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Nano Robotic Dentistry-Transforming Fiction into Reality

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ABSTRACT

Nanorobotics is anticipated to play an important role in future of healthcare. Using Nano robots in dentistry is expected to enhance accuracy, reproducibility and reliability. Nanodentistry is the most recent application of nanotechnology that has proven to be beneficial for diagnosing, treating, an d preventing oral and dental problems. In recent years, with the emergence of new technologies in dentistry has enhanced t he potential to alter dental practise in a variety of ways. Nanodentistry, with the use of nanorobotics, nanomaterials, and bi otechnology may soon be able to maintain near perfect oral health. These machines usually show up in different sizes from 0.1 to 10 micrometre. Dental nano-robots might be trained to crawl and swim within human tissue using a unique motility mechanism. Nano robots use is diversified; however, in dentistry its role is very significant. Despite the fact that Nano robot research as well as clinical trials are still in their premature phases, researchers are positive about their potential use in dentistry.

Key words: Nano robots, Nano dentistry, Nanotechnology

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INTRODUCTION

Increasing interest in the future of dental applications of nanotechnologies has led the development of a new area known as Nano dentistry [1]. Nanorobotics is a smart system made up of nanostructured materials that range from 1.0 to 100.0 nanometres in size and have an overall size of less than a micrometre [2]. According to the nanorobotics theory, computer-controlled microscopic devices must collaborate to complete both microscopic and macroscopic tasks [3,4]. Nano robots in the long run, provide fast diagnosis, eradication, individual cell surgery *in vivo*, and natural physiological function improvement [5]. The several dental applications can be its use to re-align and straighten crooked teeth, improve tooth durability, oral analgesia, desensitise teeth, and manipulate tissue [6,7]. Thus, they can be used in preventive, operative, curative, and tooth restoration procedures. Nanorobotics are generally utilised to construct and implant biologically regenerative replacement teeth which includes mineral and cellular components, resulting in comprehensive dentition replacement treatment [8]. According to the researchers, dental Nano robots can be used to eradicate caries-causing bacteria as well as to heal tooth defects. While Nano robots are not visible to the naked eye, imaging techniques like Scanning Electron Microscopy (SEM) and Atomic Force Microscopy (AFM) are used to examine them [9].

LITERATURE REVIEW

During the first decade of the twentieth century, Zsigmondy made a first detailed observation and size measurement of nanoparticles [10]. Nanorobotics is a rapidly developing field that emerged in the late 1990 s [2]. In the late 1990 s, the word "Nano robot" was coined by the robotics community. Prof Eric k Drexler created the term nanotechnology. Eric k. Drexler and Robert A. Freitas are two leading innovators in nanorobotics. They are robotic devices that can accomplish tasks at the nanoscale. Nanorobotics has gradually evolved to encompass the elements as nanorobotics system design, fabrication, programming, and control of robotic system. It became famous among the common people with the help of science fiction films, Televisions shows, and literature. Richard Feynman, a Nobel Prize-winning physicist, investigated the consequences of matter manipulation in 1959. In 1959, he declared at the American Physical

Society, that "There is plenty of room in the bottom". He ended his speech by noting, "I believe this is a development that cannot be averted". Freitas presented his Nano dentistry hypothesis, which he defines as "the science and technology that allows for the preservation of excellent dental hygiene [11].

Mechanism of action

Nano robots are made up of a variety of components, like carbon, hydrogen, sulphur, oxygen, Nitrogen, silicon and fluorine [2]. Carbon (C) in the form of diamond is the most prominent element on the Nano robots' outer surface [12]. The other elements are employed for a variety of purposes, including nanoscale gears and the manufacture of other components [13]. Propulsion in the body might come from glucose or other natural alternatives, along with oxygen. They have specialised biochemical or molecular components based on the work to be accomplished [14].

Nano robots may be powered by metabolizing

- Glucose
- Oxygen
- External acoustic energy

Remaining internal power might be employed to provide the required energy to the gadgets [1]. These devices might be programmed to function with on-board processors that can execute 1000 or more computations per second [12]. These computers will be able to maintain and stockpile the records and also be able to carry out pre planned activity [15]. Broadcast-type auditory signals can be used to communicate with the device. A navigational network might be implanted in the body to offer a clear image of passing Nano robots so that their whereabouts can be tracked. This makes it easier for clinicians to keep track of all the different sensors throughout the body. These Nano robots might be capable of distinguishing among various cell types by studying cell surface antigens. Chemo tactic sensors attached to particular antigens on target cells are used to achieve it. When the Nano robots have served their mission, they may be eliminated by allowing them to pass *via* normal human excretory pathways or active scavenger systems can also get rid of them [10].

According to current theories, dental Nano robots should be able to communicate in at least two ways

- With the doctor who is in charge of the coordination [12].
- It should join forces with the other Nano robot.

