Original Research Paper

Volume -10 | Issue - 4 | April - 2020 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar

Orthodontology

A CRITICAL REVIEW ON NANOTECHNOLOGY IN ORTHODONTICS

Bhuvaneswari M Senior Lecturer, Department Of Orthodontics And Dentofacial Orthopaedics Karpaga Vinayaga Institute Of Dental Science, Kanchipuram District.

Muralidharan D* Reader, Department Of Orthodontics, Karpaga Vinayaga Institute Of Dental Science, Kanchipuram District. *Corresponding Author

ABSTRACT Nano dentistry is the science and technology of maintaining near-perfect oral health through the use of nanomaterials includes tissue engineering and nanorobotics. Nanotechnology is manipulating matter at nanometer level . This concept can be applied to the field dentistry with the terms Nanomedicine and Nanodentistry being used respectively Nanotechnology in orthodontics are applied in nano coated arch wires, nano brackets, nano composites, to prevent white spot lesions and naomechanical sensors for orthodontic forces and moments measurements. Its future application are in nano robotics in orthodontics, use of shape memory polymer in orthodontics, BioMEMS/NEMS for orthodontic tooth movement and maxillary expansion and nanolipus device.

KEYWORDS : Nanodentistry, Nanorobotics, Orthodontics

INTRODUCTION

The word nano is a Greek word, meaning dwarf. It is used as a prefix in the metric system and denotes a factor of 10-9 or 0.000000001.The concept of nanotechnology was based on the discussion by renowned physicist Richard Feynman in 1959 who labelled that it could be possible to directly manipulate the atoms[1].

The term "nano-technology" was first used by Norio Taniguchi in 1974[2], but was revealed by K. Eric Drexlerwho projected the concept of a nanoscale"assembler" which would be able to replicate and have molecular control[3].

According to Freitas, nanodentistry will improve the provision of oral health care by involving the use of nanomaterials, biotechnology (including tissue engineering) and, ultimately, dental nanorobotics (nanomedicine).The research on nanodentistry is ongoing and has also extended to the field of orthodontics[4]. It is defined as the multidisciplinary science of the creation of materials, devices, and systems at the nanoscale level,what makes the concept of nanote ch nology unique and exciting is that their size is smaller than the critical lengths defining many physical events

The current article highlights the progress that has been made in the domain of nano orthodontics and the future scope of nanotechnology in orthodontics.

NANOTECHNOLOGY IN ORTHODONTICS

ORTHODONTICS BRACKETS

Nano indentation and atomic force microscopy studies on orthodontic brackets and arch wires the surface characteristics like roughness and surface free energy (SFE), of the brackets play a important role in reducing friction and plaque formation. A nanoindenter coupled with atomic nanoscale surface characteristics of bio-materials..

Atomic force microscopy (AFM) or scanning force microscopy (SFM) which was developed subsequently to the invention of the scanning tunneling microscope (STM), is a very high resolution type of scanning probe microscopy, with demonstrated resolution on the order of fractions of a nanometer, more than 1000 times better than the optical diffraction limit[5].

The AFM consists of a cantilever, the end of which is fitted with a tip, typically composed of silicon or silicon nitride .Attraction and repulsion forces between the tip and the sample depend on Van der Waals forces, which cause a deflection of the cantilever, in accordance with Hooke's Law. The deflection is measured using a laser light reflected from the top of the micro-lever, and will be detected by a four-quadrant photodiode. A feedback loop adjusts the distance between the tip and the sample in order to keep the force acting between them constant for perfect scanning of all the surface asperities.

The sample is placed on a piezo-electric tube that can move it perpendicularly (z direction) to maintain a constant force in the plane (x and y directions) to analyze the surface. The resulting map (x, y) represents the topography of the surface sample.

A typical AFM can provide resolutions of 1 nm laterally and 0.07 nm (sub-angstrom) vertically[6]. AFM has been utilized
to look at the nanoscale dimension of the orthodontic armamentarium and the changes taking place during the course of treatment in various studies[7-10].

Material has been introduced by UC3M in the year 2012 containing hard alumina nanoparticles embedded in polysulfone for making orthodontic brackets. The material innovated has the properties of strength, reduced friction and biocompatibility[11].

