The Review Of
DIABETIC
STUDIES OPEN ACCESS

The Impact Of Using Nanotechnology In Dentistry

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Abstract:
One area of medicine where nanobiotechnology is having a positive impact in a number of ways is dentistry. This review's goal is to educate readers on the many applications of the nano-dental complex, or nano dentistry, in healthcare and how emerging technologies are transforming the dental industry. A methodical strategy was used to gather the most recent information on dentistry and nanotechnology from sources such as Scopus, Google Scholar, PubMed, and official websites like the WHO. Using nanomaterials, nanorobots, and nanotechnology to identify, treat, and prevent dental conditions is known as "nano dentistry," and it is a rapidly developing area of dentistry. This present study will assess the development in the said area of dentistry and the sources of data will be secondary in nature. The time frame of the study will 2015 to 2023.

Keywords: Nano-Technology, Dentistry, Development, Innovation.

Introduction:

The discipline of healthcare biotechnology is always investigating new technological treatments for improved global healthcare management. Nanotechnology is one of the crucial components of healthcare that, when combined with other modern technologies, keeps medicine's perspective forward-thinking and pertinent. Jandt et al (2020); Malik et al (2023) In order to identify, treat, and prevent dental disorders, a new area of dentistry called "nano-dentistry" uses nanomaterials, nanorobots, and nanotechnology. Delivering therapeutic and diagnostic substances precisely and precisely is the main goal of nano-dentistry. Because of the small scale of nanomaterials—0.1 to 100 nm—nanotechnology is a branch of molecular manufacturing or engineering that includes structurally adjusting the properties of materials. Barot et al (2021)

By increasing the effectiveness of dental instruments, drugs, and therapies, dental health science presents chances to improve patient happiness. Additionally, it concentrates on improving the mechanical strength and kinetic reactivity of dental materials to provide stronger, more functional, and more visually beautiful products with improved biocompatibility. Amissah et al (2021); Gauba et al (2019) In the end, this makes handling dental goods simpler and more effective, which benefits both patients and professionals. Numerous dental procedures, including cavity repair, teeth whitening, and orthodontic therapy, can benefit from the extensive uses of nano dentistry. Additionally, it can be utilized to create novel materials that are more biocompatible, stronger, and long-lasting as well as to increase the longevity of dental restorations.

The creation of nanorobots that can be taught to carry out specific dental tasks, like cleaning and mending teeth, is one of the most exciting developments in nano dentistry. In addition to operating at the molecular

level, these nanorobots can be remotely controlled by magnetic fields. Subramani et al (2019) In summary, the current study aims to investigate how nano dentistry has transformed dentistry by offering less intrusive, more comfortable, and more accurate treatment alternatives. Furthermore, this study aims to investigate the implications of nanotechnology in dentistry in the areas of cosmetics, industrial, and aesthetic applications as well as diagnostics, preventative medicine, treatment alternatives, restorative, and individualized medications. Kennedy et al (2019)

The advancement of dental materials over time, which has given them improved mechanical qualities, durability, antibacterial activity, strengthening qualities, pain-reduction strategies, and quick recovery methods, will also be highlighted in this study. The main ramifications of nano-dental materials will also be covered, including metal needles, anesthetic components, ceramics, glass ionomers, nanocomposites, and nanorobots, among others. Contera et al (2020) In conclusion, a succinct descriptive analysis will be given to discuss the amazing uses of nano dentistry when it comes to reinventing and revitalizing positive oral healthcare management. All things considered; researchers can use nanotechnology as a tool to investigate a broad range of ongoing, cutting-edge nano-dental technology development with the perspective of improved healthcare management. Deepali et al (2021); Patel et al (2020)

Research Methodology:

We sought to limit the data on the most recent revisions; therefore, we used a query method that involved searching major search engines like Google Scholar, PubMed, Scopus, and some official websites like the WHO to gather pertinent data, primarily from the previous five years. Soto et al (2020); Buniyamin et al (2022) Nanotechnology, nano dental, nanomaterials, nanocomposites, nanometals, dental nanomaterial, nanorobots, and dentistry were among the search terms utilized. About 100 pertinent articles that addressed "Nanotechnology in Dentistry" were chosen and examined for inclusion in the current study, as will be explained in more detail in the following section. Peer review journals, reviews, research studies, brief letters to the editor, and magazines pertinent to nano dentistry were among the articles chosen from the search results, which were restricted to the previously mentioned keywords. The search process initially accounted for about 150–170 articles; however, we made an effort to restrict data derivation to the most highly cited and comprehended publications. Because of a lack of thorough accessibility and comprehension, data that lacked the specifics of books, technical reports, theses, dissertations, articles, or conference proceedings were shunned. For the sake of international comprehension, this review study only included English-language literature. Mirsasaani et al (2019)

General Findings and Researcher's Observation

The size and structural makeup of nanomaterials determine their physiochemical characteristics. Below is a table that provides a quick discussion of some of the most important nanomaterials.

