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THE NEW INVENTORY IN TO DENTISTRY – '**BIO–ELECTRONIC MATERIAL**'. A TERSE REVIEW

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ABSTRACT:

By fusing biological concepts with engineering and technology, bionics offers the possibility of creating products that improve and not merely repair oral health and functionality. Because of stem cell therapy and bioengineering, dental treatments in the future might concentrate more on regeneration than replacement. More natural-looking and long-lasting restorations will result from the development of biomimetic materials, which mimic the inherent qualities of teeth and tissues. The potential of bionics in dentistry to transition from conventional mechanical replacements to physiologically integrated solutions will determine its future.

INTRODUCTION:

Bionics has the potential to revolutionise dentistry by fusing cutting-edge technology with biological concepts to enhance dental procedures and results. Bionics is being used in prosthetics, implants, tissue regeneration, restorative materials, and smart devices to create solutions that duplicate and improve the structure, function, and appearance of natural oral tissues.

MEDICAL BIONICS.

The interdisciplinary subject of biomedical science and engineering known as "medical bionics" is concerned with creating technologies that use mechanical, electrical, or bio-engineered systems to replace, augment, or improve biological processes. The goal of these technologies is to enhance or replace physiological capabilities that have been compromised by illness, trauma, or birth defects. Combining the words "biology" and "electronics" results in the name "bionics."

Important Medical Bionics:

Cochlear implants, retinal implants, prosthetic limbs with bionic functions, artificial organs, neurobionics, cardiac pacemakers, and defibrillators.

Advantages and Prospects for the Future:

Regaining lost function: By recovering skills like walking, hearing, and vision, medical bionics gives patients with disabilities fresh hope.

Enhanced biological function: By improving typical human functions, bionic technology may find use in augmentative human performance as well as medicine.

Continuous innovation: New fields like brain-computer interfaces, neural prosthetics, and biohybrid technologies have a lot of potential for advancements in medicine in the future.

With continuous study into the more complex and seamless integration of technology with the human body, medical bionics is a field that is always changing. [1-4]

The role of Bionics in dentistry

In dentistry, bionics is the use of biological and engineering principles to the development of sophisticated dental materials, tools, and procedures that either supplement or improve natural dental functions. By developing solutions that replicate the mechanical and biological characteristics of real teeth and oral tissues, the aim is to enhance oral health care.

Important Uses of Bionics in Dental Practice [5, 6]

Bionic Dental Implants: Unlike standard implants, bionic dental implants are made to replace lost teeth and restore function with better integration and performance.

Progress:

*Surface Modification: By encouraging bone cell adhesion and development, nanoengineered surfaces improve osseointegration.

*Smart implants: Including sensors to track the health of the implant, distribute the burden, and identify infection or failure early on.

Bioactive and Biomimetic Dental Materials: Dental materials that are bioactive and biomimetic are being developed with the goal of fostering healing, regeneration, and the replication of natural tooth characteristics through favourable interactions with biological tissues.

Progress:

*Bioactive glasses and ceramics: Used in dental restoration to promote dentin and enamel remineralisation.

Materials intended to mimic the mechanical and cosmetic characteristics of natural teeth are known as biomimetic composites [7, 8].

Regenerative Dentistry and Tissue Engineering:

Function: Dentin, pulp, and periodontal ligament regeneration by the use of stem cells, growth factors, and scaffolds.

Progress:

*Dental pulp regeneration: is the process of growing new pulp-like tissue using stem cells taken from human exfoliated deciduous teeth (SHED).

*Periodontal Regeneration: Using scaffolds seeded with cells, the periodontal ligament is engineered to cure periodontal disease [9, 10].

Cognisant Orthodontics and Prosthodontics:

The purpose of integrating smart materials and devices into orthodontic treatments and prosthetics is to improve patient comfort and functionality.

Progress: [11]

*Shape Memory Alloys: Used to create orthodontic wires that gradually apply constant stresses.

*Pressure-Sensing Prosthetics: Sensor-equipped dentures that track proper fit and operation.

