

Biosafety of Nanoparticles Used in Orthodontics - A Literature Review

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ABSTRACT

Nanotechnology is the science of manipulating matter, measured in the billionths of a nanometer, roughly the size of two or three atoms. It is widely used in our day-to-day life including its use in medicine and is considered as a vital current technology of the 21st century based on its economic and scientific potential. Its application is being experimented in various domains in orthodontics, from surface coatings to the development of novel materials. Orthodontic materials must have specific characteristics such as biological safety, functionality, and adequate tissue response. They have to pass specific biocompatibility tests to meet regulatory standards. Any material used in oral cavity might encourage unnecessary disturbance due to its complex and varied environment. The nanomaterials have many advantages in the field of orthodontics, especially with improved mechanical and antimicrobial properties. Nanoparticles can easily penetrate tissues and can affect biological behaviours at different levels. The introduction of nanotechnology gives better opportunities to both patient and orthodontist to new physicochemical, mechanical, and antibacterial properties of nanosized materials and can be used in coating orthodontic wires, elastomeric ligatures, and brackets, producing shape memory polymers and orthodontic bonding materials. The present review article focuses on the application of nanoparticles in orthodontics. This article presents a brief overview of nanotechnology, types of nanoparticles, biological safety of different nanoparticles used in orthodontics and their applications in the field of dentistry and orthodontics.

KEY WORDS

Nanoparticles, Biocompatibility, Orthodontics, Nanoscience

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BACKGROUND

Nanotechnology is defined as "the direct manipulation of materials at the nanoscale"¹ and one of the most prominent areas for current research and development across a wide range of fields.² Prof. Kerie E. Drexler coined the term "nanotechnology" in his book "Engines of Creation" in 1986, and Norio Taniguchi, a researcher, defined it as "the processing, separation, integration, and deformation of materials by one atom or one molecule."

Nanoscience involves the study of materials on the nano-scale level between approximately 1 and 100 nm. These materials have been receiving considerable attention as a result of their unique physical and chemical properties, biological properties, and functionality due to their nano-scale size, and have elicited much interest and important applications in optics and biomedicine.⁴ Nanoparticle presents a greater surface - to - volume ratio when compared with non - nano scale particles, interacting more closely with microbial membranes and provides considerably larger surface area for antimicrobial activity.⁵ There are two ways to produce nanomaterials³

1. Top - down approach: It starts with bulk material and then breaks it into smaller pieces using mechanical, chemical or other forms of energy.
2. Bottom - up approach: It synthesizes the material from atomic or molecular species via chemical reactions, allowing for the precursor particles to grow in size.

Nanoparticles are generally classified based on different shapes of nanoparticles such as rod, rectangle, hexagon, cube, triangle, and star - shaped nanoparticles can be produced. Bulk solution synthetic methods often produce nanoparticles of multiple sizes and shapes and low yield of the desired size and shape.³ In the field of dentistry, orthodontic material must have specific characteristics such as biological safety and functionality, adequate tissue response and resistance to corrosion and metals used are also identified to be cytotoxic, mutagenic and allergenic to oral tissue. Biosafety of nanoparticle materials is a subject of concern, the future in orthodontic treatment will benefit enormously through nanotechnology and its clinical application are at a reasonable cost to the orthodontist and the patients.²

This paper intends to give an extensive understanding of the biological safety of nanoparticles and their use in orthodontics and discuss the new application of nanoparticles in orthodontics with the present research evidence.

FACTORS AFFECTING THE BIOSAFETY OF NANOPARTICLES

Medical nanoparticles as three main categories⁶ soft; hard solid; and other.

- a. Soft particles, such as polymer NPs, micelles, vesicles, liposomes, core - shell systems, gels, polymeric medicines, or polymer - drug conjugates, typically made up of polymers, proteins, or lipids.
- b. Metal and ceramic nanoparticles, such as oxides, semiconductors, and carbon nanotubes, as well as nanocrystal medicinal formulations, are examples of hard solid - core nanoparticles.

- c. Due to their nano size and structure, other particles in the third category, such as antibody drug conjugates and albumin particles, can also facilitate nano type interactions.

The nanometer size of the nanomaterials renders them

- a) A large fraction of surface atoms;
- b) High surface energy;
- c) Spatial confinement; and
- d) Reduced imperfections,

Which normally do not exist in the corresponding bulk material. At the nanometer scale, properties become size - dependent, which include

1. Chemical properties - reactivity, catalysis;
2. Thermal properties - melting temperature;
3. Mechanical properties - adhesion, capillary forces;
4. Optical properties - absorption and scattering of light;
5. Electrical properties - tunnelling current; and
6. Magnetic properties - superparamagnetic effect.⁷

The nanoparticles' enormous surface - to - volume ratio is a major factor in their new physical, chemical, and mechanical capabilities as compared to the bulk state. As particle size fall results in nanoparticles having a substantially bigger surface area per unit volume than bigger particles. This makes nanoparticles more chemically reactive than a similar mass of material made up of bigger particles.⁸

APPLICATION OF NANOPARTICLES IN DENTISTRY & ORTHODONTICS

Nanoparticles are being investigated to inhibit the formation of biofilms in the oral cavity due to their biocidal, anti-adhesive and transport characteristic. Various metal-based nanoparticles known for their size and exceptional properties and therapeutic uses in dentistry and orthodontics are discussed in Table 2.