NANOCOATINGS IN ARCHWIRES

Minimizing the frictional forces between the orthodontic wire and brackets has the potential to increase the desired tooth movement and therefore result in reduced treatment time. Nanoparticles have been used as a component of dry lubricants in recent years. Dry lubricants are solid phase materials capable to reduce friction between two surfaces sliding against each other without the need for a liquid media. Inorganic fullerene-like nanoparticlcs of tungsten sulflide (IF-WS2),which are potent dry lubricants have been used as self lubricating coatings for orthodontic stainless steel wires.

Redlich *et al*[12] coated stainless steel wire with nickel– phosphorous electroless film impregnated with inorganic fullerene-like nanoparticles of tungsten disulfide (IF-WS2) by inserting stainless steel (SS) wires into electroless solutions of nickel–phosphorus (Ni–P) and IF-WS2. Friction tests simulating archwire functioning of the coated and uncoated wires were carried out by an Instron machine and SEM/EDS analysis of the coated wires showed clear impregnation of the IF-WS2 nanoparticles in the Ni–P matrix. The friction forces measured on the coated wire were reduced by up to 54%.

NANOPARTICLE DELIVERY FROM ELASTOMERIC LIGATURE:-

Elastomeric ligatures can serve as a carrier scaffold for delivery of nanoparticles that can be anticariogenic, antiinflammatory and antibiotic drug molecules embedded in the elastomeric matrix. The release of anticariogenic fluoride from elastomeric ligatures has been reported in the literature previously [13-15].

The studies conclude that the fluoride release is characterized by an initial burst of fluoride during the first few days followed by a logarithmic decrease. For optimum clinical benefit, the fluoride ties should be replaced monthly.

NANOCOMPOSITES IN ORTHODONTICS

Uysal *et al.* conducted a study in 2010 to evaluate the bond strength of nanocomposites and nanoionomers and have shown that these nanomaterials may be suitable for bonding in orthodontics as they fulfill the previously suggested shear bond strength ranges for clinical acceptability[16]

Hosseinzadeh *et al.* in 2013 evaluated the bond strength of nanoco mp osites to ceramic brackets and found that the tensile bond strength of nanocomposites was less than conventional composites but was greater than the minimum level of clinical bond strength[17].The shear bond strength of two esthetic nanocomposites was compared with conventional composite by Sadegh *et al.* in 2013. The values calculated for bond strength were 8MPa and 6.91 MPa for nanocomposite and conventional composite respectively. They concluded that esthetic nanocomposites were suitable for orthodontic bonding.[18]

Coutinho *et al.* in 2009 evaluated the micro tensile strength of nanoglass ionomers to enamel. Their fi ndings showed that the tensile bond strength of nanofi lled glass ionomer was comparable to conventional glass ionomers but it was less than conventional resin-modifi ed glass ionomer cement.[19]Ahn *et al.* in 2009 conducted an *in vitro* study using composite suspensions and concluded that silver nanoparticles can prevent enamel demineralization as bacterial adhesion to these experimental composites was less compared to conventional composites[20].

ENAMEL REMINERALIZING AGENTS

Nano-hydroxyapatite has been introduced as nanotechnological advancement in the products for the remineralization of enamel. Calcium nanophosphate organized in the crystalline form of HA has been recently developed as a paste. Calcium nanophosphate crystals which are smaller than 100 nm, lead to improved bioactivity of the product, resulting from the increase in surface area and wettability of HA nanoparticles.

Calcium, phosphate and fluoride ions are released and organized in fluorapatite and CaF2 on demineralized tooth surface. Medeiros *et al.* in their study in 2013 concluded that calcium nanophosphate forms a protective layer on the enamel surface and provides protection against erosion[21]

TEMPORARY ANCHORAGE DEVICES

TADs are manufactured with smooth titanium surfaces because osseointegration is a disadvantage that complicates their removal. On the other hand, lack of osseointegration is also one of the factors for the failure of TADs [22]. Therefore it is postulated that the balance lies in the fabrication of an ideal surface that could stimulate initial ossointe gration and facilitate its removal once the TAD is no longer needed. Biocompatible coatings like Titanium nanotubes should be studied to evaluate if the nanotubular layer can enhance initial osseointegration and can serve as an interfacial layer between the newly formed bone and the TAD

NANO LIPUS DEVICES

Low–intensity pulsed US (LIPUS) has been reported to be effective in liberating preformed fibroblast growth factors from a macrophage-like cell line (U937), and it enhances angiogenesis during wound healing . Also, LIPUS has been reported to enhance bone growth into titanium porous–coated implants and bone healing after fracture and after mandibular distraction osteogenesis[23]