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Craniofacial Prosthetics and Reconstruction:

Function: Bionic techniques to replace missing facial structures as a result of illness, injury, or birth defects.

Progress:

*Osseointegrated Implants for Facial Prosthetics: Titanium implants are used to firmly attach prosthetic eyes, noses, and ears.

*Neural Interfaces: The experimental creation of tools to help face muscles regain their ability to sense or move. [12]

Advantages of Bionics in Dental Medicine

*Greater Materials and Surface Technologies: Better materials and surface technologies result in greater integration with soft tissues and bone.

*Biomimicry: More natural function and aesthetics are achieved by using tools and materials that closely resemble natural tooth tissues.

*Regeneration over Replacement: By emphasising tissue regeneration, artificial materials are used less frequently and long-term results are enhanced.

*Personalised Care: Real-time monitoring and therapies catered to the specific needs of each patient are made possible by smart technologies.

*By bringing cutting-edge techniques that improve oral tissue regeneration and restoration, bionics is revolutionising the field of dentistry. Advanced dental treatments that offer better functionality, aesthetics, and patient satisfaction are becoming possible thanks to the combination of bioengineered materials, smart devices, and regenerative procedures.

Examples of dental bionics include:

The following are particular instances of bionics in dentistry:

1. Bionic Dental Implants

Description: By strengthening its bio integration and functional capabilities, bionic dental implants seek to outperform conventional dental implants. These implants frequently have surfaces that have been nanoengineered to improve osseointegration, or bone integration, and occasionally they have sensors built in to track the implant's condition in real time.

As an illustration, consider titanium dental implants that have bioactive surfaces to improve osseointegration, such as hydroxyapatite or titanium dioxide nanotubes. [13]

2. Regeneration of Bionic Teeth Using Stem Cells

Description: Bionic techniques are being developed to use stem cells to rebuild natural teeth instead of artificial implants to replace missing teeth. This entails encouraging the development of dentin, pulp, and enamel by creating new tooth structures from the patient's own cells.

An illustration would be the regeneration of dental pulp employing dental pulp stem cells (DPSCs) or stem cells from human exfoliated deciduous teeth (SHED) in conjunction with biomimetic scaffolds [14].

3. Intelligent Dental Prosthetics

In order to offer real-time data on the stresses and pressures exerted to dentures and bridges while chewing, smart prostheses integrate sensors and electronics. Through adjustment to the dynamic forces encountered during oral activities, these devices can enhance fit, comfort, and function.

As an illustration, consider dentures with integrated pressure sensors that report on occlusal forces to enhance prosthetic function and fit [15].

4. Periodontal Regenerative Devices

Regenerative periodontal devices, which aid in the regeneration of damaged gum tissue and bone, are being developed using bionics. These devices help patients with periodontal disease regenerate tissue by using scaffolds and growth hormones.

As an illustration, consider guided tissue regeneration membranes, which are composed of bioactive substances that release growth factors to encourage the repair of periodontal ligaments and alveolar bone [16].

5. Bionic Dental Systems

Bionic orthodontic systems employ sophisticated materials, such shape-memory alloys, to fabricate wires that gently and consistently press on teeth to promote mobility. Throughout orthodontic treatment, these materials can adjust to the temperature of the mouth and maintain the ideal force levels.

As an illustration, consider NiTi (Nickel-Titanium) shape-memory alloy wires, which, at body temperature, revert to their original shape and exert a continuous force on teeth movement [11].

6. Bionic TMJ (Temporomandibular Joint) Implants

Bionic joint replacements that imitate the natural mobility of the jaw are being developed for patients suffering from severe abnormalities of the temporomandibular joint (TMJ). The biocompatible materials used to create these implants allow them to mimic the natural TMJ's anatomical movements.

As an illustration, consider TMJ prosthetics, which are intended to mimic normal joint function and are composed of biocompatible materials like titanium or ultra-high molecular weight polyethylene. [17]

7. Bionic Teeth with Intelligent Components

Description: Bridges, crowns, and fillings are being made with smart dental materials. These materials react to changes in pH or pressure in the surrounding environment by changing their characteristics, and they can release fluoride or other ions to prevent decay.

