PalArch's Journal of Archaeology of Egypt / Egyptology

# NANO ENABLED TOOTH BRUSHES– A REVIEW

*Ranjeth Rajan KV[1], Dr.Hannah.R[2], Dr. Lavanya Prathap[3]*

[1]Saveetha Dental College and Hospital,Saveetha Institute of medical and technical sciences,Saveetha University,Chennai- 600077.

[2]Senior LecturerDepartment of Oral and maxillofacial pathology,Saveetha Dental College and Hospitals,Saveetha Institute of medical and technical sciences,Saveetha University,Chennai- 600077.

[3]Assistant ProfessoDepartment of Anatomy,Saveetha Dental College and Hospitals,Saveetha Institute of medical and technical sciencesSaveetha University,Chennai- 600077

[1]151901069.sdc@saveetha.com,[2]hannahr.sdc@saveetha.com,[3]lavanyap.sdc@gmail.com

**Ranjeth Rajan KV, Dr.Hannah.R, Dr. Lavanya Prathap. NANO ENABLED TOOTH BRUSHES– A REVIEW-- Palarch's Journal Of Archaeology Of Egypt/Egyptology 17(7), 706-717. ISSN 1567-214x**

**Keywords: Nanoparticles; Silver; Toothbrush; Gold**

## ABSTRACT

Nanotechnology is the art and science of material engineering on a scale of less than 100 nm. It revolutionized the medical and dental fields by improving mechanical and physical properties of materials, and helped introduce new diagnostic modalities and nano-delivery systems. Regular mechanical removal of bacterial plaque is essential to prevent the onset of dental diseases such as dental caries, gingivitis and periodontal disease. Oral hygiene practices involve the thorough daily removal of dental plaque and debris using intra oral cleaning devices. Tooth brushes are the most commonly used oral hygiene aids.This review will aim at giving comprehensive data regarding the various advantages and disadvantages associated with using nano enabled tooth brushes.Article search from various databases like pubmed, scopus and Google scholar were done. The outcome was based on the studies which discussed the advantages and disadvantages of nanoparticles embedded tooth brushes.The collected data was analyzed using appropriate statistical tools. Nanoparticles commonly used were silver. The advantages were antibacterial properties, decreased gingivitis, decreased bad breath. Disadvantages were release of nanoparticles from the toothbrush..As technology advanced, nano enabled toothbrushes came into being as an alternative to manual tooth brushing

## INTRODUCTION

Dental caries and periodontal disease are the most common oral diseases. Etiology being the interaction between human immune system and bacteria of dental plaque(1,2).Tooth brushing is a daily routine which helps to remove plaque from the tooth surface without damaging the adjacent structures(3). Dental plaque has been known to cause many dental diseases including dental caries, gingivitis, periodontitis, tooth sensitivity, tooth discolouration and oral ulceration(4–7). Presently Many nano-enabled consumer products are known to be in the dental products global market. Nanoparticles are created by either following the top down, bottom up, or molecular self-assembly approach(8).Toothbrush is an oral hygiene instrument used to clean the teeth, gums, and tongue. Although manual nylon bristle toothbrushes are the most commonly used, a considerable amount of plaque still persists(9) .

With the advent of nanotechnology, nanoparticle coated Toothbrushes were introduced(10). Each micro-fiber bristle of this brush can cover more surface area of the teeth, and penetrate even the most intricate areas and additionally they possess antimicrobial and anti-inflammatory property(11).The nano toothbrushes have been found to decrease more plaque and gingivitis associated bacteria than manual toothbrushes(12). Although nanoparticles have numerous advantages, they are accompanied with few disadvantages too. The main disadvantage being environmental hazard and toxicity. Waste treatment of currently available nano-enabled consumer products is estimated. Recycling and landfilling may serve as hot spots for EOL treatment of nanoproducts.This limits the scientific investigations of potential environmental effects of these materials, and especially the knowledge of nanoparticles behaviour and potential effects at the end-of-life stage of the products is scarce. Nano silver is the most used nanoparticle in consumer products. Although Nanoparticles embedded toothbrushes have lots of advantages, they are criticized for their toxic effects. However, if brushing of the teeth is not done cautiously, it could result in trauma to the soft tissues as well as hard tissues of the oral cavity. Amongst them,Abrasion is the most commonly associated trauma, usually seen on the cervical margins of teeth.

Numerous studies have been conducted at the university level involving many recent technological advancements in dentistry(13–16). Many surveys have also been conducted inorder to create awareness among the dental students about the recent advances(17–20). This has encouraged us to perform this review on nanoparticles embedded in tooth brushes(21). This review will aim at giving comprehensive data regarding the various advantages and disadvantages associated with using nano enabled toothbrushes.

