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NANOROBOTICS IN ORTHODONTICS- A REVIEW

Dentofacial Orthopedics

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ABSTRACT

Orthodontic robotic applications have advanced during the past ten years . In this study, published orthodontic research is surveyed and examined across eight different fields: Robotic dental assistants, robotic simulation and diagnosis of orthodontic issues, robotic patient education, teaching, and training, and robotic wire-bending, robotics in craniofacial surgery and implant implantation, nano- and microrobots for accelerating tooth movement and for remote monitoring, robotics in automated aligner production, and robotics for TMD rehabilitation. The present article aims to provide an early glimpse into the impact and future implications of nanorobotics in Orthodontics.

KEYWORDS

Nanorobotics, Dentistry, Artificial Intelligence, Nanotechnology

INTRODUCTION

"Nano" is derived from the Greek word which stands for "dwarf". Nanotechnology is the science of manipulating matter, measured in billionths of meters or Nanometers, roughly the size of two or three atoms. It is distinguished primarily by the scale at which it acts, one billionth of a meter or one ten thousand the width of human hair. In simple terms, it is engineering at the atomic or molecular scale.[1]

Today, nanotechnology is revolutionizing practically all fields of human endeavor. Nanotechnology takes a molecular and atomic-level approach to manipulate materials. Our understanding of poorly understood health concerns has been expanded by this technology, which works with matter at nanoscale dimensions, and it has also provided new methods of diagnosis and therapy. To continuously give patients with better and more comfortable dental treatment, dentistry particularly Orthodontics also must undergo significant revolutions.

Since dentistry as a whole consists of numerous multidisciplinary branches, nanotechnology is used in all of them. Nanotechnology is another interdisciplinary field that includes nanorobots, nanoelectronics, nanomaterials, and nano-biotechnology. Each of these has a unique use in several branches of dentistry, including orthodontics, local anesthesia and drug delivery in oral surgery, periodontal medicine, and advanced diagnosis in oral medicine and diagnosis.[2]

Engineering and computer science are combined in the interdisciplinary topic of robotics. The "intelligent connection between perception and action" is what robotics is referred to as.[3]

Nanorobots

In his 1950 science fiction novel I, Robot, author Isaac Asimov first used the word "robotics".[4]

A robot is described as "a reprogrammable, multifunctional manipulator designed to move materials, parts, tools, or specialized devices through various programmed motions for the performance of a variety of tasks" by the Robot Institute of America.[5]

Robots come in a wide variety of designs and are employed in a variety of settings and applications. Despite having a very wide range of applications and forms, they all have three fundamental constructional features in common:

All robots have some sort of mechanical construction to carry out a certain duty, electrical components to power and regulate the machinery and some level of computer programming code that determines when or how to do actions.[6]

Nanorobots are hypothetical minuscule objects that are measured in nanometers (1 nm = one-millionth of a millimeter). When completely developed from the hypothetical stage, they would operate at the atomic, molecular, and cellular levels to carry out operations in the industrial and medical domains that have previously been the stuff of science fiction. The nanorobots used in nanomedicine are so small that they can move freely throughout the human body. Due to its strength and inertness, scientists predict that the exterior of a nanorobot will be made of carbon atoms arranged in a diamondoid form. Super-smooth surfaces will reduce the possibility of provoking the body's immune system, enabling the nanorobots to operate without hindrance. Oxygen and natural body carbohydrates such as glucose may serve as sources.

Nanorobotics In Dentistry

The development of a brand-new discipline termed nano dentistry is being fueled by the increased interest in the potential dental uses of nanotechnology. To realign and straighten an uneven set of teeth and increase their durability of teeth, nanorobots numb the mouth, desensitize the teeth, and manipulate the tissue. Additional preventive, restorative, and curative procedures are carried out by nanorobots.[7]

Nanorobots may use specialized motility mechanisms to navigate precisely through human tissues. They will gather energy, detect, and control their environment. An onboard nanocomputer that executes pre-programmed instructions in response to nearby nanorobots via acoustic signals or other techniques may be in charge of controlling these nanorobotic functions.[8]

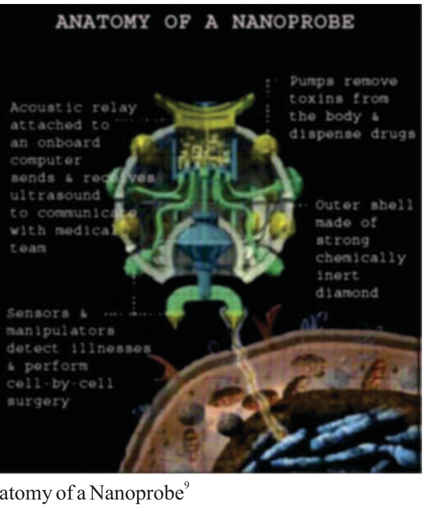

Fig. 1. Anatomy of a Nanoprobe[9]

