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Silver Nanoparticles and its Medical Applications

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Abstract
Silver nanoparticles may penetrate cell wall of bacteria, altering membrane structure and killing cells. Nanoscale size and a high surface-to-volume ratio contribute to their effectiveness. Silver ions enhance cell membrane permeability, create reactive oxygen species and inhibit DNA replication. 1–100 nm silver nanoparticles. Physical and chemical approaches are costly and hazardous for assembling silver nanoparticles. This method is non-toxic and eco-friendly since it uses plant fluids, microbes, and fungus. Nanotechnology is a fast-growing area with biomedical applications. Silver is a nontoxic antimicrobial and disinfectant. Silver nanoparticles are antibacterial, antiviral, and antifungal. Best alternative is biological approach. Medical applications Therapeutic and detection uses for silver nanoparticles. Silver nanoparticles have downsides due to their antibacterial Nano-toxicity. Methodology, synthesis, silver nanoparticles have pharmacological and biological uses. Infertility management, antimicrobial effects, skin damage, burns Comprehensive cancer therapy overview.
Keywords: Nano particles, silver Nano particles, applications of Nano particle, Nano technology.

I. Introduction

Nanoparticle shapes vary by use. Spherical, diamond, octagonal, and thin-sheet silver nanoparticles are prevalent. Some silver oxides have a silver-atom-rich surface. Their huge area contracts many tendons. In laboratory and animal research, silver nanoparticles suited for human therapy were evaluated for biological safety and survival. Nanoscale silver vs. macroscale Physically and chemically distinct. Antimicrobial properties of silver nanoparticles have indeed been investigated for use in dentistry. Acrylic resins, which are used in the treatment of prostheses and partial dentures; composite polymer, which is used in the treatment of restorative dentistry; endodontic irrigating solution; obturator material; orthodontic adhesive materials; periodontal outer layer for directed tissue regeneration; and implant placement titanium coating; all of these could potentially benefit from the addition of silver nanoparticles. Ingested silver ions have not been shown to cause any systemic damage in any study. Their impact on the natural world is cause for concern. When interacting using hazardous compounds and chemical molecules, nanoparticles may either increase or lessen the toxicity of the environment. This research discusses the antibacterial mechanism of silver nanoparticles, as well as their potential applications and safety in the field of dentistry.

II. Sliver Nanoparticles

Silver nanoparticles' effect on bacteria is unknown. Morphology of bacterial cells and its putative operational mechanism are suggested. Nano-silver vs. other salts Exhibit antibacterial characteristics; their biggest area improves microbe interaction. Silver nanoparticles within E. coli cells are antimicrobial. Protoprotein accumulates after short-term exposure. Silver nanoparticles may target bacterial membranes, which might disrupt proton drives. Silver nanoparticles generate a molecular weight fraction in bacterial cells. So, bacteria protect DNA against silver nanoparticles. Nanoparticles assault the respiratory chain, killing cells. Various researchers report antibacterial silver NPs. Inside and outside of the cell membrane, sulfur-producing proteins generate amino acids. They're linked to silver. Inactivated bacterium. Silver nanoparticles emit silver ion, which inhibits enzymes that connect with Sulphur-containing phosphorus and DNA proteins. Size and shape affect antibacterial action. Quantitative research shows that NPs smaller than 20 nm induce maximal penetration through to the Bacterial cell membrane and cell death. ABC Nanotech sold 99.98% pure silver nanoparticles. Precursor-induced plasma system incorporated silver nanoparticles like silver wire. Citrate stabilized silver nanoparticles. Percent of silver ions in 3 kDa silver nanoparticle particles evaluated by cellulose filter centrifugation. Unfiltered silver nanoparticles were suspended and analyzed using ICP-MS. Silver nanoparticles' soluble silver content in unfiltered silver nanoparticles, silver was multiplied by 100 and divided by silver in filters.