Various metal-based nanoparticles are -

- a) Gold nanoparticles
- b) Silver nanoparticles
- c) Titanium - based nanoparticles
- d) Fullerene nanoparticles
- e) Chitosan nanoparticles
- f) Fluoride releasing nanoparticles
- g) Hydroxyapatite nanoparticles
- h) Zinc nanoparticles
- i) Copper nanoparticles
- j) Magnesium nanoparticles
- k) Quaternary Ammonia Nanoparticles

Original research on novel nanoparticles in orthodontics, both in-vitro and in-vivo, was identified and extracted from Medline via PubMed, Google Scholar, and Scopus from 2010 to 2020 (Table 1)

These metal-based nanoparticles are coated on orthodontic material and employed as nano - adhesives for bonding orthodontic appliances, with filler - particle sizes of less than 100 nm. These nanocomposites are made through flame pyrolysis, which involves incorporating nano - sized fillers into composites.⁴ Nanoparticles are inserted into orthodontic arch wires in an electroless method to create nanocoated arch wires.

Sl. No	Author	Study Design	Characteristic	Outcome
1.	Mohamed K - Al Nafari et al. in the year 2017 ¹⁶	Original Research article-animal study	Incorporated gold and silver nanoparticles into the primer of orthodontic adhesive system and coated the brackets on the sheep teeth.	Incorporating Au and Ag nanoparticles did not affect the bond strength or the primer ability to wet enamel surface.
2.	Gamze Metin - Gürsoy et al. in the year 2016 ⁴¹	In vivo study	Used nano - silver coated orthodontics brackets in contact or placed near the gingiva or oral epithelium.	It was found to have better tissue compatibility features compared to the standard type orthodontic bracket.
3.	Gamze Metin - Gürsoy et al. in 2017 ⁴⁰	In vivo study	Used nano - silver coated orthodontic brackets on the teeth to check the antibacterial properties.	Nano - coated orthodontic bracket is effective in the inhibition of <i>S. mutans</i> and reduction in smooth surface caries.
4.	Mhaske et al. in the year 2015 ⁴²	In vitro study	To access the antiadherent and antibacterial properties of against <i>Lactobacillus acidophilus</i> .	Nano - silver coated orthodontic wire can be used to prevent the development of dental plaque and dental caries during orthodontic treatment
5.	Priyanka K. Shah et al. in the year 2018 ¹⁹	In vitro study	Compared the frictional properties between silver coated SS wire and uncoated SS wire	The study confirmed improvement in frictional properties of arch wires by modifying the surface.
6.	Alma E. Hernández - Gómora et al. in the year 2017 ⁴³	In vitro study	Silver nanoparticles were synthesized in situ on orthodontic elastomeric modules (OEM) using silver nitrate salts	Orthodontic elastic modules decorated with AgNPs demonstrated higher physical properties such as maximum strength, tension and displacement compared to conventional module
7.	Adith Venugopal et al. in 2017 ⁴⁴	In vitro study	Prepared two different titanium alloy: one coated with regular AgNPs (Ti - AgNP) and the other coated with titanium biopolymer - AgNP(Ti - BP - AgNP)	The Ti - BP - AgNP surface showed clear zone of inhibition and had remarkable antibacterial activity towards the oral bacteria <i>S. mutans</i> , <i>S. sanguinis</i> and <i>A. actinomycetemcomitans</i> .
8.	Danna Mota Moreira et al. ¹⁸ in 2018	In vitro study	Introduced novel antimicrobial orthodontic band cement with in situ-generated Agnps.	These resins have comparable mechanical properties to the control group and sustained Ag+ ion release, significant bacterial inhibition and excellent biocompatibility.
9.	Baocheng CAO et al. ²² in 2013	In vitro study	Orthodontic brackets coated with a thin film of nitrogen - doped TiO2 NPs particle size 33 nm	The bracket coated with the TiO2 - xNy thin film shows high antimicrobial activity against <i>S. mutans</i> , <i>L. acidophilus</i> , <i>A. viscosus</i> , and <i>C. albicans</i> . The coated bracket was effective in prevention of enamel demineralization and gingivitis during orthodontic treatment.
10.	Maryam Poosti et al. ⁴⁵ in 2013	In vitro study	The light cure orthodontic composite containing 1 % (w / w) TiO2 nanoparticles was quite effective in inhibiting bacterial growth	Adding TiO2 nanoparticles to orthodontic composite enhances its antibacterial effects without compromising the physical properties (shear bond strength)
11.	Daniela Delloso et al. ⁴⁶ in 2017	In vitro study	The author suggested adding titanium oxide nanotubes have the potential to improve GICs surface roughness and hardness and may reduce biomechanical degradation of the material	Addition of 3 %, 5 %, 7 % TiO2 to a conventional GIC showed significantly increased its Knoop microhardness (KHN). It was also found that the addition of TiO2 nanotubes to a conventional GIC significantly increased its fluoride - releasing pattern. Hence, TiO2 NP - GIC has improved microhardness and fluoride release capability, without affecting surface roughness suggesting its potential for higher stress - bearing site restorations.
12.	Chia - Tze Kao et al. ¹ in 2002	In vitro study	The plated metal bracket was produced by the titanium nitride (TiN) ion - plating method. Both TiN - and non - TiN - plated brackets may release detectable ions into the test solution, including nickel, chromium, manganese, copper, and iron (ferric) were tested under atomic absorption spectrophotometry and atomic emission spectrophotometry for anti - corrosion properties.	The TiN - plated metal bracket did not increase the anticorrosion ability of the standard bracket. The biocompatibility of the TiN plating versus the standard bracket material resulting from bracket immersion in the test solution revealed no toxicity on human osteogenic sarcoma (U2OS cells)
13.	M. Redlich et al. ²⁵ in 2008	In vitro study	The SS wires coated with nickel-phosphorus (Ni-P) and IF - WS2nanoparticles. The properties of the coated wires after friction were analysed by a Raman microscope.	The results displayed excellent friction and wear properties due to their unique fullerene - like structure. The toxicity of the fullerene - like nanoparticles have provided indications that they are biocompatible.
