



Silver Nanoparticles and Its Application in Pediatric Dentistry: A Review

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Abstract

Dentistry's main objective is to preserve the oral cavity because it serves as a doorway to the entire body. Most dental illnesses are primarily caused by plaque biofilm, and while many biomaterials have been used to treat them, restrictions related to the material qualities preclude realization of desired results. Nanotechnology, the term currently revolutionized the research field associated to particles at nanometer scale (1–100 nm). Nanoparticles (NPs) can occur naturally be industrially engineered or exist as byproducts. With their greater surface to volume ratio, these materials are more reactive as compared to non-nanoscale particles. This unique property makes these materials as fillers/modifier of choice in different products and materials, whereby they play a vital role in improving the properties. Silver NPs find use in many devices that are used in medical procedures, in therapies and molecular diagnostics, including dentistry. However, the recent studies showed concern about environmental and health associated risks with their use. Applications of nanoparticles (NPs) in dentistry have found utility in endodontics, periodontics, restorative dentistry, orthodontics, and the treatment of oral cancer. Due to its antibacterial qualities, silver nanoparticles (AgNPs) have been used in dentistry and medicine. AgNPs have been added to biomaterials to stop or lessen the growth of biofilms. They provide an excellent antibacterial effect without altering the material's mechanical qualities because of their high surface-to-volume ratio and small particle size. AgNPs are distinguished by this special quality, which makes them the preferred filler for a variety of biomaterials where they significantly enhance the characteristics. In this review, the impact of adding AgNPs to various biomaterials used in paediatric dentistry will be discussed.

Keywords: *Silver Nanoparticles, Its Application, Pediatric Dentistry*

Introduction

By manipulating shape and size at a nanoscale scale, nanotechnology is the design, characterization, and application of structures, devices, and systems (1 nm to 100 nm).[1] Silver nanoparticles are among the many nanoparticles that have attracted the greatest attention for research in recent years. Since many years ago, wound dressings, catheters, and prosthesis have all been made using silver (Ag) ions or salts, which are known to have a broad antibacterial impact. Ag is a powerful antibiotic, but it also has several benefits, including minimal toxicity, strong biocompatibility with human cells, long-lasting antibacterial activity due to continuous ion release, and little bacterial resistance. In dentistry, silver nanoparticles are used to develop antibacterial materials to improve the quality of the dental appliance for a better treatment outcome.[2]

Silver nanoparticles are added to a variety of dental materials, including acrylic resins, root canal fillings, glass ionomer cement, and pit and fissure sealants, to enhance microbial growth inhibition and the physical properties of the modified materials. This is done because silver nanoparticles have the ability to prevent microbial colonisation.[3] Reviewing the literature on specific silver nanoparticle properties and their uses in paediatric dentistry is the goal of this paper.

Production of Silver Nanoparticles: There are physical, chemical, and biological ways to make silver nanoparticles. Both top-down and bottom-up techniques can be used to make silver NPs. In the top-down approach, bulk metals are mechanically ground, and the resulting nanosized metal particles are then stabilised by the addition of colloidal stabilisers.[4,5] Contrarily, the bottom-up techniques use sonodecomposition, electrochemical processes, and metal reduction. The simplest approach involves reducing the metal salts AgBF_4 chemically with NaBH_4 in water. The NPs that are produced in this manner range in size from 3 to 40 nm.[6] There is also the electrochemical approach, which entails the electroreduction of AgNO_3 in aqueous solution in the presence of 10 nm-diameter polyethylene glycol nanoparticles.[7] In order to produce silver nanoparticles with a diameter of 20 nm, sonodecomposition uses ultrasonic vibrations to cause cavitation, a phenomenon in which the passage of ultrasonic waves through an aqueous solution results in small bubbles that eventually burst.[8]

Moreover, employing microwave radiation with a varied frequency, silver NPs are reduced. This approach is quicker and produces a higher concentration of silver NPs between 15 and 25 nm in size. Using aqueous foams as a template is another way to create NPs. The resultant NPs are aerosol stabilized and range in diameter from 5 to 40 nm.[9] Chemicals that are poisonous and dangerous are used in the physical and chemical processes, raising questions about the health of the environment and

living things. Hence, using less expensive, ecologically friendly biological approaches would be an alternative. The majority of biological techniques used fungi, bacteria, and plant extracts.[10,11]

Application in Pediatric Dentistry

Silver Nanofluoride (NSF): Fluoride and silver nanoparticles have recently been combined in novel compositions. The effectiveness of the silver nanofluoride suspension against cariogenic infections and its cytotoxicity were both examined in-vitro. 33.54 g/ml was the tested MIC, while 50.32 g/ml was the tested MBC. The readings were identical when compared to Silver diamine fluoride (SDF). Unfortunately, the discoloration of the enamel surface was not assessed in this investigation.[12]

A formulation using fluoride, silver nanoparticles, and chitosan as a carrier was also assessed. Dental cavities were treated with a single application of this customized varnish, and observation intervals of seven days, five months, and twelve months were recorded. At the seven-day mark, 81% of the samples had arrested cavities; at the five-month mark, 72.7% of the samples still had arrested carious lesions; and at the 12-month mark, 66.7% of the samples still had arrested carious teeth. The enamel of the teeth was free of dark and black stains.[13]