Dental antimicrobials derived from silver nanoparticles have already been investigated. Acrylic resins for dentures in prosthetic limbs treatment, reinforcement polymer in replacement therapy, endodontic irrigating remedy as well as debonding material, orthodontists' adhesive materials, periodontium membrane for oriented tissue regeneration, as well as implant placement titanium coating could all benefit from the addition of silver nanoparticles. Silver nanoparticles could also be added to implant placement titanium coating. There is no evidence that ingested silver ions cause any kind of systemic damage. The damage they do to the environment is cause for concern. When interacting with potentially harmful substances and molecules of a chemical, nanoparticles may either increase or reduce the toxicity of the system. This research focuses on the mechanism through which silver nanoparticles inhibit the growth of bacteria, as well as their potential applications and safety.

III. Biocompatibility of Nano Technology with Nanoparticles

Surface-modified silver nanoparticles increase medication delivery and intracellular absorption. The plasmatic characteristic of nanoparticles of noble metals on particular cell types or inside individual cells, such as silver utilised for imaging & cancer therapy. Imaging and targeting certain locations are beneficial. Silver nanoparticles' photosynthetic characteristics kill cancer cells and tumours. Silver nanoparticles can mark cells at low doses. Biodegradable polysaccharide-coated silver nanoparticles While maintaining normal cell morphology, nitrite extensions are attached to the cell surface. Nanoparticles supply biomedical energy because their size and structure are comparable to biological molecules. Different ways of packaging silver nanoparticles are being studied for scale applications. Toxic chemicals, energy, and traditional synthesis demand greater temperature and pressure. Green chemicals technology may be used instead of these chemical processes to reduce or eliminate hazardous material generation. Recent green chemistry strategies for metal nanoparticle production Nano researchers are focusing on development. Silver nanoparticles, eco-friendly solvents, and biodegradable packaging for hazardous compounds Includes renewable nanoparticle-producing materials. Polysaccharides and light chemistry are behind these approaches. Polysaccharides, phytochemicals, microbes, and yeasts create noble metal nanoparticles. These economical and alternative methods may incorporate silver nanoparticles intracellularly and extracellularly. Plant-based goods Their microscopic surroundings, such as extracellular matrices, affects skin cell behaviour (ECM). Gelatine ECM was employed as a biodegradable polymer. GE is a collagen product found in animal tendons, cartilage, and connective tissue. Low cost, low antigen density, high biological function, biocompatibility, and biodegradability make GE appealing in biological applications. GE doesn't denature during electrospinning, despite the electric field. GE, which decomposes quickly at body temp, reduces tissue regrowth. Pure GE NF matting as scales, very fragile. Nanoparticles are nanotechnology's building components. Nanoparticles as bactericide delivery vehicles New antimicrobial design paradigm. Low toxicity, high efficiency, and biocompatibility are desired in biological nanomaterials. A cold-tolerant strain of S. Platensis may produce an antibacterial, anti-cancer silver nanoparticle. Antibacterial and anticancer silver nanoparticles from Pursuant to section Platensis cold-resistant strain Biocide with usefulness.