14.	Friedman H et al. ²⁴ in 2007	In vitro study	Cobalt films impregnated with IF - WS2 nanoparticles (Co + IF) were successfully deposited by both electroless and electro - deposition processes onto stainless steel substrates. The films were characterized by a number of analytical techniques, which ascertained their morphology, crystallinity and chemical composition.	Nano - composite coatings show lower friction and wear as compared to either the cobalt coating or the stainless-steel substrate itself; however, better adhesion was observed for films obtained by electroless deposition.
15.	Mirhashemi AH et al. ²⁸ in 2013	In vitro study	Incorporated chitosan (CS) and zinc oxide (ZnO) nanoparticles (NPs), into the composite and assessed antimicrobial properties.	ZnO - NPs and Chitosan NPs cause inhibition of bacterial biofilm, which is more prominent with higher NP concentrations especially in 10 % weight concentrations. The 5 % group significantly reduced <i>S. mutans</i> and the 10 % group inhibited <i>S. sanguis</i> and <i>Streptococcus mutans</i> and <i>Lactobacillus acidophilus</i> significantly.
16.	Sodagar. A et al. ²⁰ in 2016	In vitro study	Incorporated nano - chitosan of different concentration 1 %, 3 %, 5 % and 10 % in the orthodontic composite and measured the shear bond strength along with its antimicrobial properties.	The bond strength is decreased as the percentage of chitosan nanoparticles and the bacterial biofilm inhibition in composite containing chitosan nanoparticles is significantly more than conventional composite resins. According to the author, the use of 1 % weight of NP might be advisable with mechanical modifications.
17.	Mary A. S. Melo et al. ³⁰ in 2014	In vitro study	The author used four groups: non - fluoride - releasing microfilled composite, fluoride - releasing microfilled composite, resin - modified glass ionomer cement (RMGI), and fluoride - releasing nanofilled composite (FN). He evaluated for fluoride releasing and enamel demineralization inhibition capacity of fluoride - releasing nano filled cement around orthodontic brackets using an artificial caries biofilm model	Their studies have shown evidence that only RMGI was capable of decreasing demineralization around orthodontic brackets and the inclusion of nanofillers fluoridated composite resin did not provide greater inhibition of demineralization.
18.	Enan and Hammad ³¹ in the year 2013	In vivo study	Added nano - hydroxyapatite (Nano - HA) to conventional GIC used for band cementation and measured the microleakage under orthodontic bands, which was assessed by the methylene blue dye penetration method after 60 days.	GIC with 15 % nano - HA is a promising material for orthodontic banding that may guarantee a minimal amount of demineralization around the bands at the end of orthodontic treatment.
19.	Chung et al. ³² in 2016	In vitro study	Prepared inorganic-organic nanocomposites by HA asinorganic component of nanocomposites (75 % w) and natural polymers (chitosan, alginate and albumin) as organic components of nanocomposites (25 % w) and checked for cytotoxicity using MTT assay test.	The results showed no cytotoxicity in the MG - 63 cell line (human bone osteosarcoma). HA nanoparticles were biocompatible.
20.	Ramazanzadeh.B et al. ³⁴ in the year 2015	In vitro study	Used three groups: ZnO nano - coated brackets, CuO nano - coated brackets and combined ZnO - CuO nano - coated brackets. All these brackets were subjected to antimicrobial test against <i>S. mutans</i> .	It has been observed that CuO and ZnO - CuO nanoparticles coated brackets have better antimicrobial effect on <i>S.mutans</i> than brackets coated with Zinc oxide or CuO alone.
21.	Behroozian et al. ⁴⁷ in the year 2016	In vitro study	Deposited ZnO nanoparticles on SS wire and measured friction during sliding the wire with an uncoated porcelain bracket	The deposition of such nanoparticles significantly decreased the frictional forces between the SS wire and porcelain brackets in the sliding technique. The benefits are decreasing treatment time and the risk of root resorption are potential advantages of decreasing friction between brackets and wires.
22.	Figuroa et al. ³⁷ in the year 2015	In vitro study	Incorporated Copper oxide nanoparticles to orthodontic adhesive at 0.0100 wt %, 0.0075 wt %, and 0.0050 wt % and measured the bond strength.	It was observed higher bond strength was obtained with the orthodontic adhesive that included 0.0100 wt % of copper NPs
23.	Toodehzaeim et al. ³⁸ in 2018	In vitro study	Incorporated CuO nanoparticle into adhesive (Trans - bond XT adhesive 3M Unitek, USA) in three concentrations 0.01, 0.5 and 1.0 wt. % and assessed the shear bond strength and antimicrobial properties.	Incorporating CuO nanoparticles in all three concentrations has no negative effect on shear bond strength of adhesive. These nanoparticles probably can act as nano - fillers and enhance shear bond strength of adhesive. And increasing concentration of copper oxide nanoparticles does not increase the <i>S.mutans</i> inhibition zone
24.	Imani. M et al. ⁴⁸ in 2019	In vitro study	2019 synthesized of magnesium oxide nanoparticles using the Taguchi method. The size and morphology of the synthesized magnesium oxide nanoparticles was studied through scanning electron micrograph and tested for antibacterial activity against <i>E. coli</i> and <i>S. aureus</i>	The optimum condition MgONPs antibacterial activity against <i>E. coli</i> and <i>S. aureus</i> was improved. Magnesium oxide nanoparticles could serve as an alternative to the most commonly used antibiotics used due to their good antibacterial properties
25.	Melo M. A et al. ⁴⁰ in 2014	In vitro study	Dimethylaminododecyl methacrylate (DMADDM) synthesized antibacterial monomer, was incorporated into orthodontic cement at 0 %, 1.5 %, 3 % and 5 % mass fractions and then the bond strength of brackets to enamel was measured. A microcosm biofilm using human saliva are representative of the microbial consortium and complex communities that colonize the oral cavity was used to measure metabolic activity, lactic acid production, and colony - forming units.	DMADDM - containing orthodontic bracket cement possessed a strong antimicrobial activity when incorporating 3 % of DMADDM. The anti-biofilm potency increased with increasing the DMADDM mass fraction, the enamel bond strength had a slight decrease at 5 % DMADDM.

