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Applications of Zinc Oxide and Hydroxyapatite Nanoparticles in Orthodontics: a Perspective

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ABSTRACT

Nanotechnology is widely applied to orthodontic practices like Brackets, orthodontic wires/ligatures and orthodontic retainers. Fixed orthodontic appliance is inclined to plaque biofilm deposition and furthermore improve the opportunity of complete demineralization (additionally called white spot injuries, WSLs) the underlying indication of caries. These injuries are portrayed by their obscurity and a decline in fluorescence brilliance when contrasted with sound polish surfaces. Despite the fact that mechanical treatment is utilized to expel the dental plaque in the oral disorders, it brings about minimising symptoms and better patient compliance. A portion of the nanoparticles like Zinc oxide, Silver, Gold,Copper oxide, Hydroxyapatite, Titanium oxide possess significant antimicrobial properties and forestalls the microbial attachment or lacquer remineralization, reducing contact in orthodontic therapy. Recent advances contributed to widespread reaching utilization of clinical nanosystems in different areas of dentistry like prevention, prognosis, care, tissue regeneration, and restoration. The advancement of oral medication nanosystems for prophylaxis is huge for ensuring excellent oral care. Nanomaterials in oral cosmetic agents are utilized in toothpaste and other mouthwash to improve oral health. These procedures spread nanoparticles and nanoparticle-based materials, particularly spaces of utilization identified with biofilm the board in cariolog, periodontology and orthodontics. Likewise, nanoparticles have been coordinated in differing restorative produces for the consideration of veneer remineralization and dental hypersensitivity .The aim of the article is to survey the updated literature with Zinc oxide and Hydroxyapatite nanoparticles and its antimicrobial viability ,Sheer bond strength and Nanoparticle based dental filler.

KEY WORDS: ORTHODONTIC THERAPY, FIXED ORTHODONTIC APPLIANCE, ZINCOXIDE, HYDROXY APATITE, NANOPARTICLES.

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INTRODUCTION

Nanoparticles are currently used in dental practice for several applications in the field of orthodontics nano particles is applied as nano-coatings in arch wires and brackets to reduce friction , Fabrication of hollow wires , orthodontic brackets, as antimicrobial agent to prevent white spot lesion. Direct bonding with resin adhesives has become the most popular method for orthodontic bonding. One of the most important considerations for a good orthodontic adhesive is to have adequate bond strength which is able to withstand both occlusal and orthodontic forces. An orthodontic bonding agent must possess high bond strength balanced with the ability of the material to leave little or no residue on enamel upon removal. The bonding material must be inexpensive and accessible. At present, most orthodontic cements available in the market already have these features, however, finding a bonding agent that may also prevent white spot lesions (WSLs) is a challenge. An obstacle on the crown level during fixed orthodontic procedures (FOP) are white spot, enamel demineralization and tooth decay, (Bishara et al 2007, Uysal, 2010, Panchali, 2016, Florence 2020).

Nanoparticles are incorporated into orthodontic adhesives/cement and can be coated on the surfaces of orthodontic appliances to prevent dental plaque or enamel demineralization during the treatment. Various literature studies showed that the addition of antimicrobial NPs to orthodontic adhesive agents and resin-modified glass ionomers cements (RMGICs) might prevent plaque accumulation and bacterial adhesion, (Gunes 2008) This review provides a useful insight into the antimicrobial effects and orthodontic adhesives incorporated with zinc oxide and hydroxyapatite nanoparticles.

Antimicrobial Activity Based On Literature Review: Dental disorders have affected over 3.47 billion individuals in the world and is one of the three most common reasons for worldwide infections. Among the oral disorders, the most common were dental caries and periodontitis. Together, they contribute to the most widely recognized irresistible human ailment in the world. Regardless of whether caries and periodontitis are multifactorial ailments, the primary etiological factor is the occurrence of pathogenic microorganisms. These microbes are composed inside an extracellular framework to shape a bacterial biofilm, (Frencken et al .2017).