IV. Mechanism of a Nanoparticles

Microbes encounter metals and metalloids, and biochemistry develops metal resistance mechanisms. Complex skin compounds, intracellular precipitation, and metal ion radix are some of these processes. By Replacing Cellular Flux Pumping System, solubility and toxicity change. Most metals combine the aforementioned strategies to achieve resistance and equilibrium. Cellular machinery converts metal ions to metal. Although the nanoparticle set's dynamics are not fully known, bacterial genes in silver nanoparticle formation and numerous ideas have been offered to elucidate the involvement of proteins. Next, silver causes AgNP-induced cancer cell apoptosis. Cellularity of nanoparticle impacts Normal lung cell molecular pathways IMR-90 and U251 brain cancer cells were investigated. Silver nanoparticles may absorb cytosolic proteins, influence intracellular variables, and control gene expression including anti-inflammatory cytokines. Microarray analysis is used in cellular transcriptome study; the human lung is epithelial line A549. This research shows silver nanoparticles change the sequence of over 1000 genes. Antibacterial measures for silver nanoparticles have not been thoroughly explained. Silver nanoparticles release silver ions to destroy bacteria. Silver ions bind to the membrane due both gravity and sulphur proteins. Resin ions may enhance cytoplasm membrane permeability, and bacteria can damage the sheath. Respiratory enzymes remain inactive after ingesting free silver ions, creating reactive oxygen species and interfering with ATP synthesis. Agents may degrade cell membranes and convert DNA. Since sulphur & phosphorus are DNA components, silver ions in DNA transcription create difficulty halting bacteria. Silver ions in the cytoplasm reduce ribosomes, inhibiting protein synthesis. Fungi-made silver nanoparticles Steps include: Fungal Ag^+ capture Fungal enzymes reduce silver ions. Naphtha and anthrax quinones Extracellular enzymes assist reduction, as in Oxispore, NADPH-based nitrate reductase, and the shuttle queen process, causing nanoparticle production. Involved in fungus producing silver nanoparticles, however the specific algorithm is not entirely known. Microorganisms are slower than plant extracts in synthesising silver nanoparticles. Silver nanoparticles including plant extracts are viable.

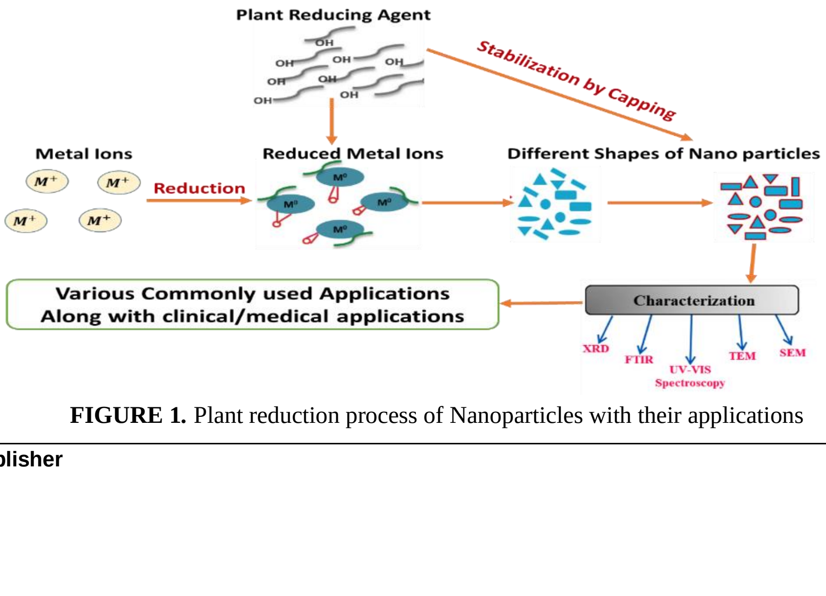

FIGURE 1. Plant reduction process of Nanoparticles with their applications

V. Silver Nanoparticles with its Antibacterial Mechanism

Various antibacterial mechanisms have been postulated for silver nanoparticles' antibacterial properties. Silver nanoparticles emit silver ions, destroying bacteria. Free silver ions may deactivate respiratory enzymes, creating reactive oxygen species but stopping ATP synthesis. Reactive oxygen species may damage cell membranes and DNA. As Sulphur and phosphorus are key DNA components, silver ions may interfere with Replication of DNA, cell reproduction, or kill microbes. Silver inhibits protein synthesis by denaturing cytoplasmic ribosomes.