## MATERIALS AND METHODS

Article search from various databases like pubmed, scopus and Google scholar. Articles published between 2010 and 2020 were included in the study. The outcome was based on the studies which discussed the advantages and disadvantages of nanoparticles embedded tooth brushes.The collected data were analyzed using appropriate statistical tool.The Type of study is Review study. The Timeline of included articles are published between 2010 and 2020 . Inclusion criteria enabled to include randomised control trials and invitro

studies. Exclusion criteria included, Review articles. Articles that were retracted and Articles in other languages than English. Outcome measures were Nanoparticles used, Methodology employed, Advantages and disadvantages.The title of the articles and the abstracts were first reviewed.Then the full text of selected articles were retrieved and further analysed.The collected data tabulated.

## RESULTS AND DISCUSSION

For this study ,6 Articles were collected from pubmed and google scholar (2010 to 2020) and analyzed. Nanoparticle commonly used was Silver. The other nanoparticles employed were gold and zinc. Advantages were antibacterial activity, decrease in gingivitis, decreased bad breath. Disadvantages were the release of nanoparticles from the tooth brush. The properties exhibited by silver nanoparticles were good antimicrobial properties. The disadvantages were poor antimicrobial activity and release of silver nanoparticles (Table 1).

Nanoparticles are known to have large surface area and better antimicrobial and anti gingivitis properties. Nanoparticles used in nano enabled toothbrushes are silver, zinc, gold. Silver nanoparticles are the most preferred of all because of its good antimicrobial activity and its longevity(8). Gold nanoparticles were found to have both bacteriostatic and bactericidal activity. The main advantages as already enlisted include its antibacterial property and protection against inflammation of the gingiva(10). Nano Enabled toothbrush majorly cuts down on bacteria both within the mouth and the tooth brush itself. The bactericidal property of gold nanoparticles is due to the penetration of bacterial cell walls and killing them instantly.

The nano enabled tooth brushes effectively helps in removing plaque in people with limited mobility. When compared to uncoated toothbrushes, nano-enabled brushes decrease Streptococcus mutans count significantly and also enable low plaque scores. These bristles of these brushes were also found to have more nonviable bacteria than conventional nylon bristles. Although there are many advantages, the main disadvantage is the release of nanoparticles from toothbrush bristles. These released nanoparticles could pose to be a risk factor causing potential environmental hazard and cytotoxicity(11). So further studies are required to research on the toxic effects of these released nanoparticles from the tooth brushes

### Silver Nanoparticle

Silver nanoparticles is one of the most common metal nanoparticles(22). It is known for itantimicrobial activity and antioxidant property. It has many applications as coatings over clothes, electronic devices, wound dressings and biomedical devices in order to release nanoparticles continuously in small amounts so that a protective antibacterial property is rendered (9)(23).The use of silver in oral care has been known for centuries and has attained worldwide recognition in the 19th century as the main component in dental amalgams(24). Fusarium oxysporum have been used to reduce the silver ions (25). The silver nanoparticles thus formed range between 5 and 15 nm and also consist of silver hydrosol (22). silver found in the environment is usually

considered to be quite safe. But there are numerous reports regarding the environmental and health risks of silver nanoparticles when ingesting as they can be toxic (26).

Silver is the most frequently used nanoparticles. Its use has been advocated in various forms for the restoration of teeth. Because of their high biological activity and ability to bind to the dentin apatite and tooth enamel they are considered with prime importance(11). But the greatest risk associated with chronic exposure to colloidal silver is argyria. Although intake in small supplements is believed to aid in wound healing, improve skin disorders, and prevent or treat diseases certain infectious diseases and even cancer (23).Nanoparticles have been embedded in toothbrushes in order to exploit its antimicrobial property which is rendered both to the oral cavity asn as a self cleansing mechanism for the bristle. But the disadvantage found is that Ag NPs can be released from commercially available toothbrushes and can lead to potential consumer oral exposure and environmental exposure(9). From the two commercially available toothbrushes that were tested, the adult toothbrushes showed slightly higher Ag release both in terms of total Ag release and Ag NP release(11). Hence further research is required to improve the design inorder to retain the silver nanoparticles in the bristle and also understand the side effects of silver nanoparticles better .

**Gold Nanoparticles**

Gold nanoparticles are small gold particles with a diameter of 1 to 100 nm which, once dispersed in water, are also known as colloidal gold(27). Gold nanoparticleshave been deeply studied, revealing an ability to enhance the electronic signal when the bioreceptor detects the analyte at very low concentrations, for example, gold nanoparticle modified DNA bioreceptor detects an analyte at a concentration as low as 0.05 nm(28).The optical-electronics properties of gold nanoparticles are being explored widely for use in high technology applications such as sensory probes, electronic conductors, therapeutic agents, organic photovoltaics, drug delivery in biological and medical applications, and catalysis(29). Even though, it is generally accepted that plain gold nanoparticles are toxic both in vitro and in vivo in a certain range of concentrations.With proper surface modifications the toxic effect can be reduced or even eliminated.Gold nanoparticles are quite dense, thus allowing them to be used as probes for transmission electron microscopy. To detect biomarkers in the diagnosis of cancers, heart diseases, and infectious agents(28). These nanoparticles are a fraction of the size of human hair and are less than 100 nm in diameter. Nano gold particles are so small that they are generally found as a colloidal solution, which means that the gold nanoparticles are suspended in a liquid buffer.Gold nano enabled toothbrushes are particularly useful for those looking to whiten their teeth in a natural way. It merges the antibacterial properties of gold(10) .