REFERENCES

1. Feynman R. Th ere's plenty of room at the bottom. In: Gilbert HD, editor. Miniaturization. New York: Reinhold; 2004. p. 282-96.
2. Taniguchi N. On the basic concept of 'Nano-Technology'. Proceedings of International Conference on Production Engineering. Tokyo: Part II, Japan Society of Precision Engineering; 1974.
3. Drexler KE. Nanosystems. Molecular Machinery, Manufacturing and Computation. New York: John Wiley and Sons; 1992. p. 990-8.
4. Freitas RA Jr. Nanodentistry. J Am Dent Assoc 2000;131:1559-65
5. Binning G, Quate C, Gerber C. Atomic force microscope. Phys Rev. Lett 1986; 12:930
6. Kusy RP, Whitley JQ. Effects of surface roughness on the coefficients of friction in model orthodontic systems. J Biomech. 1990; 23(9)913-925.
7. Bourauel C, Fries T, Drescher D, Plietsch R. Surface roughness of orthodontic wires via atomic force microscopy, laser specular reflectance, and profilometry. Eur J Orthod. 1998; 20:79-92.
8. Silikas N, Lennie AR, England KER, Watts DC. AFM as a tool in dental research. Microsc Analysis 2001; 82:19-21.
9. Lee GJ, Park KH, Park YG, Park HK. A quantitative AFM analysis of nano-scale surface roughness in various orthodontic brackets. Micron 2010; 41:775-782.
10. Kakaboura A, Fragouli M, Rahiotis C, Silikas N. Evaluation of surface characteristics of dental composites using profilometry, scanning electron, atomic force microscopy and gloss-meter. J Mater Sci Mater Med 2007; 18:155-163.
11. Universidad Carlos III de Madrid - Ofi cina de Informatcion Cientifi ca.Nanoparticles provide reinforcement for invisible braces in orthodontics. Science Daily 29 October 2012
12. Redlich M, Katz A, Rapoport L, Wagnerb HD, Feldmanb Y. Improved orthodontic stainless steel wires coated with inorganic fullerene-like nanoparticles of WS2 impregnated in electroless nickel–phosphorous film. Dent Mater 2008; 24:1640-1646
13. Wiltshire WA. Determination of fluoride from fluoridereleasing elastomeric ligature ties. Am. J Orthod Deniofacial thop. 1996; 110(4):383-387.
14. Wiltshire WA. In vitro and in vivo fluride release from orthodonic elastoomerc ligature ties. Am. J Orthod Dentofac Orthop. 1999; 115(3):288-292.
15. Miura KK. Aniticariogenic effect of fluoride-releasing elastomers in orthodontic patients. Braz. Oral. Res 2097; 21-(3)228-233.
16. Uysal T, Yagci A, Uysal B, Akdogan G. Are nano-composites and nano-ionomers suitable for orthodontic bracket bonding? Eur J Orthod 2010;32:78-82
17. Hosseinzadeh-Nik T, Karimzadeh A, Ayatollahi MR. Bond strength of a nano-composite used for bonding ceramic orthodontic brackets. Mater Des 2013;51:902-6.
18. Akhoundi S, Chalipa J, Arab S, Kharrazifard J, Ahmadyar M. Evaluation of shear bond strength of orthodontic brackets bonded with nano-filled composites. J Dent Tehran Univ Med Sci 2013;10:461-5.
19. Coutinho E, Cardoso MV, De Munck J, Neves AA, Van Landuyt KL, Poitevin A, et al. Bonding eff ectiveness and interfacial characterization of a nano-filled resin-modifi ed glass-ionomer. Dent Mater 2009;25:1347-57.
20. Ahn SJ, Lee SJ, Kook JK, Lim BS. Experimental antimicrobial orthodontic adhesives using nanofi llers and silver nanoparticles. Dent Mater 2009;25:206-13.
21. Medeiros IC, Brasil VL, Carlo HL, Santos RL, De Lima BA, De Carvalho FG. In vitro effect of calcium nanophosphate and high-concentrated fl uoride agents on enamel erosion: An AFM study. Int J Paediatr Dent 2014;24:168-74.
22. Miyawaki S, Koyama I, Inoue M, Mishim K, Sugahara T, Takano-Yamamoto T et al. Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage. Am J Orthod. Dentofacial Orthop. 2003; 124(4):373-378
23. El-Bialy TH, Royston TJ, Magin RL, Evans CA, Zaki AM, Frizzell LA. The effect of pulsed ultrasound on mandibular distraction. Ann Biomed Eng. 2002; 30(10):1251-1261.