Similar to this, a fluoride varnish with silver nanoparticles was tested for its ability to remineralize primary teeth with white spot lesions. After being examined with the DIAGNOdent laser wand, anterior primary teeth were added to the research. Fluoride varnish and silver nanoparticle powder were combined at a weight percentage of 0.1%. One tooth in each quadrant received the experimental fluoride varnish coating, while the opposing quadrant received the standard fluoride varnish coating. For three weeks, the therapy was administered once each week. At three months, follow-up examinations were conducted using the DIAGNO dent to assess changes in remineralization. After treatment with silver nanoparticles, it was discovered that the rate of remineralization was greater than that of plain water.[14]

Orthodontic Application

Individuals receiving orthodontic treatment are more likely to develop caries or white spots. AgNPs have been employed in orthodontics because of their antibacterial properties to either stop enamel demineralization or microbial adherence. To increase bond strengths and stop cavities or white spots from forming, they have been employed as coatings on orthodontic brackets as well as in cements or adhesives. [15, 16]

Silver Nanoparticles Modified Glass Ionomer cement (GIC)

Glass ionomer cement (GIC), which can release and store fluoride, is used extensively in paediatric dentistry. Fluoride inhibits the bacterial enzyme enolase, therefore this release transforms this cement into an anti-caries agent.[17] However, to preserve its anti-caries action, this material needs to be periodically supplied with fluoride. In this situation, GIC would be more effective at fending off oral illnesses if it were impregnated with long-lasting antimicrobial compounds. A biomaterial with antibacterial activity against both Gram-positive and Gram-negative bacteria was produced via the association of GIC with AgNP. According to the authors, the oxidative disintegration in the cement matrix caused by the release of silver ions, which inhibits tooth caries and prevents the growth of oral biofilms, is what causes the antimicrobial action.[18,19]

Silver Nanoparticles modified Pit and Fissure Sealants

The effectiveness of pit and fissure sealants with additional silver nanoparticles was assessed by Salas-López EK et al. In compared to traditional sealants, the microleakage of this novel sealant was evaluated in first permanent molars. It was discovered that the silver nanoparticles mixed sealant showed 33.6% microleakage on average, compared to 30.6% for the conventional sealant. Moreover, the silver nanoparticle sealant group displayed a marked decline in fluorescence. The adhesion of the pit and fissure sealants with silver nanoparticles showed an average difference more than 25% between the groups. The silver nanoparticle group had a tendency to diminish fluorescence faster. This suggested that the teeth tended to remineralize when the microorganism caused its demineralization.[20]

Pediatric Endodontics

In order to improve the results of endodontically treated teeth, materials utilised in root canal therapy should be able to destroy bacteria. Effective root canal treatment depends on eliminating bacteria. The most often used filler substance in root canal therapy is gutta-percha. Gutta-percha with a nanosilver covering was created by Shantiaee Y et al. in 2011 and tested for microleakage in obturated teeth. Although the results were similar to those of regular gutta percha, the nanosilver coated version had somewhat reduced leakage.[21]

Safety concerns

Toxicology is one of the important factors in using silver nanoparticles in biomedicine. The toxicity brought on by nanomaterials is known as nanotoxicity. Over the years, numerous in vitro and in vivo experiments have been conducted to investigate the toxic effects of AgNPs on living tissues and organisms.[22] The factors that affect the toxicity of AgNPs include particle shape, size, and surface chemistry; crystallinity; capping agents; ionic strength; pH; and the presence of ligands, divalent cations, and macromolecules.[23] Due to the exposed and complex nature of AgNPs, uncertainty (and to some degree controversy) remains regarding the extent to which each constituent ion, ion-protein complex, and particle contributes to cellular toxicity.[24] In some in vitro studies, it has even been reported that AgNPs cause oxidative stress and disrupt the mitochondrial function of human cells.[25] AgNP toxicity is inversely correlated with the activity of the free Ag⁺ ions produced by the NPs. The negative effects these NPs have on living cells have caused major concern, despite the fact that they show amazing promise for a wide range of applications. Further downsides include dental materials becoming stained when they come into contact with silver Nanoparticles and corrosive agents. These NPs with antibacterial characteristics endanger marine life when they are introduced into the environment. To solve these problems, new strategies and approaches must be discussed and considered.[11]

Conclusion

The term "nanotechnology," which is now revolutionizing the field of study pertaining to particles at the nanometer size. Nanoparticles can be created artificially, organically, or as byproducts of other processes. These materials are more reactive than non-nanoscale particles due to their higher surface to volume ratio. This special quality makes these materials the preferred fillers and modifiers in a variety of goods and materials, where they significantly enhance the qualities. Pediatric dentistry has seen a bright future with silver NPs. Yet, there are some difficulties that need to be researched and further explored in order to be resolved. We are optimistic about the future of these tiny particles.

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