Application of Nanotechnology in Dentistry

Nano-glass ionomers are created by combining traditional glass ionomers with nanoparticles. Nanomaterials can benefit from polishing, increased wear resistance, and aesthetics thanks to non-holonomic systems. Joseph et al (2023) Together with other nanomaterials including fluor aluminosilicate glass, nanofillers, and nanoclusters, a bonded nanofiller technology-based formulation of ionomer cement is treated to improve its mechanical qualities. When used as hardened restorative materials, these nanofillers enhance the teeth's physical characteristics. They have greater flexibility, compressive strength, and transparent qualities. It's been demonstrated that they outperform traditional glass ionomers. They can also be applied to surfaces that are exposed to topical fluoride sources because of their capacity to release fluoride. Haleem et al (2023); Foong et al (2020) They can be utilized in a variety of dental fillings and are very excellent at preventing cavities when exposed to acid.

Additional uses for noncolumnar nanomaterials could include core buildups, sandwiched restorative technologies, better crystallization qualities, and a variety of therapeutic indications. Better-class glass ionomers are frequently made using bioactive materials such as fluorapatite and hydroxyapatite. Nano-hydroxyapatite, nano-fluorapatite, and chitosan nanoparticles are a few significant examples. Because of

the decreased shrinkage and polymerization properties that enhance filler volume and decrease resin matrix, nanocomposites have a more noticeable aesthetic use. Prabakar et al (2023); Kochan et al (2022) With higher fluorapatite and knowledgeable mechanical resistance, they also stop tooth decay. In addition, the nanocomposites' great strength and ion-releasing capabilities enable them to effectively repair fractures and prevent dental cavities. Up to a point, the mechanical strength gains more from the increasing amounts of nanofillers due to the enrichment qualities of nanocomposites, which also directly aid remineralization. Agnihotri et al (2019)

In few documented instances, inorganic fillers at the nanoscale are utilized in nanocomposite denture materials. These fillers are notable for their exceptional color retention, durability, and high abrasion resistance qualities as compared to acrylic or microfibre compositions. Filtek Supreme is one example of a dental nanocomposites that contains glass particles and amorphous calcium phosphate (NACP). The heat-cured PMMA enhanced with nano-zirconium oxide improves dispersion, flexibility, transverse strength, biocompatibility, and denture harnessing while decreasing aggregation. Uppal (2021); Sreenivasalu et al (2022) These nanoparticles are utilized in removable prosthodontics and resin matrices. Utilizing nanoparticles like sodium triphosphate (TP) or tri-metaphosphate (TMP) in chlorhexidine coatings for soft liner dentures is an additional purpose. These coatings give coatings and fillings their antibacterial qualities. Dissanayaka et al (2023)

Additional nanomaterials utilized in prostheses include cement loaded with nanoparticles, which strengthens the link between enamel and dentin. Endodontic dentistry has advanced significantly thanks to nanotechnology. Calisir, et al (2019); Guo et al (2023) With positive results, nanoparticles are utilized in a variety of endodontic applications, including fillers, composites, sealers, root healing materials, and photodynamic treatment. Endodontic therapy is enhanced by the use of nanoparticles with antibacterial and anti-leakage qualities as disinfectants in a variety of dental applications. Different forms of bio-ceramic nanoparticles, like as zirconia, glass ceramic, and bioglass, are found in endodontic sealers. These particles make a strong link with the dentin and release calcium and phosphate ions. Amorphous calcium phosphate (ACP) nanoparticles, 2-methacryloyloxyethyl phosphorylcholine (MPC), and di-methylamino hexadecyl methacrylate (DMAHDM) are a few examples of these sealers. Nandagopal et al (2023)

Nanotechnology Applications in Orthodontics:

The orthodontic industry is seeing advancements in the usage of nanorobotics and nanocomposite formulations. Some animal studies support the use of nanorobots and nanoelectromechanical devices to speed up tooth repair and movement techniques. Umapathy et al (2022); Padmanabhan et al (2023) Likewise, research has expanded on the application of nanoparticle-based delivery systems (elastomeric ligatures) by demonstrating anti-cariogenic fluoride, which has anti-inflammatory, anti-cancer, and antibacterial effects in the dental matrix. Due to the enhanced efficiency and timer perseverance of nanorobots, smart brackets with nanomechanical sensor technology also outperformed traditional bracket devices. Reducing traumatic side effects and improving tooth movement predictability have been made possible by three-dimensional force movement systems. Ali et al (2023); Zakrzewski et al (2021)