Various Possible Uses Of Nanorobots In Dentistry

1. Nanocomposites
2. Major tooth repair
3. Tooth durability and appearance
4. Nano impression
5. Maintenance of oral hygiene

6. Cavity preparation and restoration
7. Dentin hypersensitivity
8. Orthodontic treatment
9. Esthetic dentistry
10. Inducing anesthesia
11. Diagnosis and treatment of oral cancer
12. Bone replacement materials
13. Nanoencapsulation
14. Bionic mandible
15. Implants

Nanorobotics In Orthodontics

Robotics in orthodontics was further subcategorized into eight domains, as shown below:

(1) Robotic dental assistants
(2) Robotics in the diagnosis, management, and simulation of orthodontic problems
(3) Robotics in orthodontic patient education, teaching, and training
(4) Wire-bending robotics including labial and lingual wire-bending robotic systems and customized fixed appliance robotics
(5) Nanorobots/microrobots for the acceleration of tooth movement and remote monitoring and telecommunication
(6) Robotics in maxillofacial surgeries and implant placement
(7) Robotics in automated aligner production
(8) Rehabilitative robots in management of TMD.[10]

Robotic Dental Assistants

Grischke et al. presented a standard 7DoF robot assistant in 2019. With dentists as their target audience, the authors looked at the prospect of active robotic support during procedures by handling tools through a multimodal communication framework. The visual motions were the most challenging to handle, however, the web interface and verbal and haptic gestures were more robust, suggesting that the users almost achieved expert-level time after only a brief overall engagement time.[10]

Fig.2 . Robotic Dental Assistant

Robotics In Diagnosis

Using Blender's secondary development technology, it was suggested to design a software simulation system for a dental orthodontic robot. This technology turns orthodontic surgery into a simulation operation that can be interactively simulated in a computer using tooth arrangement algorithms and calculations of tooth positions. Additionally, it can create orthodontic brackets for people with malformed teeth.[11]

Fig 3. Application Of Artificial Intelligence In Diagnosis

Patient Education

Dental students tested the humanoid, a full-body patient simulation system (SIMROID), in 2018 to see whether a robotic patient was more realistic for the students to become familiar with real patients than the frequently used dummies. Students acknowledged the robot patient's educational value, particularly for "risk management".[12]

A patient robot for practicing orthodontic bonding has been introduced, with the idea being that delivering instant feedback following training and iterative learning, will be helpful in the practice of orthodontic bonding.

Wire Bending Robotics

A crucial component of fixed orthodontic therapy is accurate arch wire bending [80]. Using a robot with accurate posture control capabilities, as opposed to the conventional manual bending system, can increase the precision and efficiency of archwire bending.

In the past ten years, several different types of arch-wire-bending robots have been proposed. These include the Motoman UP6 robot, which optimizes the bending process and properties, the LAMDA system (Lingual Archwire Manufacturing and Design Aid), which bends only 1st-order bends in the XY plane, motion planning and synchronized control of the dental arch generator of the multi manipulator automatic tooth arrangement robot.

Fig 4. Lamda System

Continuing, clinical outcomes were evaluated in terms of effectiveness and efficiency in various CAD/CAM systems in comparison to conventional approaches, showing the premise in improving or at least achieving similar outcomes to conventional appliances can also shorten overall treatment duration.

Incognito was proven to be more effective when compared to Insignia, which is a labial appliance. Additionally, it was discovered that using bespoke arch wires made by various CAD/CAM appliances, the precision of virtual setup implementation was clinically successful in achieving tooth movement as planned in the setup. However, the accuracy varies depending on the type of tooth and movement.[13]

Nanorobots/Microrobots

Dentifrice with nanorobots (Dentifrobots). Mouthwash or toothpaste-delivered sub-occlusal resident nanorobotic dentifrice might patrol all supragingival and subgingival surfaces while continuously debriding calculi. These imperceptibly little dentifrobots would be affordable, safely turn off if ingested, and be trained to clean teeth more effectively.

Devices for diagnosing and treating sleep apnea are also being developed, in addition to monitoring uses. These may be a viable, practical, cost-effective method for objectively tracking compliance with wearing OSA oral equipment and monitoring a person's sleep patterns.

