, the interesting concept of nanotechnology was introduced by James Clerk Maxwell. The term ‘Nanotechnology’ was coined by Kerie Drexler in the earlier days. In the 1920s Zsigmondy brought about the concept of ‘nanomaterials’. He also introduced the term-nanometre. Later in 1965, Richard Feynman won the nobel prize for his lecture which was titled “There’s plenty of room at the bottom”. This lecture introduced the concept of manipulation of materials at a very basic atomic level. (Hulla, Sahu and Hayes, 2015)(Ahmed, Elhissi and Subramani, 2013) At this time, these concepts were just known to be imaginary, but they facilitated a new stream of thinking. In 2000, R.A Freitas introduced the term Nanodentistry. It was his contribution that led to the use of Nano robots in orthodontics, regeneration of dentition and in nanomaterials. In the last few years,

Nanotechnology has been an extremely active field of research because of its undiscovered potentials. (Mirsasaaniet *al.*, 2019)

Brief on Nanotechnology:

Nanotechnology has revolutionised the existing treatment options. (Sharma *et al.*, 2019) Molecular nanotechnology basically is involving the production of materials that fall in the size range between 0.1-100 nanometres. (ZenuJha, Neha Behar, Shiv Narayan Sharma, G. Chandel, D.K. Sharma, M.P. Pandey, 2011) Although the size range of these particles is considerably small, the potential they have is vast. (Gupta, 2011) It is a proven fact that at a Nano-scale, almost every material exhibits a different property than they do at their normal size or even at a larger size. Nanotechnology is a new field of technological innovation that allows the creation and operation of nanomaterials. The nanoparticles employed in this field may lead to nano-toxicity that might cause certain toxic effects. On the other hand, these can be used in nano-medicine to facilitate molecular biology, tissue culture and others.(Tolochko, 2009)(‘Review of Therapeutic Applications of Nanotechnology in Medicine Field and its Side Effects’, 2019)

Bridging Dentistry and Nanotechnology:

Nanotechnology has been used extensively in the field of dentistry. Nano materials are used to solve problems in clinical dentistry. (‘Nanobiomaterials in Clinical Dentistry’, 2019) Though the use of nanotechnology in dentistry is not very well established, it does have a great potential that is yet to be discovered. It can prove to be very beneficial in this field, as it can improve the quality of healthcare and can be beneficial. Incorporation of nanotechnology into the field of dentistry will enhance the biocompatibility of the biomaterials and their properties. It can be said that nanotechnology has brought about a huge revolution in the field of dentistry. It has led to the formulation of new biomaterials and newer techniques used in dentistry.

Nanoparticles in Nanodentistry:

Nanodentistry will allow better quality of oral health through use of nanostructured biomaterials. There has been a lot of significant development in this field over the years. (Karthiga, Rajeshkumar and Annadurai, 2018)These materials are incorporated with Nanoparticles to enhance their qualities. Various nanoparticles are used to attain benefits. For example, Silver Nanoparticles are used because they have the capacity to eliminate the caries causing bacteria. (Şuhaniet *al.*, 2018)Selenium nanoparticles are used in treatment of malignancies due to their anti-cancer properties. (Menonet *al.*, 2018) Plants, their derivatives and their other compounds have therapeutic effects that can be applied and consist of multiple medicinal values.(Ashwini, Ezhilarasan and Anitha, 2017)(Anitha and Ashwini, 2017)(Perumalsamyet *al.*, 2018)(Lakshmi *et al.*, 2015)(Ezhilarasan, 2018) Recently, Herbal Medicine is gaining more importance. (Ezhilarasan, Lakshmi, Vijayaragavan, *et al.*, 2017)(Ezhilarasan, Lakshmi, Nagaich, *et al.*, 2017) Green synthesis of nanoparticles that is plant mediated proves to be very beneficial and effective in treating dental diseases. (Subbiah, Elango and Jayesh, 2019) Green synthesis is a comparably eco friendly approach, it involves lesser costs and lesser use of toxic chemicals.(Rajeshkumar, Venkat Kumar, *et al.*, 2018)(Rajeshkumar, Agarwal, *et al.*, 2018) Metal Nanoparticles are applied in various aspects of dentistry because they present an array of properties like antimicrobial; antibacterials; anti-inflammatory, cytotoxic which can prove to be beneficial. (Song and Ge, 2019)(Gheena and Ezhilarasan, 2019) Nanoparticles in Orthodontics have been used to attain an antimicrobial effect. White spot lesions during orthodontic treatment are common due to plaque accumulation. To avoid this, Zinc Oxide/Nitrogen/Titanium nanoparticles are coated over the brackets. (Batra, 2016) Nanoparticles may also be useful in controlling the formation

of biofilm due to their anti-adhesive properties. (Allaker, 2013) These different types of metal nanoparticles have also been used as intra canal medicaments, obturation materials as well as irrigants in Endodontics. (Kandaswamy, Nagendrababu and Deivanayagam, 2016) Nanoparticles play a very important role in target specific delivery of drugs, this may be a novel therapeutic strategy for treatment of different diseases. (Mehta *et al.*, 2019)(Ezhilarasan, Sokal and Najimi, 2018)

Applications of Nanodentistry:

In dentistry, Nanotechnology has been integrated and research has been carried out extensively. Nanodentistry has been applied to various concepts within dentistry, like implantology, dental biomaterials, dental instruments, bone regeneration, diagnostic tools for oral pathology. (Subramani and Ahmed, 2018) Nano dentistry in administration of local anaesthesia is helpful by preparing a colloidal suspension of micro sized analgesic active particles. After coming in contact with the surface, these Nano robot particles entire via the gingival sulcus or the dentinal tubules and reach the desired location. Dentin Hypersensitivity can be cured by using gold nanoparticles. These nanoparticles form the smallest fillings and are used to fill the affected dentinal tubules.