Antimicrobials Nano-silver silver nanoparticles don't travel on the surface when dealing with amino silica due to their antibacterial activity. No silver nanoparticles leaked from the antibacterial surface in aqueous media. Better disinfection of immobilized silver nanoparticles in glass substrate; Silver underfoot Releases in ionic form; nevertheless, the quantity of silver inside the solution is contained in the suspension and silver plate. Pulp silver nanoparticles have no antibacterial activity and are much smaller than silver nanoparticles, yet they have the same size and form. Comparing silver nanoparticles to silver ions, e.g., Very goal-oriented. Silver's antibacterial property depends on its quantity and release rate. Inert silver reacts with skin moisture and wound fluid to become ionized. Ionized silver binds with tissue proteins, Bacteria It binds to the cell wall, causing membrane cell degeneration & structural death. Silver inhibits bacterial growth by binding to DNA and RNA. Alkaline metal and crystalline aluminosilicate Ion exchange silver zeolite. Silver ions partly replace. Japan makes antibacterial silver zeolite ceramics. Food safety, medical supply disinfection, and item cleaning are potteries. Antimicrobial bulk or surface coatings are alternatives to antibiotics. Drug-resistant bacterial species limit the preventative use of antibiotics. To avoid bacterial contamination in medical devices Biofilms are made using silver nanoparticles. Nanoparticles are deposited on device surfaces or employed in polymeric coatings. Slowly escaping silver destroys surface microorganisms. As an antibacterial agent in medical devices, silver's specific antimicrobial action is not established. Medical devices Variable silver antibacterial activity.

VI. Clinical Applications of a Silver Nanoparticles

Antimicrobial properties of silver nanoparticles have indeed been investigated for use in dental applications. Acrylic resins, which are used in the treatment of prostheses and partial dentures; composite polymer, which is used in the treatment of restorative dentistry; endodontic irrigating solution, as well as obturation material; orthodontic adhesive materials; periodontal membrane for guided tissue regeneration; and implant placement titanium coating; all of these could potentially benefit from the addition of silver nanoparticles. It has been shown that ingesting silver ions does not result in any systemic adverse effects. Concerns have been raised over the damage they do to the environment. When interacting using dangerous waste and chemical compounds, nanoparticles may either increase or lessen the toxicity of the surrounding environment. This research discusses the antibacterial mechanism of silver nanoparticles, as well as their potential applications and safety levels, in the context of dental care.

Prosthetic-Treatment using Silver Nanoparticles: Dentures are often made of acrylic resin. Oral bacteria may colonise acrylic, producing dental stomatitis. Silver nanoparticles added into the acrylic resin suppress Streptococcus mutans, E. coli, and S. aureus growth. Acrylic resin containing silver nanoparticles provides antifungal activity against Candida albicans, a significant opportunistic infection on denture bases.

As potential antimicrobials for use in the mouth, silver nanoparticles have indeed been investigated. Acrylic resins, which are used in the treatment of prostheses and partial dentures; composite polymer, which is used in the treatment of restorative dentistry; endodontic irrigating solution, as well as obturation material; orthodontic adhesive materials; periodontal outer layer for directed tissue regeneration; and implant placement titanium coating; all could benefit from the addition of silver nanoparticles. Ingested silver ions have not been shown to cause any systemic damage in any studies. Concerns have been raised about the damage they might do to the environment. When interacting with potentially hazardous materials & chemical compounds, nanoparticles may either increase or lessen the toxicity of the situation. This research examines the antibacterial action of silver nanoparticles, as well as their potential applications and safety, in the context of dental care.

Restoration-Treatment using Silver Nanoparticles: Secondary caries may be caused by germs that are still present within the prepared tooth cavity as well as by microleakages at the contacts between the tooth and the restoration. Adhesives and composite resins may include silver nanoparticles. Low-concentration antimicrobials prevent subsequent caries. Cariogenic bacteria suppress biofilm growth in restorative adhesives using silver nanoparticles. Silver ions released daily from composite resin containing silver nanoparticles showed no meaningful impact on fibroblasts. Researchers embedded silver nanoparticles inside a biocompatible polymer coating to destroy microbes without harming humans.

Silver nanoparticles have the potential to improve the strength of porcelain. The hardness & fracture toughness of porcelain are both contributed to the residual compression load that is produced when a particle reaction is combined with the thermal expansion of silver nanoparticles.

Endodontic-Treatment using Silver Nanoparticles: In endodontic intracanal irrigation, silver nanoparticles may replace sodium hypochlorite. Gutta-percha coated using silver nanoparticles is used to seal root canals. Antibacterial silver nanoparticles are added to mineral trioxide aggregation to improve pulp capping, apexing tooth, and also perforation filling in teeth.