Compliance with the use of detachable appliances is a highly variable, multifaceted problem that needs to be safely addressed in research plans and clinical practice. Electronic microsensors, like the Smart Retainer and the TheraMon, appear to hold a lot of promise because they are simple to use and be trustworthy and accurate enough to measure the wear time of removable orthodontic appliances by identifying temperature changes, which are then converted to wear time information.[14]

Robotics In Maxillofacial Surgeries

Numerous technologies that can autonomously perform an osteotomy operation by a prearranged surgical plan have been presented. These systems include surgical robots with optical surgical navigation systems and certain types of hard tissue lasers. The robot is suggested to track patient movements in real time throughout the procedure. For grinding bone surfaces, drilling holes, deep-sawing osteotomy cuts, choosing osteosynthesis plates, bending and intraoperative placement in a specific position, and planning orthognathic surgery, robotic surgical techniques are used.[15]

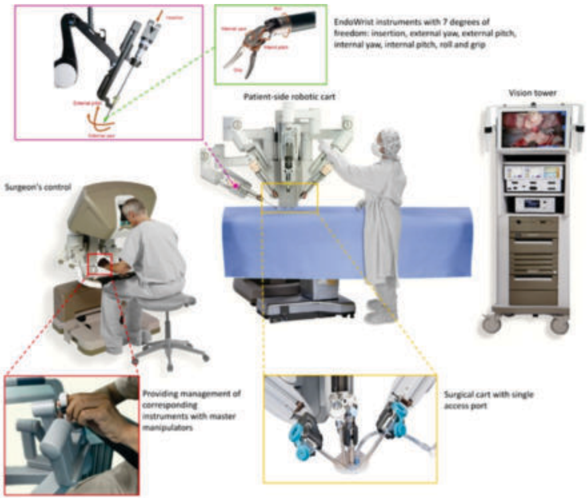

Fig 5. Robotic surgery operating room schematic

Robotics In Automated Aligner Production

A robotic system for forming features in orthodontic aligners developed by Hilliard was patented in 2011. The system consists of a control system, a platen for positioning the aligner in three dimensions, a heating station for selectively heating a small region of the aligner, and a thermoforming station for manipulating the heated region to form the desired feature in the aligner. A CPU running CAD software may be a part of the control system, allowing a user to create features for aligners. With the help of the current invention, auxiliary devices that increase the usefulness, scope, and duration of the application of polymeric shell orthodontic aligners can be added to an automated process for installing activation features and other necessary features.

Fig 6. Automated Aligner Production

Rehabilitative Robots

The use of safe and efficient maxillofacial massage and exercises to treat patients with myofacial pain and limited mouth opening has been suggested. This is done by dramatically reducing muscular stiffness. With sonographic features, such as the frequency of visibility of the distinct echogenic bands and the elasticity index ratios, being a helpful predictor of therapeutic efficacy and their usefulness, range, and duration of application, appropriate treatment regimens have been discussed and evaluated, reaching an efficacy of 70.3%.

Fig 7. Rehabilitative Robot

For the practical rehabilitation of patients with TMD, neurological rehabilitative exoskeleton robots have also been developed. Various designs were shoulder-mounted robotic exoskeletons for better aesthetics and portability, incorporating visual feedback into therapy routines to promote active participation with safety design considerations, assisted motion of the jaw using EMG- and ECG-based feedback systems accurately tracking the progress of a patient over time, central path generator co-design, and allowing the adaption to the environment and changing the chewing pattern in real-time parameters smoothly and continuously.

Limitations With Nanorobotics

1. Technical Difficulties

- mass production technique's viability
- Assembly and placement of a molecular-size item with precision
- directing and controlling the simultaneous actions of a large number of autonomous microscale robots.

2. Biological Difficulties

- creating biocompatible nanomaterials
- ensuring compatibility with every complex human body part

3. Social Difficulties

- Integrity Popular acceptance
- Regulation and protection of people

CONCLUSION

The field of orthodontics is developing towards a new era of data-driven and robotically aided medicine. Robotics is unquestionably a technological advance, and its obvious uses in orthodontics have enormous potential. Notably, the use of robots has led to rapid advances in the accuracy and efficacy of our treatments as a result of the integration of AI and ML into our routine clinical practice. Therefore, all practitioners must possess a foundational understanding of and training in these technologies. The most recent advancements in robot technology, ML and AI, have not yet been fully incorporated into orthodontic research and have not yet attained the technological and financial preparedness to enter the dentistry market.

In the past ten years, significant research has been done in the fields of surgical robots, simulative robots for diagnosis, and Arch wire-bending robots. Nanorobots and rehabilitative robots hold great promise and have received a lot of attention in the orthodontic literature. On the other hand, more scientific information will need to be acquired in the future about patient robots, assistive robots, and automated aligner production robots.