Prosthodontics and Dental Implantology:

During the process of impression taking, recording all the details accurately without any voids is very important especially when a prosthetic replacement has to be provided. Nanofillers are integrated along with the conventional impression materials to enhance the properties of the material. This prevents the formation of voids in the impression and it has better flow properties. (Thomas, Mathew and Muthuvignesh, 2014) Recently, even nanostructured ceramics are being developed. This leads to an increased strength of the ceramic as well as toughness. (Manu Rathee*, no date) Nanotechnology applied in dental implantology can facilitate the application of mineral content of the bone as a coating over the implant which provides better results. (Paiet *al.*, 2016)

Periodontics:

Recent developments in the fields of Nanotechnology and Nanodentistry have been useful in various treatment processes across different fields, including Periodontics. Nanocomposites have been under study to check if they can be ideal drug delivery systems to manage periodontal diseases. Other dentifrices as well as nanoparticles are being used in this field. (Venkatasubramanyam and Chakravarty, 2018)(TrophimusGnanabagyan Jayakaran1, 2013)

Orthodontics:

In orthodontic treatment, these nanorobots facilitate direct manipulation of the position of the tooth. This makes the treatment rapid and painless. Nanotechnology in Orthodontics has been developed to improve orthodontic bonding. (El-Bialy, 2019) Nanoparticles have a range of activities like anti-inflammatory, anti-microbial, anti-cariogenic. These nanoparticles can be delivered as medicaments through orthodontic ligatures. (Subramani, Subbiah and Huja, 2019)

Restorative Dentistry:

When nano fillers are added to impression materials, their properties are enhanced and it causes lesser voids in the impression so formed. Nanoparticle incorporated composites show enhanced properties of superior hardness and increased flexural strength. This facilitates a better ability to polish the composite and attain a better colour for the tooth. (Kudvaet *al.*, 2013) Nanotechnology can be utilised widely in the field of Endodontics. It can be applied in fillers, irrigants, and composites to yield better results. (Akbarianradet *al.*, 2018)

Oral Medicine:

Nano dentistry can be used to treat oral cancer by the use of nanoshells which produce heat and then selectively destroy the cancer/tumour cells. In oral health, Nanodentistry includes methods that are based on nanotechnology. This is done by means of diagnostic and therapeutic tactics. Nanodentistry will make it possible to provide potential treatment opportunities suiting the needs of the particular case. It can be used to administer local anaesthesia or be a permanent cure to hypersensitivity.

Other applications:

Mouth rinses and toothpastes are already available which are based on nanoscaled mineral content or even purely nanoparticles. (Hannig and Hannig, 2019) Engineered Nanomaterials can have multiple benefits. They can be used to strengthen the structure of the tooth and also act as anti-bacterials to provide infection control. Nanofillers also improve the quality of restorative dental materials. (Besiniset *al.*, 2015)

Added benefits of Nanodentistry:

Nanotechnology involves the use of nano-structured materials that are applied in Dentistry, to achieve better results. ('Nanobiomaterials in Dentistry', 2016) Nanomaterials have gained importance because of their numerous applications in different areas of science. (Zafaret *al.*, 2017) On-going research shows that the application of nanotechnology in dentistry will enhance the quality of dental care. Nano dentistry will make it possible to maintain oral health as close to perfect as possible through the use of nanomaterials. (Kumar PS, Kumar S, Savadi RC, John J, 2011)

Potential Harm:

Nanoparticles may cause harm in the field they are used in. This is because their properties are dependent on their size. A particle could turn toxic as its size reduced from 100nm to 1nm. This would induce toxicity and cause a lot of harm to the patient. The reaction of the patient's body to the nanomaterials is unpredictable. It may cause hypersensitivity or adverse effects which cannot be predicted beforehand. Another possible harm is that these nano sized particles can be inhaled or ingested by the patient. These have the ability to cross cell membranes and reach the liver and bring about severe damage. (AlKahtani, 2018)

Future Scope:

As of now, the use of nanotechnology is limited to the available sources of materials. In the future there will be more developments which will lead to better outcomes. The future utilisation of nanotechnology will yield better results in improvement of oral health status. (SuleTugbaOzak, 2013) In the upcoming years, maybe nanotechnology in dentistry will be successful in administration of drugs and providing gene therapy when required. (Vijayalakshmi and Kumar, 2006) Nanodentistry is known to be the future of dentistry. Dentists collectively believe that within 10-20 years, nanorobots will be efficient enough to provide diagnosis accurately. (Smitha, Naik and Naganandini, 2011) Further research should be conducted in Nanodentistry to ensure an efficient drug delivery system, reduce the toxic effects that are caused. Nanotechnology can also be employed in different fields like agriculture, biomedicines and food. (Verma, Chevuri and Sharma, 2018) Nanotechnology can bring about a major revolution in the health care sector, especially in the field of dentistry. (P, 2014)

2. CONCLUSION:

Nanodentistry is a new approach. It incorporates the advanced methods of nanotechnology into the conventional materials to enhance the properties of the dental materials. Nanotechnology in dentistry has been proved to enhance the properties of existing dental materials and provide more benefits. This field of Nanodentistry has a very bright future because of its great potential. It will lead to greater satisfaction of the patients. This will be because it will enhance the properties of the materials and yield better results than that obtained by using the conventional materials.

AUTHOR CONTRIBUTIONS:

All authors have contributed equally to the review of literature.

CONFLICT OF INTEREST:

None

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