The following are the four major components of a Nano robot

- Camera
- Payload
- Capacitor
- Swimming tail

Several Nano robot designs have been proposed, but multi-armed spider-like arrangement appearing to be the most optimal design since they are speedy in completing their task and are also in multitasking [15]. Diamonded structures are used to make these Nano robots [2]. The surface must be very-smooth so that when Nano robot is implanted inside the body, it does not provoke immune system, allowing them to function effectively. A Nano computer in the dental Nano robot will perform pre-programmed duties, accept process signals, communicate, and react to various tracking devices. It makes sure that Nano mechanical components work properly. The manufacturing process will include sensing devices, actuator, and control, and fuel, communication, also interfacing beyond spatial scales and in organic or biotic systems [12].

Applications of Nano-dentistry

Nanocomposites: The use concerning Nano-particle technology into restorative material is one of the most recent advancements in composite resin [2]. Nanocomposites are created when inorganic phases in an organic or inorganic composite attain nanoscale [16,17]. Nanotechnology allows the fabrication of Nano-dimensional filler particles that are introduced to composite resin either alone or in nanoclusters. Recently, researchers announced the creation of a rechargeable Nano-Amorphous Calcium Phosphate (NACP) loaded with composite resin [18]. After polishing, nanoparticles generate a composite with a smooth surface and excellent aesthetic quality. The nanoparticles not only improved the remineralizing characteristics of the composites, but they also kept the same amount of Ca and P release [20]. They're simple to work with and offer a better level of strength and abrasion resistance. It was called a "smart" material by researchers because of the constant ability to remove bacterial acids generated along tooth surfaces by releasing Ca and P, preventing secondary caries [19]. An alum inosilicate powder with average particle size of about eighty nanometres along with alumina to silica ratio of 1:4 is often used as Nano filler [21]. Since the fillers in nanocomposites are smaller than the wavelength of light, they offer a higher translucence, allowing for much more aesthetic repair with a wide range of colour possibilities. These are being used to create artificial teeth. Prosthetic teeth made of Nano-composite are more durable than acrylic teeth.

Nano diagnosis: At the molecular and cellular levels, Nano diagnostic instruments can be utilised to detect disease early [9]. Utilizing selected Nano devices and conducting multiple investigations at the subcellular scale, nanomedicine can expand the effectiveness and dependability of in-vitro investigation using human fluids and tissues samples [1]. Nano devices could be placed inside the body to confirm the appearance of disease early or to detect harmful substances, cancer cells, and other things *in vivo* [8,22].

Digital dental imaging: Digital imaging has expanded largely due to nanotechnology. In digital radiographs acquired with nanophosphor scintillators, the radiation

dose is decreased [23]. Hence, it has augmented the image quality as well as reduced patient exposure.

Diagnosis and treatment of oral cancer

The nanoelectromechanical system, oral fluid Nano sensor test, and optical Nano biosensor can all be utilized to detect oral malignancy [11]. Out of which the Nano Electro Mechanical System (NEMS) is a device that converts biochemical signals into electrical signals [2]. These are highly effective in the identification of bacteria, fungus, and viruses, as well as the diagnosis of oral cancer and diabetes mellitus [21].

Nano robotic dentifrice (dentifrobots)

Use of dentifrobots is an interesting area in the field of dentistry. Using toothpaste, a sub occlusal-dwelling Nano robotic dentifrice could scan all supra gingival and subgingival surfaces [10]. It converts trapped organic materials into odourless and non-toxic fumes [2]. It also debrides calculus on a continuous basis [24].

Nano anaesthesia: Lidocaine injections are commonly utilised in dental procedures because they have a long acting time and different degrees of effectiveness, reducing patient discomfort and a variety of consequences [2]. In today's Nano dental world, a colloidal solution comprising millions of active analgesic micron-size dental robots are injected into the gingiva of the patient [21]. When Nano robots come into contact with the crown or mucosa, they can enter the pulp *via* the gingival sulcus, lamina propria, or dentinal tubules [9]. Thus, Nano robots migrate from the tooth surface to the pulp in 100 seconds [18]. As commanded by the dentist, when these robots reach the pulp, they inhibit the sensory nerves from conveying pain signals to the area that has to be treated [15]. The targeted tooth is anaesthetized as soon as the dentist clicks the key on the remote. After that, dentist commands the Nano robot to restore all sensation and re-establish nerve traffic control after the procedure is completed [11]. This method provides anxiety-free, needle-free comfort for the patient, as well as improved control over the anesthetized area [25].

Nano impression materials: Impression materials can be modified using nanomaterials [26]. Nano fillers are mixed into vinyl poly siloxanes to create one-of-a-kind siloxane impression materials [2]. The fundamental advantage of this material is that it has improved flow and hydrophilic properties, resulting in fewer defects at the margins, good model pouring, and even more accurate placement [14,27].