As an illustration, consider glass-ionomer cements, which gradually release fluoride to help prevent secondary caries. [18]

These examples show how the integration of smart materials, regenerative techniques, and creative prosthetic designs is driving bionics' advancement in dental care. By increasing the effectiveness and durability of dental therapies, the expanding field is improving patient outcomes.

Role of Bionics in prosthodontic treatment

When it comes to prosthodontic treatment, bionics is revolutionary since it can lead to greater osseointegration, increased patient comfort, increased usefulness, and even the possibility of regenerative therapies. Improvements in tissue engineering, bioactive materials, and smart prosthetics have greatly enhanced the results of fixed and

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removable prosthodontics. Future advancements in bioactive scaffolds and stem cell technology may lessen the necessity for traditional prostheses, favouring biological integration and regeneration.

In prosthodontics, bionics refers to the fusion of cutting-edge technologies with biological principles to create prosthetic materials and devices that closely resemble the structure, look, and function of natural dental and oral tissues. Thanks to these advancements in functionality, lifespan, and aesthetics, patient outcomes in fixed and removable prosthodontics have improved dramatically. Key areas where bionics is influencing prosthodontic treatment are listed below:

A. Bionic Dental Implants

Because bionic dental implants offer better osseointegration, mechanical stability, and functionality, prosthodontics has been completely transformed. In order to replicate the natural relationship between bone and teeth, surface changes, smart materials, and the addition of bioactive coatings encourage quicker healing and integration with surrounding bone tissue.

Technological Progress:

*Surface Engineering: By improving bone cell adhesion, titanium implants with nano-engineered surfaces—such as coatings made of nanotubes or bioactive ceramics—enable faster and more robust osseointegration.

*Implants having integrated sensors that track implant health, stress, and bone integration are referred to as "smart" implants.

B. Bionic Materials for Prosthetics

Bioactive and biomimetic materials that interact with surrounding tissues have been developed as a result of advancements in bionic materials used in fixed and removable prostheses (e.g., crowns, bridges, dentures). With these materials, restorations will be long-lasting and aesthetically beautiful while also trying to mimic the mechanical characteristics of natural teeth.

Technological Progress:

*Bioactive Ceramics and Glasses: Implants made of zirconia and lithium disilicate are examples of bioactive materials that bind chemically to soft tissue and bone.

*Biomimetic Composites: Composites engineered to replicate the hardness and translucency of natural enamel, but with enhanced strength, wear resistance, and aesthetic qualities.

C. Intelligent Dentures and Detachable Prostheses

Smart prosthetics are made to adjust to the changing stresses in the oral environment. Examples of these devices are dentures fitted with bioactive materials or sensors. By offering real-time input on fit and occlusion, these bionic dentures can help patients prevent pressure sores and discomfort.

Technological Progress:

*Smart materials are those whose characteristics alter in response to pressure, temperature, or pH to provide improved oral environment adaption.

*Pressure-Sensing Dentures: Detachable prosthesis with integrated sensors that track the forces applied to the mouth and modify the fit as necessary.

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D. Tissue engineering in Prosthodontia Regenerative Medicine

By combining tissue engineering and regeneration technology, bionics is revolutionising the field of regenerative prosthodontics. This includes regenerating lost oral tissues like soft tissue, bone, and even teeth utilising stem cells, growth factors, and bioactive scaffolds.

Technological Progress:

*Stem cell therapy: By using stem cells to restore periodontal and dental pulp tissues, traditional prostheses may one day no longer be required.

*3D bioprinting and scaffolds: Tissue regeneration is encouraged around prosthetic devices by using specially made scaffolds that are 3D printed and loaded with bioactive chemicals.

E. Bionic Prosthetics for the Temporomandibular Joint (TMJ)

More advanced TMJ prosthetics that can replace damaged joints and return normal jaw function have been made possible by bionics. Bioinspired materials that replicate the jaw joint's natural mobility and load-bearing capability are used in the creation of these prostheses.