When it comes to disinfecting endodontic root canals, the use of sodium hypochlorite is indeed the gold standard. Dentine's tensile properties and flexural strength are both decreased by sodium hypochlorite, and it also irritates the periapical tissues. Irrigation of the root canal with solutions containing silver nanoparticles had no effect on the mechanical properties of the dentine. In a different piece of research, scientists found that silver nanoparticles had a higher level of biocompatibility over sodium hypochlorite. A watering solution that included silver nanoparticles was equally effective as sodium hypochlorite in killing the bacteria Enterococcus faecalis & Staphylococcus aureus. There is a school of thought that suggests using solutions containing silver nanoparticles for endodontic endodontic treatment irrigation.

Root canal obturation uses gutta-percha. Gutta-antibacterial percha's capabilities are limited. Gutta-percha coated using silver nanoparticles was equally effective as ordinary gutta-percha in inhibiting bacterial leakage. Gutta-percha-coated silver nanoparticles and ordinary gutta-percha had the same fibroblast cytotoxicity and subcutaneous tissue reaction/inflammation.

Mineral trioxide aggregate is used for pulp-capping, apexification, and perforation sealing. Mineral trioxide aggregate needs antimicrobial chemicals to be antibacterial. Mineral trioxide aggregates enhanced antibacterial action against anaerobic endodontic infections. Silver nanoparticles increased mineral trioxide aggregate's antifungal activity against Candida albicans. Incorporating silver nanoparticles into mineral trioxide aggregate increases pH, compressive strength, radiopacity, and setting time.

Orthodontic-Treatment using Silver Nanoparticles: Silver nanoparticles reduce enamel caries, a common orthodontic issue. It is possible to reduce the formation of biofilm using adhesives that contain silver nanoparticles. Silver nanoparticles, which are effective against enamel caries, may be used as a treatment for orthodontic ligatures. By releasing silver ions, they have the potential to reduce the adhesion of Mutans to various surfaces. Over the course of four months, the material may emit silver ions, which have antibacterial properties. Biocompatible silver nanoparticle compositions aren't cytotoxic or mutagenic. The components might result in a light irritation as well as delayed-type hypersensitivity. There is no change to the mechanical properties, such as shear bond strength.

Dental Implant Treatment using Silver Nanoparticles: Peri-implant infection threatens implant therapy. Due to the possibility of infection during peri-operation, conventional antibacterial treatments are ineffective. Due of their safety and antibacterial qualities, silver nanoparticles are used to dope implant surfaces.

By controlling the release of silver ions, the researchers were able to demonstrate the long-term antibacterial influence that silver-coated titanium implants have. It is possible that the antibacterial activity of implants might be increased by immobilizing silver nanoparticles on their surfaces. When inserted into bacterial cells, silver nanoparticles inhibit bacterial growth without killing the organisms. Because of their greater capacity for proton consumption, larger silver nanoparticles placed in titanium had a greater antibacterial activity. In low concentrations, silver nanoparticles are lethal to the bacteria Staphylococcus aureus and Pseudomonas aeruginosa, but they have no effect on osteoblastic cells. Titanium that has been infused with silver nanoparticles has the potential to increase bone density, bone development, and trabecular patterns without causing damage to the tissues that are nearby.

Periodontal-Treatment using Silver Nanoparticles: Chronic periodontitis is caused by microorganisms. Biofilm disruption and inflammation suppression are necessary for periodontal therapy. Silver nanoparticles are antimicrobial without causing bacterial resistance. When coupled with medicines including cefotaxime, ceftazidime, meropenem, and ciprofloxacin, silver nanoparticles boost bactericidal effects. When coupled with silver nanoparticles, dormant medicines regain antibacterial action against multi-resistant pathogens. Synthesized silver nanoparticles may suppress periodontal-infecting gram-negative bacteria. Smaller silver nanoparticles were more effective against oral anaerobic pathogens. Intra-bony defect therapy employing guided nature tissue repair outer layer called membrane containing silver nano-particles improves medical progress.