In the biofilm, the microorganisms are amassed to shape a hindrance that opposes anti-toxins furthermore, advances incessant fundamental diseases. Additionally, icroorganisms are multiple times progressively impervious to hostile to microbial treatment. Additionally, in biofilms, microbes can escape the resistant framework by delivering super antigens. To battle these bacterial contaminations, metal, metal oxide, and different NPs give off an impression of being promising choices due to their particular physio-synthetic properties, (Seil and Webster,2012 ;Valm, 2019) Sodager et al (2013) investigated the antibacterial properties of ordinary orthodontic composite containing silver/hydroxyapatite nanoparticles. In his investigation antibacterial properties of the composite groups were tested against *Streptococcus mutans, Lactobacillus acidophilus*, and *Streptococcus sanguinis*. Plate dissemination strategy was followed to discover the zone of hindrance. Antibiofilm activity showed that silver/hydroxyapatite nanoparticles indicated zone of inhibition against all the microorganisms tested. NiTi orthodontic wires were covered with ZnO nanoparticles utilizing the chemical deposition activity. Coating characteristics just as the physical, mechanical and antibacterial properties of the wires were researched. The covered wires introduced up to 21% decrease in the frictional powers and antibacterial action against Streptococcus mutans, ZnO nano coating fundamentally improved the surface nature of NiTi wires (Kachoei et al 2016).

A recent study by Scribante et al (2020) demonstrated the utilization of remineralizing solution which initiated decrease of demineralized areas .Bond quality characteristics were essentially diminished for the two sections and connections subsequent to remineralizing treatment. His investigation additionally indicated higher grip esteems brackets in both conditions tested. Remineralized enamel showed significantly higher micro hardness values than demineralized enamel and lower values than intact enamel, Ohtsu et al (2017) in their examination called attention to the antibacterial viability of ZnO/HAP These discoveries proposed that the coatings utilized in the investigation assumes critical job for the surface adjustment of Ti inserts, with a capacity to consolidate the avoidance of irresistible sicknesses with osteogenic action. In a study involving pure and ZnO (0% – 43%) in various forms doped with nano Hydroxyapatite powders .Sol gel method is used to synthesise the nanoparticles. The characterisation of this nanoparticles were performed using XRD, FTIR assay (Deepa.,2013)

In vitro Antimicrobial assay was carried out against gram negative bacteria in which pure and doped nHAp samples were observed irrespective of the ZnO content.Another study was performed focussing on the antimicrobial efficacy of silver, titanium dioxide and zinc oxide nanoparticles against S*treptococcus mutans* (Reddy et al .,2018) Viable bacterial count is determined in the study which showed a significant difference in the colony forming units among all three concentrations of silver (Ag), titanium dioxide (TiO2) and zinc (ZnO) nanoparticles. The study further proved that the Silver, Zinc oxide and Titanium dioxide which showed significant antimicrobial effects were found to be concentration dependent.

Some other works investigated by Grenho et al (2015) about the development of three dimensional and inter connected porous granules of nanostructured hydroxyapatite. *In vitro* and In vivo experimental models were performed in this study. In the In vitro model ,when the granules exposed to *staphylococcus aureus* and *staphylococcus epidermidis* showed antibacterial

activity cytocompability assay towards osteoblast cell line showed inflammatory response. *In vivo* models also showed antibacterial effects .Altogether these nano HA-ZnO porous granules possess significant antibacterial activity and employed in orthopaedic and dental applications.

Nanoparticle Based Dental Fillers: HA-NPs have been incorporated into oral care products, for example, dentifrices and mouthwash to decrease or erase dental affectability by hindering open dentinal tubules on the outside of the dentin also, associated with the mash, or to advance the remineralization of lacquer by supplanting calcium and phosphate particles in the regions from which minerals dissolved, restoring its integrity and shine, (Jena et al.,2017 ;Vano.,2014) Hydroxyapatite nanoparticle is one of the commonly metal nanoparticle for the teeth filling but the literature regarding its efficacy for filling in infectious mouth is still not clear .study conducted by Konar et al (2019) using Graphene oxide ,hydroxyapatite ,zirconia nanoparticles against *Enterobacter ludwigii* and *Escherichia coli*. field emission scanning electron microscopy (FESEM), fluorescence microscopy and zeta potential techniques. The findings revealed that Zirconia nanoparticles are not efficient dental filler, whereas graphene oxide nanoparticle is the best filler followed by hydroxyapatite nanoparticles, that can reduce the bacterial load significantly.