The inclusion of nanoparticles in these brackets prevented plaque formation, decreased biofilms, accelerated the healing process, and created an intimacy effect. Orthodontic bracelets retain plaque and encourage the formation and growth of biofilms, lowering pH and demineralizing the enamel. In order to minimize side effects and modify the applied force within the biological range, they also developed a real-time feedback system. Bhushan et al (2022)

Nanotechnology Applications in Periodontics and Implantology

Modern dental methods known as regenerative nano dentistry, nano-periodontics, and nano-implantology use nanomaterials, nanoscale structures, and processes to regenerate and repair diseased or damaged bone, gum, and tooth tissues. Nanoparticles are gradually used in these dental specialties in a variety of combinational compositions. Dentin is the inner layer of a tooth that makes up the majority of its structure. Regenerative nano dentistry uses materials and methods at the nanoscale to regenerate this layer. Utilizing nanodiamonds, hydroxyapatite nanoparticles, and other nanomaterials, this method can promote teeth's

inherent ability to regenerate new dentin layers and restore broken or diseased teeth. Hossain et al (2022); Vasiliu et al (2021)
Here, periodontal illnesses that impact the gums and the bone tissues that support the teeth are treated by nano-periodontics technicians using nanomaterials and nanoscale structures. In order to eradicate bacteria, lessen inflammation, and encourage tissue regeneration, this method makes use of nanoparticles that can deeply enter gum tissues. Chandra et al (2020); Sakthi et al (2022) Likewise, osseointegration—the process by which a dental implant fused with the surrounding bone tissue—is encouraged by nano-implantology, which makes use of nanoporous titanium surfaces. With the application of nanoporous coatings, this technology can expand the dental implant's surface area, improve bone cell attachment to the implant surface, and encourage quicker tissue regeneration and recovery. Wang et al (2022)

Nanotechnology Applications for Hypersensitivity Management:
A typical tooth problem brought on by exposed tooth roots is hypersensitivity. The usage of dentine tubules, which isolate and shield tooth roots from outside pain stimuli, is one method of treating hypersensitivity. Fernandez et al (2021); Butrón et al (2020) The hypersensitivity problem is permanently resolved when patients' dentine tubules are filled with nanorobots, which gradually obstruct the sensitive tubules. These dental tubules are where gold nanoparticles are most commonly utilized. Additionally, by desensitizing, inhibiting microtubules, and decreasing the number of microtubules in mineralizing agents, reconstructive dental nanorobots can also selectively control hypersensitivity. Castro-Rojas et al (2021); Mohamed et al (2023)

Nano-dentistry:
One area of dentistry called "preventive nano dentistry" makes use of nanotechnology to stop tooth decay and other issues with oral health. In order to prevent or cure tooth damage at the molecular level, nanoparticles and materials are used. Nanocomposite fillings, which are composed of particles the size of nanometers and resemble the natural mineral structure of teeth, are one use of preventive nano dentistry. Mousavi et al (2021); Radhi et al (2021) Compared to conventional composite fillings, they are more robust, long-lasting, and less prone to break. In a similar manner, coatings of nanoparticles are put on teeth to stop bacteria from adhering to them, lowering the risk of gum disease and tooth decay. Xu et al (2022); He et al (2021) Applying nanoparticles to toothpaste is another innovative way to make toothpaste with particles as small as nanometers that can pierce tooth enamel and act as a barrier to prevent cavities. Similar to this, early detection of oral health issues like gum disease or tooth decay by tiny nanosensors enables prompt intervention and treatment. Yazdanian et al (2022) Additionally, broken enamel can be repaired or remineralized by applying nanogels to the teeth, preventing cavities and tooth decay. By offering more effective and efficient means of treating and preventing oral health issues, preventive nano dentistry holds the potential to completely transform the dental industry. It might lessen the need for invasive surgeries while also improving overall dental health outcomes. Thangavelu et al (2022)