Silver nanoparticles modulate inflammatory growth factors and cytokines to reduce inflammation. Silver-nanoparticle-coated periodontal dressing helps cure gingival wounds. This therapy speeds wound healing by promoting collagen production and neovascularization. Some silver nanoparticles may cause irritation in periodontal dressing.

VII. Precautions of Silver Nano-particles while in Dental Applications

Silver nanoparticles worry some of the researchers. Free silver ions cause silver nanoparticle toxicity. Silver nanoparticles' microscopic size may disrupt biological molecules, cells, and organs. Silver nanoparticles may produce oxidative stress and decrease mitochondrial function, according to lab research. Massive silver nanoparticle dosages may be identified in organs, particularly the liver and spleen. Silver nanoparticles may pass the blood-brain barrier through trans-synaptic transport and also accumulate inside the brain, raising concerns.

Silver nanoparticles reduce inflammatory cytokines & angiogenesis even at low concentrations. Anti-inflammatory silver nanoparticles. fibroblasts and keratinocytes are biocompatible. Organs may eliminate silver in 8 weeks. Silver nanoparticles orally administered to rats had no harmful effects. Another clinical investigation found no clinically significant harmful effects from colloidal silver. Mineral trioxide aggregate containing silver nanoparticles could not inflame rat subcutaneous tissues. High-silver-nanoparticle periodontal dressing is biocompatible when gingival wound healing. Although regulators haven't completely recognized silver nanoparticles' safety, physicians use them in wound dressings. Because of a wound, silver nanoparticles may enter the body. The silver Nano-particles circulate to the liver and spleen. Ingested silver nanoparticles' systemic toxicity is unknown. If unleashed, they might harm marine life. When silver nanoparticles interact using materials and chemical substances, their toxicity may rise or decrease. Nanoparticles may hurt or aid the environment. Nanomaterials must be evaluated to assure human and environmental safety.

VIII. Conclusion

several uses for silver nanoparticles in medical technology, including silver nanoparticle wound dressing. Textile textiles include coatings. The inside and exterior of Devices might be coated to lessen their antibacterial action because of the uncontrolled discharge of silver ions. Dental materials' mechanical characteristics and antibacterial qualities may be improved by adding silver nanoparticles. Many scientists think that silver nanoparticles may continuously discharge silver ions to kill germs, even if the exact mechanism behind their antibacterial properties is still poorly known. Silver nanoparticle-containing dental materials are being created in greater quantity for prosthetic, therapeutic, endodontic, orthodontic, periodontal, and implant treatments. According to several laboratory research, human cells are cytotoxic to silver nanoparticles. The potential toxicity for silver nanoparticles is yet unclear from a therapeutic perspective. Because there is currently a lack of clinical data, further research is required. Financial Disclosure: This study received no grants from commercial or non-profit organizations. Conflict of Interest: The authors declare that they have no conflicts of interest in this work.

References

[1] Kesharwani P, Gorain B, Low SY, et al. Nanotechnology based approaches for anti-diabetic drugs delivery. Diabetes Res Clin Pract. 2018;136:52–77. doi:10.1016/j.diabres.2017.11.018

[2] Saravanan M, Barik SK, Mubarakali D, Prakash P, Pugazhendhi A. Synthesis of silver nanoparticles from Bacillus brevis (NCIM 2533) and their antibacterial activity against pathogenic bacteria. Microb Pathog. 2018;116:221–226. doi:10.1016/j.micpath.2018.01.038

[3] Oves M, Aslam M, Rauf MA, et al. Antimicrobial and anticancer activities of silver nanoparticles synthesized from the root hair extract of Phoenix dactylifera. Materials Science and Engineering: C. 2018;89:429–443. doi:10.1016/j.msec.2018.03.035

[4] N. Yogeesh. (2021). Mathematical Approach to Representation of Locations Using K-Means Clustering Algorithm. International Journal of Mathematics And Its Applications, 9(1), 127–136. Retrieved from http://ijmaa.in/index.php/ijmaa/article/view/110

[5] Samuel MS, Jose S, Selvarajan E, Mathimani T, Pugazhendhi A. Biosynthesized silver nanoparticles using Bacillus amyloliquefaciens application for cytotoxicity effect on A549 cell line and photocatalytic degradation of p-nitrophenol. J Photochem Photobiol. 2020;202:111642.