Technological Progress:

*Bioactive surfaces on osseointegrated total joint implants promote integration with the surrounding bone and offer long-term stability.

*Bionic sensors in TMJ prostheses: A few prototype TMJ prosthetics use sensors to track joint wear and stress, which enables the early identification of possible malfunctions.[5,7,10,13,15,17]

The future prospects of bionics in dentistry

Bionics in dentistry has the potential to completely change how prosthodontics and dental care are provided in the future. With developments in biomimetic materials, smart implants, regenerative methods, sensory-enhanced prosthetics, and 3D bioprinting, the emphasis will move from merely substituting missing tissues to regaining and even improving biological function. More natural-looking, long-lasting restorations as well as better patient satisfaction will result from these advancements. Dental care may become even more individualised and refined with the use of AI and neural interfaces, improving the accuracy and efficiency of procedures.

Bionics in dentistry has a bright future ahead of it, with continued progress predicted to revolutionise prosthodontics and dental care. [11, 13, 17, 18, 19]

The following are important fields where bionics is probably going to have a big impact:

1. Intelligent Dental Implants

upcoming prospects:

*Real-time Monitoring: Health metrics including osseointegration, peri-implant bone levels, and early infection or implant failure identification can all be tracked in real-time using implants that have sensors installed in them. Preventive measures and individualised implant care may result from this.

*Self-Adapting Implants: Longevity and fewer replacement surgeries will result from the development of implants that can adjust over time to mechanical loads and alterations in the surrounding tissues.

*Anticipated Impact: These developments will enable earlier, less intrusive interventions and raise the success rates of dental implants while also lowering problems.

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For instance:

*Bionic Sensor Implants: These intelligent implants provide improved integration and functional results by measuring loading forces and identifying bone loss surrounding the implant site.

2. Tissue engineering and Regenerative Dental Medicine

upcoming prospects:

*Biological Tooth Replacement: Regenerative methods employing scaffolds, growth factors, and stem cells may enable full biological regeneration of teeth, obviating the need for artificial materials. Entire tooth structures could be grown again using stem cells from the dental pulp or periodontal ligament, thereby doing away with the requirement for traditional dental implants.

*Tissue Regeneration: Thanks to developments in tissue engineering, it will be feasible to replace lost periodontal tissues like gingiva and alveolar bone in addition to teeth. These tissues are lost as a result of disorders like periodontitis.

*Anticipated Impact: By reorienting the focus from replacing teeth and tissues to their regeneration, this could completely transform prosthodontic treatment, resulting in more natural-looking results and long-term functionality.

Example: Tooth Regeneration: Using scaffolds, stem cell-based techniques can regenerate pulp, dentin, and enamel, possibly resulting in biological tooth replacements.

3. Biomimetic Substances for Dental Repairs

upcoming prospects:

*Advanced Biomimetic Materials: Better functional and aesthetic restorations will be possible with the development of restorative materials that closely resemble the natural qualities of dentin and enamel. With time, these materials will be able to regenerate, self-heal, or release healing chemicals like fluoride.

*Self-Healing Restorations: Dental restorations with materials that have the ability to mend microcracks and wear over time will last far longer and require fewer replacements.

*Anticipated Impact: Long-lasting restorations that function like natural teeth and require less upkeep over time will be made possible by biomimetic and self-healing materials.

As an illustration, consider self-healing composites, which are restorative materials that have the potential to autonomously repair minor flaws or cracks, extending the life and robustness of dental crowns and fillings.

4. Bionic Appearances with Enhanced Perceptual Feedback

upcoming prospects:

*Sensory Integration: Patients may receive feedback from bionic prosthesis, such as bridges or dentures, simulating the feel of real teeth through the use of sensors and actuators. This will support the restoration of the mouth cavity's functional and sensory capacities, including the ability to perceive texture, pressure, and warmth.

*Neural Interfaces: Work is being done to create neural interfaces that will enable dental prosthesis to communicate with the neurological system and replace lost motor or sensory function. Patients will benefit from increased comfort, adaptability, and chewing efficiency thanks to these prosthesis.