To truly bring robotics to orthodontics, significant instructional efforts, greater system intuitiveness, and the development of cost-effective systems must be overcome.

Simply put, "The future is here, and it will be amazing." Which potential that becomes reality will depend on time, developments, resources, and needs. Only our imagination will prevent us from using man-made nanomachines for these and other interesting future purposes.

Finally, I'd like to add that it's time for nano as we move from macro to mini, micro, and now nano.

REFERENCES

1. Kaehler T. Nanotechnology: basic concepts and definitions. Clin Chem. 1994;40:1797e1799.
2. Arwa Saifee & Dr. Sandhya Jain; Saudi J Oral Dent Res, Nov., 2019; 4(11): 785-788
3. B. Siciliano, O. Khatib, and T. Kröger, Springer Handbook of Robotics, Heidelberg Springer, Berlin, 2nd edition, 2016.
4. Asimov, I, Robot, Gnome Press, New York, 1950.
5. "Robotics," https://www.lexicocom/definition/robotics.
6. M. Ben-Ari and F. Mondada, Elements of Robotics, Springer Open, Cham, 2018
7. Abhilash M. Nanorobots. Int J Pharma Bio Sci. 2010;1:1e10.
8. Verma SK, Prabhat KC, Goyal L, Rani M, Jain A. A critical review of the implication of nanotechnology in modern dental practice. Natl J Maxillofac Surg. 2010 JaneJun;1(1):41e44.
9. Verma SK, Chauhan R, Nanorobotics in dentistry e A review, Indian Journal of Dentistry (2013), http://dx.doi.org/10.1016/j.ijd.2012.12.010
10. Hindawi BioMed Research International Volume 2021, Article ID 9954615, 16 pages https://doi.org/10.1155/2021/9954615
11. .J. Grischke, L. Johannsmeier, L. Eich, and S. Haddadin, "Dentronics: review, first concepts and pilot study of a new application domain for collaborative robots in dental assistance," in 2019 International Conference on Robotics and Automation (ICRA), Montreal, QC, Canada, 2019.
12. 12C. Zhou, S. Pan, and T. Zhou, "Design and implementation of software simulation system for a dental orthodontic robot," IOP Conference Series: Materials Science and Engineering, vol. 646, 2019.
13. K. Futaki, T. Yamaguchi, K. Katayama, et al., "The utility of a patient robot in orthodontic practice," Dental, Oral and Craniofacial Research, vol. 2, pp. 259–263, 2016.
14. B. E. Larson, C. J. Vaubel, and T. Grünheid, "Effectiveness of computer-assisted orthodontic treatment technology to achieve predicted outcomes," The Angle Orthodontist, vol. 83, no. 4, pp. 557–562, 2013.
15. B. Balan and S. Narayanan, "Nano robotics-its time for change," International Journal of

Oral Care and Research, vol. 2, pp. 41–46, 2014
16. K. Khan, T. Dobbs, M. C. Swan, G. S. Weinstein, and T. E. Goodacre, "Trans-oral robotic cleft surgery (TORCS) for the palate and posterior pharyngeal wall reconstruction: a feasibility study," Journal of Plastic, Reconstructive & Aesthetic Surgery, vol. 69, no. 1, pp. 97–100, 2016.
17. J. K. Hilliard, Robotic system for forming features in orthodontic aligners, United States patent US Google Patents, 2011.
18. H. Kalani, A. Akbarzadeh, S. N. Nabavi, and S. Moghimi "Dynamic modeling and CPG-based trajectory generation for a masticatory rehab robot," Intelligent Service Robotics, vol. 11, no. 2, pp. 187–205, 2018.
19. Feynman RP. There is plenty of room at the bottom. Eng Sci. 1966 Feb;23:22e26, www.dharwadhubli.com.
20. Frietas RA. Nanodentistry. JADA. 2000;131:1559e1569, www.dharwadhubli.com.
21. Jhaveri HM, Balaji PR. Nanotechnology. The future of dentistry a review. Jr I Prosthetic. 2005;5:15e17.
22. Nanorobotics e Wikipedia, the free encyclopedia.
23. Reifman EM. Nanotechnology Impact on Dentistry in Loss Angeles. California in 2020 AD; Expert from Award Winning Book Nanotechnology: Speculation on the Culture of Abundance; 1996.
24. Feynman R. There's plenty of room at the bottom. In: Gilbert HD, ed. Miniaturization. New York: Reinhold; 2004:282e296.
25. Laureates N, Rohrer H, Binnig G. Scanning Tunnelling Microscope. Available at: http://www.nobelprize.org. [Cited on 2010 Mar 15].