[6] Pugazhendhi A, Edison TNJI, Karuppusamy I, Kathirvel B. Inorganic nanoparticles: a potential cancer therapy for human welfare. Int J Pharm. 2018;539(1–2):104–111. doi:10.1016/j.ijpharm.2018.01.034

[7] Shanmuganathan R, Karuppusamy I, Saravanan M, et al. Synthesis of Silver nanoparticles and their biomedical applications - A comprehensive review. Curr Pharm Des. 2019;25(24):2650–2660. doi:10.2174/1381612825666190708185506

[8] Yogeesh N. "Graphical Representation of Mathematical Equations Using Open Source Software." Journal of Advances and Scholarly Researches in Allied Education, vol. 16, no. 5, 2019, pp. 2204-2209 (6), www.ignited.in/p/304820.

[9] Bapat RA, Chaubal TV, Joshi CP, et al. An overview of application of silver nanoparticles for biomaterials in dentistry. Mater Sci Eng C. 2018;91:881–898. doi:10.1016/j.msec.2018.05.069

[10] 23. Gad MM, Fouda SM, Al-Harbi FA, Napankangas R, Raustia A. PMMA denture base material enhancement: a review of fiber, filler, and nanofiller addition. Int J Nanomedicine. 2017;12:3801–3812. doi:10.2147/IJN.S130722

[11] Yogeesh N. "Study on Clustering Method Based on K-Means Algorithm." Journal of Advances and Scholarly Researches in Allied Education (JASRAE), vol. 17, no. 1, 2020, pp. 485-489(5), www.ignited.in//I/a/305304.

[12] Bacali C, Baldea I, Moldovan M, et al. Flexural strength, biocompatibility, and antimicrobial activity of a polymethyl methacrylate denture resin enhanced with graphene and silver nanoparticles. Clin Oral Investig. 2019. doi:10.1007/s00784-019-03133-2

[13] Dias HB, Bernardi MIB, Marangoni VS, de Abreu Bernardi AC, de Souza Rastelli AN, Hernandes AC. Synthesis, characterization and application of Ag doped ZnO nanoparticles in a composite resin. Mater Sci Eng C. 2019;96:391–401. doi:10.1016/j.msec.2018.10.063

[14] Ai M, Du Z, Zhu S, et al. Composite resin reinforced with silver nanoparticles–laden hydroxyapatite nanowires for dental application. Dent Mater. 2017;33(1):12–22. doi:10.1016/j.dental.2016.09.038

[15] Yogeesh N. "Mathematics Application on Open Source Software." Journal of Advances and Scholarly Researches in Allied Education [JASRAE], vol. 15, no. 9, 2018, pp. 1004-1009(6), www.ignited.in/p/304819.

[16] Meng M, Li XC, Guo JW, et al. Improving the wear performance of feldspathic veneering porcelain by ion-exchange strengthening. J Dent. 2019;90:103210.

[17] Sugiharti R, Widyasar E, Rusminah N, Mustika I. Evaluation of silver nanoparticles addition in periodontal dressing for wound tissue healing by 99mTc-ciprofloxacin. J Young Pharm. 2019;11(1):17–20.

[18] Yogeesh N. "Mathematical Maxima Program to Show Corona (COVID-19) Disease Spread Over a Period." TUMBE Group of International Journals, vol. 3, no. 1, 2020, pp. 14-16.

[19] Mazumder JA, Khatoon N, Batra P, Sardar M. Biosynthesized silver nanoparticles for orthodontic applications. Adv Sci Eng Med. 2018;10(12):1169–1173. doi:10.1166/asem.2018.2289