Orthodontic treatment: Orthodontic Nano robots can handle periodontal tissues such as gums, periodontal ligament, cementum, and alveolar bone directly, allowing for rapid and painless straightening, rotating, or vertical position changes between minutes and hours during orthodontic therapy [2,21,28]. Nanotechnology is being used to develop a novel stainless-steel wire that combines very-high strength with good deformability, corrosion resistance, and surface quality [29].

Dental hypersensitivity: Dentin hypersensitivity is a medical condition produced by pressure changes supplied hydro dynamically to the pulp inducing hypersensitivity [9,21]. This is due to hypersensitive teeth have eight times greater surface density in dentin tubules, as well as tubules with double diameter [8]. Reconstructive dental Nano robots use native biological materials to precisely and correctly restrict particular dental tubules in mins, providing patients with a speedy and permanent treatment for hypersensitivity [15].

Major tooth repair: Entire tooth replacement, including cellular and mineral components, is known as complete denture replacement [9]. Nano dental techniques involve genetic and tissue engineering, tissue-regenerating procedures for major dental repair [21]. Biologically autologous full replacement teeth are primarily manufactured and installed by nanorobotics [30,14].

Challenges: Since the domain of Nano robots has great potential in a wide range of applications, it faces many challenges and risks [15].

Bio compatibility: It is critical to design biocompatible nanomaterials that are compatible with all aspects of the human body. Smaller particles tend to be more bioactive and toxic [9]. It develops bio-compatible Nano-materials [12]. Their capacity to interact with other biological systems is boosted since they can readily pass through the skin, lungs, and, in rare circumstances, blood-brain barriers [2].

Basic engineering: The viability of serial manufacturing procedures is a concern [2]. It is difficult for them to achieve precise positioning and assembly of molecular scale parts. It’s challenging to manipulate and coordinate the operations of a large number of separate microscale robots at the same time. Nanorobotics devices can now be developed and linked to the macro world for control, using modern scientific skills. These Nano robots are now used extensively in the fields of biomedicine and dentistry, particularly in the treatment of cancer [9]. It also aids in the removal of the defective section of our DNA structure, as well as some other treatments that have proven to be the most effective in saving human lives.

Cost factor: Presently, the use of nanotechnology can be considered as costly affair. Nonetheless, it has the potential to drastically lower costs while also increasing capabilities. It is used in aerospace, construction, agriculture, steel, environment, medical, transportation, and other fields to cut labour costs and save time [2]. A new application that is anticipated to be developed over the next decade will include economic, durability and high-performance gadgets. Nano-medicine intended to transform the methods of diagnosis and treatment of diseases [31].

Social issues: The public's perception of nanotechnology's acceptability is crucial in furthering nanotechnology research and its eventual integration into consumer products and beneficial applications [2]. To guarantee the public about nanotechnology products

would be safe, governments around the world must take effective approach to ensure that environmental, health, and safety concerns are addressed as nanotechnology research and development progresses [31].

Human safety and ethics

The current condition of nanotechnology discussion necessitates the establishment of more balanced ethical perspectives [32]. Although nontoxicity is still an emerging field, several nanomaterials can cause serious medical problems. It can be the occupational hazard for the people that work for companies making nanoparticle-containing materials who are most vulnerable [21]. The properties which enable Nano-materials to enter the body through various methods can be advantageous in the creation of targeted cancer medicines [2].

Advantages

- At the cellular level, Nano robots will regenerate missing tissue
- Nano robotic probes are primarily used for disease monitoring, evaluation, and treatment
- They have the ability to detect and activate neuro-electric impulses in the body [2].

Disadvantages

- Groups of Nano robots can be dangerous.
- The cost of implementation is quite expensive.
- It's challenging to maintain [13,29 33,34,35].

Problems for research of Nano robots in India

- The process of making crucial decisions is extremely slow.
- Inadequate funding to support.
- Involvement of individual businesses is insufficient.
- Availability of talented workers is a barrier [36].

DISCUSSION

It has been claimed in the literature that using robots in dentistry enhances accuracy, reproducibility, and reliability. Nanorobotics is anticipated to play a significant role in the healthcare industry in the future. Nanorobotics technology holds great promise for prolonging one's healthy lifetime [2]. Nano robots are effective in destroying infected cell thus aid in improving illness. It will also assist in the development of approaches for diagnosis, prevention, and treatment planning [12]. With the discovery of Nano robots, life will be simple and easy. Drug delivery technologies will be more precise and controlled. The gene therapy would also be possible [37]. Nano robots will be beneficial to dentistry in the future [38].

CONCLUSION

Nano robots are expected to hold a lot of potential because their applications those are nearly limitless. Nano dentistry will result in more efficient and effective dental care. Nano robots, which were previously only seen in science fiction, are finally becoming a reality. With the use of nanotechnology in dentistry, dentistry has become less stressful for dental surgeons. It is one of the most effective techniques to maintain dental health. It also uses mechanical dentifrobots, total orthodontic realignment, hypersensitivity treatment, and other techniques to maintain oral health. More studies on this fascinating new branch of science may bring greater success in nanotechnology in the future.

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