Sheer Bond Strength: Influence of silver (Ag), zinc oxide (ZnO), and titanium dioxide (TiO2) nanoparticles on shear bond strength (SBS) was investigated by Reddy et al .In the study he observed that there was a significant difference between control, Ag, ZnO, and TiO2 with SBS at 5% level of significance. The Scanning electron microscopic examination confirmed homogenous distribution of nanoparticles in the adhesive in all three groups. Further to mention in the study, it was concluded that the incorporation of various nanoparticles in to adhesive materials in minimal amounts may decrease SBS and may lead to the failure of bracket or adhesive (Reddy et al.,2016). The addition of silver, zinc oxide or titanium dioxide nanoparticles into orthodontic bonding agent at a concentration (1%) did not show any effect on bond strength. These nanoparticles have shear bond strength values above the minimum for clinical routine use.

The findings in the study suggest significant differences is observed in ARI, considerably more adhesive remains on the enamel surface following bracket removal in Ag, ZnO, and TiO2 groups compared to the control group. In an experimental study 80 extracted human pre molars were used and divided in to 4 groups, the study was conducted to evaluate the SBS of resin-modified glass ionomer cements. (RMGICs) modified by nano-zinc oxide (NZnO) and nano-hydroxyapatite (NHA) in comparison with composite resins. Findings of the study showed that the amount of SBS was similar among all groups and addition of NZnO and NHA particles had no negative effect on SBS of RMGIC (Sari et al.,2015). Similar study was based on the addition of silver and Hydroxyapatite nanoparticles on the shear bond strength (SBS) of an orthodontic adhesive.

SEM and EDAX analysis showed significant changes between the study groups and the control .Incorporation of silver/HA nanoparticles containing 5% and 1% silver maintains and increases the SBS of orthodontic adhesives, whereas increasing the amount of particles to 10% has an undesirable effect when compared to the control group (Baratali et al.,2015). Saffarpour et al (2016) suggested that the incorporation of Zincoxide nanoparticles in to the dental adhesives increased the antimicrobial effects without affecting the bond strength properties. Adhesive system with hydroxyapatite nanoparticles as load, characterizing it and evaluate the effectiveness of its bond to dental structure. Evaluating with microshear test and characterization technique. It was found that the nanoparticles showed statistically significant difference between the groups. It has been observed that Combined effect of Zinc oxide and CuO has also been studied and it has been observed that CuO and ZnO/CuO nanoparticles coated brackets have better antimicrobial effect on S.mutans than brackets coated with Zinc oxide or CuO alone (Sarah 2018; Dumont et al 2013).

Clinical Significance: Various research has been published in the application of Nanotechnology in the form of metallic nanoparticles like silver, gold, titanium ,nickel, Copper oxide, zinc oxide, hydroxyapatite coated in the orthodontic adhesives as bonding agent to evaluate the sheer bond strength, nano fillers, enamel remineralising agents, fabrication of brackets. This nanoparticle application in the field of orthodontics is in a growing stage ,although several studies were done in orthodontics incorporating the nanotechnology but they are mostly in the in vitro phase and in future several in vivo research to be carried out in order to investigate the antimicrobial ,anti-inflammatory ,cytotoxicity efficacy to use in the clinical treatment for the patients .

CONCLUSION

Nanotechnology has carried enormous changes to the field of Orthodontics. As of now, these improvements are found for an enormous scope in different field identified with oral prophylaxis. Right now, oral care products like toothpastes and mouthwash which contain NPs with anti-microbial, mitigating, and remineralizing properties. In view of promising outcomes and changed, diversified properties, nanomaterials contain various possibilities, and their uses brief numerous points of view that make it workable for them to be compelling. In any case, the advantages of NPs include similar reasons that make them Safe–Properties like small particle size , surface properties, quantum state, movement, conglomeration, change, and the formation of free radicals. In this manner, Incorporation of NPs is as of now one of the most contemplated component of dentistry, because of the practically boundless fields of utilization, furthermore, subsequently administrative and wellbeing concerns must be considered and addressed, particularly

concerning the utilization of hydroxy /Zinc oxide NPs in oral care products.

Conflict of Interest: Nil

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