*Anticipated Impact: By restoring function and sensation, sensory-enhanced prosthetics will give patients a more natural experience and boost their quality of life.

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An illustration of smart dentures with pressure sensors would be ones that can sense pressure when being chewed on and alter it in real time to prevent ulcers or discomfort.

5. 3D Printing and Bioprinting in Prosthodontics

upcoming prospects:

*3D Bioprinting of Tissues: Using complex tissue scaffolds, 3D bioprinting can be utilised to build customised dental prosthesis that encourage the regeneration of neighbouring tissues, like gums and bone. In the future, this technology might also enable the printing of whole biological teeth.

*Custom Prostheses: 3D printing will enable more precise, patient-specific dental prostheses, cutting costs and manufacturing times while enhancing functionality, fit, and appearance.

*Anticipated Impact: 3D bioprinting will improve dental prosthetic accuracy and customisation, opening up new possibilities for accessibility, affordability, and close integration with adjacent tissues.

An illustration of this would be 3D-manufactured Custom Implants, which offer a better fit and appearance than traditional techniques. These are fully customised implants or prosthetic crowns that are 3D manufactured utilising biomaterials.

6. Bionic Dental Care

upcoming prospects:

*Smart Orthodontic Devices: In the future of orthodontics, braces and aligners with real-time force monitoring and adjustment capabilities may be available. Better results would result from more effective treatment that takes less time.

*AI-Driven Orthodontics: By utilising bionic technology and artificial intelligence (AI), orthodontic treatment regimens may be optimised based on real-time data gathered from smart appliances. This may result in more rapid and more customised therapies.

*Anticipated Impact: By utilising smart technology, orthodontic treatments will become more comfortable, successful, and efficient, leading to better results in shorter amounts of time.

For instance, shape-memory braces use orthodontic wires composed of alloys that can change their force in response to changes in temperature and mouth pressure. This allows the wires to gently and continuously shift teeth.

7. Replacement of the Bionic Temporomandibular Joint (TMJ)

upcoming prospects:

*Advanced TMJ Prosthetics: Patients with TMJ diseases will benefit from improved usefulness and comfort thanks to bionic TMJ prosthesis, which more closely resemble the joint's natural motion. The materials used to create these prostheses will support osseointegration and long-term durability.

*Smart TMJ Devices: In order to enable early intervention in the event of mechanical failure, smart TMJ prostheses may incorporate sensors to track wear and load distribution in the joint.

*Anticipated Impact: By providing more robust and effective joint replacements that closely resemble the natural movement of the TMJ, these prosthetics will enhance the quality of life for individuals suffering from severe TMJ diseases.

For instance, bionic total joint implants are state-of-the-art replacements for the hip and knee that promote bone fusion and improve mechanical performance.

8. Integration of Artificial Intelligence (AI)

upcoming prospects:

*AI in Prosthodontic Treatment Planning: By evaluating patient data and forecasting the success rates of different prosthodontic techniques, AI may help with the creation of individualised treatment plans. This could maximise the choice of prosthetic tools and methods according to the requirements of each patient.

*Machine Learning for Diagnostics: Artificial intelligence (AI) has the potential to analyse data from smart implants, aligners, and prosthetics in order to detect early problems and offer useful information for preventive care.

*Anticipated Impact: Artificial intelligence will enhance the personalisation, predictiveness, and efficacy of prosthodontic therapies, resulting in superior results and more efficient care.

We anticipate that bionic technology will become increasingly important in the transformation of both simple and complex dental procedures as research proceeds.

SUMMARY:

Sensory feedback is provided by smart devices implanted in orthodontics, implants, and dentures. This enables more individualised, adaptive treatments that improve comfort and function.By enabling personalised, patient-specific prostheses and scaffolds for tissue regeneration, these technologies will expedite production and enhance the functionality and fit of dental restorations.

With increased study, biological restorations that regenerate tissues and devices that closely resemble natural structures will become more commonplace, and dental treatments will become more functional, long-lasting, and natural-looking.

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