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Nanotechnology In Orthodontics And Its Future Implications : A Review

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ABSTRACT:
Nanotechnology is interpretation of miniature matter at nanometer level. Nano medicine and Nano dentistry are terms used to describe if they associated with nanotechnology.
Nanotechnology helps in providing a promising grasp in advanced diagnosis, biosensors, target drug delivery. In dentistry it has been widely used in diagnosis of dental treatment, care, and prevention of oral diseases..This review brings forth various implications and benefits of nanotechnology in orthodontics.
Keywords: Nanotechnology, applications in orthodontics, Nanomedicine.

I. INTRODUCTION

The term 'Nano' is derived from Greek word meaning 'dwarf'. A nanometer is 10^{-9}in notation. [(1-4)] Nanotechnology allows exploration of dentistry and medical science along with material fabrication, devices and systems at nanoscale level.

Recently various advanced techniques such as nano characterisation, nano fabrication have been used to improve upon the biomaterial type of a substance.

Nanotechnology in medical field has been applied in diagnosis, prevention, and treatment of diseases

Three approaches are used in nanoparticles fabrication – they include Bottom up approach, Top down approach and Functional approach.[9]Nano pores, nanotubes, quantum dots, nanoshells, dendrimers, liposomes, nanorods, fullerenes, nanospheres, nanowires, nanobelts, nanorings, nanocapsules are few of nanoparticles widely accessible.[10]

Nanotechnology in dentistry

It is the field of achieving an almost perfect oral and dental health with an integrated use of nano particles like tissue engineering and nanorobotics. Newer treatment modalities involving nanotechnology in dental field includes delivery of local anesthesia, permanent hypersensitivity cure, nano dentifrices, treatment of oral carcinogens.

Orthodontics and Nanotechnology

Nano-indentative and atomic force microscopic studies on brackets and its surface characteristics which include roughness and surface free energy (SFE) .These coating on arch wires helps to reduction of friction and plaque accumulation. Nano indenter coupled with atomic force microscope (AFM) helps to determine bio-materils at nano scale surface. Nanotechnology also affects few aspects such as hardness, elastic modulus, yield strength, fracture toughness, scratch hardness and wear properties by nano indentation studies.
surface roughness characteristics were compared by D'Antò et al [17] of stainless steel (SS), β-titanium (β-Ti), and nickel-titanium (NiTi) wires using AFM. The results of the study showed advantages of AFM which improved topographical three dimensional images with a very high resolution of about 10 A .

Arch wires with Nano coatings for reducing friction

Minimization of frictional forces between wire and brackets will cause an increase in desired tooth movement and decreases treatment duration. Recently nano particles are employed as component of dry lubricants. Friction reduction is done by solid phase dry lubricants between two surfaces sliding against each other. Inorganic fullerene-like nano particlcs of tungsten sulflide (IF-WS2) are potent examples of dry lubricants and their utilization is done in self lubricating coatings for stainless steel wires used in orthodontics. Coated stainless steel wire with nickel–phosphorous electroless tungsten disulfide (IF-WS2) are fabricated by an insertion of stainless steel (SS) wires into electroless solutions of nickel–

phosphorus (Ni–P) and IF-WS2 were done by Redlich et al [19]

Instron machine and SEM/EDS analysis are used for friction tests for simulating archwire functioning and properties of coated and uncoated wires. The studies depict that there was reduction of frictional forces measured on coated archwire by 54%.

Orthodontic adhesive containing nanoparticles

Nano fillers of size 0.005- 0.01 microns are contained in nano composites . Macrofills, hybrids and microhybrids are added to make filler particles mechanically strong.
They are dense, large particles like mined quartz, melt glasses, ceramics and comminute them to small particle size.[20]outstanding optical properties, easy handling characteristics and superior polishiability are few of its advantages of adding nanoparticles .[23]

Nanocomposite and a nanoionomer restoratives were tested by Uysal et al [28] for determining their shear bond strength and failure site locations in comparison with a conventional light-cure orthodontic bonding adhesive (Transbond XT). They found out that nano restored composite to be mechanically superior than conventional ones. Improved mechanical properties are obtained when composite and ionomer cements have been impregnated with nano particles.

Elastomeric ligatures releasing nanoparticles

In fixed orthodontic therapy, teeth are often at risk of enamel decalcifications due to prolonged treatment time. Elastomeric modules used to hold arch wire in brackets tend to release fluoride which has anti cariogenicity, anti inflammatory and antibiotic drug molecules like few applicative modes. They have beneficial effects of elastomeric modules liberating nano particles. Studies indicate that anti cariogenic effect can also be achieved by fluoride releasing elastomeric modules.

Inhibited biofilms of oral cavity during tooth movement

The study conducted by S J Ahn[42] et al compared an experimental composite adhesive containing silica nanofillers and silver nanoparticles with two conventional composite adhesives and resin modified glass ionomer [RMGI]) for studying characteristics of its surface , its physical properties and antibacterial activities inhibiting cariogenic streptococcal growths. The results suggested that ECAs had rougher surfaces than conventional adhesives due to the addition of silver nano particles.

Bio MEMS/NEMS for orthodontic tooth movement and maxillary expansion

They include micro machined elements fabricated from substrates of silicon which are manufactured by techniques which are used to fabricate integrated circuits. Implantable bioMEMS have been used as biosensors for in vivo diagnosis of diseases and drug delivery microchips [43-45]. They have a physical or analytical function which the device performs along with electrical functions. Nano electromechanical systems (NEMS) have ability to combine electrical and mechanical functionality at nano scale level. It has been formulated that micro fabricated bio catalytic fuel cells which are also called as enzyme batteries has ability to increase orthodontic tooth movement by electric stimulations. MEMS/NEMS are at their initial stage of progression where areas concerning soft tissue biocompatibility, food effects at varying temperature and pH range needs to be addressed.

Nano LIPUS devices

LIPUS is Low–intensity pulsed Ultra sound radiations. The studies have depicted that there has been an efficiency in liberation of preformed fibroblast growth factors from a macrophage-like cell line and it also enhances angiogenesis during wound healing.[53] LIPUS has been reported to enhance bone growth into titanium porous–coated implants[54]and bone healing after fracture[(55-56)] . The specific mechanisms by which ultrasonic stimulation works on bone cell activities are unknown and require more research in near future.

Smart brackets with nano mechanical sensors

Orthodontic brackets fitted with nano mechanical sensors at their base provides real-time feedback about applied orthodontic forces. This real-time feedback microsystem chip encapsulates into small low profile contemporary bracket systems with reduced dimensions.
Orthodontist are allowed to adjust force applied which should be within a biological range to induce orthodontic tooth movement having no side effects.

II. CONCLUSION

Nanotechnology has been a boon to mankind which allowed miniatured, nano-leveled formulations of biomaterials that has benefitted both dental and medical science. Nanotechnology though in orthodontics lies at its initial level. There is a scope of research in this sector. In today's world of nanotechnology there are possibilities and advances which have potential to convert these technologies into clinical application and practice.

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