**Table 1:** Characteristics of included studies

| Name of the author | Year | Article title | Nano particle used | Type of study | Method used | Advantage | Disadvantage | Conclusion |
|---|---|---|---|---|---|---|---|---|
| Hamal J D et al (3) | 2014 | An in vitro comparison of antimicrobial toothbrushes | Silver | Invitro | microbiological analysis - plate count assay | - | No significant reduction in CFUs Streptococcus mutans and Candida albicans | Does not deliver the advertised claim of a 99.9% reduction in CFUs |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Al-Ahmad A et al (8) | 2010 | An antimicrobial effect from silver-coated toothbrush heads. | Silver | In vitro | microbiological analysis - plate count assay | - | no significant reduction in CFUs - Streptococcus oralis, Streptococcus mutans, Streptococcus sanguis, Actinomyces viscosus, Lactobacillus casei and Candida albicans | Silver-coating did not improve any antimicrobial effects - residual bacteria present on the toothbrush head. |
| Ozgul Baygin et al(9) | 2017 | Short-term antibacterial efficacy of a new silver nanoparticle containing toothbrus | Silver | Randomised control tro | microbiological analysis plate count assay, visible plaque inde | Significantly decreased Streptococcus mutans | - | Eliminate the remaining bacteria on the bristles. |

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|---|---|---|---|---|---|---|---|---|
| | | h | | lled clinical trial | x and ging ival bleed ing inde x | | | |
| Pa vi th ra Du rg es h et al( 10 ) | 2 0 2 0 | Micro bial conta mina tion and plaqu e score s of nanog old-c oate d tooth brus h | g o l d | R a n d o m i s e d c o n t r o l l e d tr i a l | micr obio logi cal analy sis - plat e coun t assa y, Plaq ue scor es | sign ific ant ly low er am ou nt of mic rob ial cont am ina tio n as com par ed to unc oat ed toot hbr us hes | - | nano - gold toot hbru shes hold prom ise as a mec hani cal aid. Mor e resea rch - clini cal appl icab ility of nano - gold toot hbru shes |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | and low plaque scores | | . |
| Mackevica A et al (11) | 2017 | The release of silver nanoparticles from commercial toothbrushes. | silver | in vitro | inductively coupled plasma-mass spectrometry | - | Increased release of silver nanoparticles from the toothbrush (2.8%) | Ag NP-impregnated toothbrushes can cause consumer as well as environmental exposure to Ag NPs. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Johnson, C. R. et al (12) | 2020 | Nano-Enabled, Antimicrobial Toothbrushes – How Physical and Chemical Properties Relate to Antibacterial Capabilities | Silver and zinc | in vitro | ThermoiCAP Q Inductively Coupled Plasma - Mass Spectrometer, Amitimicrobial assay | More no nviable bacteria on the bristle surface. (Staphylococcus epidermidis and Rothia dentocariosa) | 76% of silver and 59% of zinc nanoparticles released. Increase - bacterial cell acumulation -surface - Ag/Zn bristles. Decreased antimicrobial activity after use. | Ag or Zn content alone is insufficient to predict antimicrobial property - further governed by the bioavailability and surface topography of Ag or Zn at the bristle surface. |

**Zinc Nanoparticles**

Zinc oxide nanoparticles are also metal nanoparticles with diameter less than 100 nanometers(30). They have a large surface area relative to their size and high catalytic activity. The exact physical and chemical properties of zinc oxide nanoparticles depend on the different ways they are synthesized. They

can be synthesized using physical methods, chemical methods and green methods. Zinc oxide is most commonly used in sunscreens, it is larger and provides greater UVA protection than titanium dioxide products(3).

Some studies indicate that nanoparticles in large doses can harm living cells and organs.Nano zinc oxides are increasingly used in the cosmetics and the paints & coatings sectors. Especially in the cosmetics sector, nanozinc oxides are used for making different skin creams and lotions(31). Growing customer awareness and demand for reliable and safe cosmetic products could support product penetration.Zinc oxide nanoparticles are known for their excellent antimicrobial and antioxidant activity. Zinc oxide nanoparticles can thus be used embedded in tooth brush in order to render its antimicrobial activity to both the oral cavity and the toothbrush bristles. Green zinc oxide nanoparticles are also known to counteract all the side effects of chemically prepared zinc oxide nanoparticles. Further research is required to enhance the use of these nanoparticles in tooth brush.

The main limitation of this study is the limited studies on this topic. With a sharp increase in nanotechnology, use of nano enabled toothbrushes in everyday practice is not very far.

## CONCLUSION

Weighing the advantages and disadvantages of nano enabled toothbrushes based on the evidence available, there is a lot of potential for improvement in the design and function of these toothbrushes in order to make its function more evident and widely useful. Potential disadvantages include high cost and toxicity, this can be overcome by using more green methods to manufacture the nanoparticles..

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