Nanotechnology Applications in Diagnosis:
By enabling more precise and effective diagnostic methods, nanotechnology in dentistry holds the potential to completely transform diagnosis and treatment. Smart dental probes are small, nanoscale sensors that can identify early indications of tooth decay by examining the chemical makeup of a tooth's surface. This is one example of how nanotechnologies are being employed in dental diagnosis. Pushpalatha et al (2022); Moradpoor et al (2021) Unlike traditional X-rays, smart probes may provide photographs of a tooth's surface, giving dentists more precise and comprehensive information. Small nanoscale instruments known as nano biosensors are able to identify proteins in saliva linked to a number of oral illnesses. Dentists can more easily diagnose and treat diseases because to biosensors' rapid ability to detect bacterial or fungal infections. Raja et al (2019)
In a similar vein, the broad field of nanoparticle imaging allows nanoparticles to draw attention to oral illness or inflammatory regions. Dentists can detect and treat oral cancer more easily since nanoparticles can also be used to target cancer cells. In a similar vein, invasive treatments can be avoided by using nano-

based drug delivery devices to administer medications directly to damaged or diseased oral regions. This strategy can improve therapeutic efficacy and reduce adverse effects.
Advanced research techniques in the field of dental science are made possible by nanotechnology in these many ways. A new optical phenomenon brought forth by dental laser technology more recently readily enters micropores at the demineralization foci when irrigated in the oral cavity. Karthikeyan et al (2019); Gulati et al (2023)
These techniques have shown promise in the pathophysiology and diagnosis of illnesses. Biosensor technologies that contain biological diagnostic features and have the potential to be widely implemented in oncology are examples of other diagnostic devices. All things considered, nanotechnologies are creating fascinating opportunities for more accurate and effective dental diagnosis and treatment. Gupta et al (2020) We may anticipate seeing more creative use of this technology in dental treatment as research progresses. Nagarale et al (2022)

Other relevant Uses:
Invasive dentistry uses dental adhesives, a kind of restorative dentistry. By serving as glues between compostable materials and resins, nano-adhesives, nano-sized fillers, and nano-reinforced bonding agents enable technicians to create more conservative designs for cavity protection, enhance mechanical qualities, and support healthy tissue. The Adpe Single Bond Plus Adhesive (St. Paul, MN, USA) is a significant example of a nano-adhesive. In a similar vein, nanotechnology has transformed the field of surface disinfection by creating nano-sized droplets that are effective against infections through the use of nano-emulsions. Sterilization and incision technologies can use these nanoparticles to avoid postoperative infections by killing minute germs, including viruses. Nagarale et al (2022); Ha et al (2019)
Another significant application is the production of surgical sutures using nano-stainless steel needles and crystals, which provide effective microscale dental and periodontal procedures. Nano-needles, nano-piers, and nano-forceps are possible additional recently introduced dimensions that give surgical instruments better molding qualities and surface detailing capability. Bordea et al (2020); Sinjari et al (2019) The last step is the reduction of medium biofilm development and tooth roughness through nano-dental ultrafine teeth polishing. In addition, it defends against harmful germs and cancer-causing microbes while enhancing aesthetics and tooth restoration. Altwaijri et al (2020)

Some short-Comings:
Despite the fact that nanotechnology has many uses in dentistry, it's critical to recognize the limitations of its ongoing use. These constraints are social, ethical, mechanical, chemical, and biological. Accessibility and cost control of nano-dental products are the first obstacle. Another drawback is that these products are difficult to market in nations with weak economies, sluggish R&D, and already financially strapped healthcare systems. Creating biocompatible nanomaterials to guarantee their compatibility with the human body presents another difficulty. Given their reduced size, nanoparticles can readily penetrate human skin cells, the lungs, and the blood–brain barrier, raising possible health risks. Additionally, hypersensitivity reactions may result from the oral surface becoming hypersensitive and hyperactive to nanoparticle emulsions. Vellaichamy et al (2023); Samanta et al (2022); Raura et al (2020)

Conclusion:
The quality, appearance, durability, wearing characteristics, resistance, sensitivity, and hyperactivity of teeth have all been improved thanks to nano-dental research, as this article has shown. Nanotechnology is anticipated to develop further and find additional uses in the realm of health science. Gupta et al (2022); Choubisa et al (2022) This forecast is predicated on the possible advantages and cost-effectiveness, the hazards related to nano-dental research, and the socio-environmental, public, and vocational benefits. While attempting to address its shortcomings, scientists have been delving deeper and deeper into the realm of nano-dental science throughout time. Sen et al (2020) Future studies should focus on overcoming the constraints imposed by the nano-dental sector and adjusting the sociocultural and economic agenda to the clinical applications of nano dentistry. In the near future, nano dentistry is expected to take the place of

traditional treatment modalities. Scientists must continue to be committed to nano-research at this time, handle constraints, perform safety evaluations, and create marketing, acceptability, and promotional plans in order to gain practical acceptance.

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