Table 1. Concise Chart of the Studies between 2010 to 2020

Nano Particles	Size	Properties	Uses
Gold nanoparticles (AuNPs)	Turkevich et al. created AuNPs in 1951 of size 10 - 20nm ⁹ Brust and Schrifin achieved a breakthrough in AuNP synthesis in 1994 of size from 1.5 - 5nm ¹⁰	Excellent Biocompatibility, low toxicity, optoelectronic properties, ^{11,12} dimensionally stable, Imagining and sensing ¹³ , photo thermal therapy, ¹⁴ genetic regulation ¹⁵ drug treatment ¹²	Microscopic examination of carcinogenic cells ¹³ immunochemical studies for protein identification & DNA detection, tissue engineering, ² imaging agents because of its optical properties, ¹³ fillers in dental nano composite ¹⁶
Silver nanoparticles	1 to 100 nm ¹⁷	Excellent Biocompatible, anti-inflammatory, antioxidant, antimicrobial, bactericidal properties, anticancer, biosubstances ¹⁵	Effective anti - tumour drug delivery system, ¹⁸ for its antimicrobial properties used in treatment of syphilis in twentieth century, ¹⁹ used in dentistry in cements and resins, coated brackets, bands and wires. ²
Titanium nanoparticles	Less than 100nm	Biocompatible, corrosion resistant, effective photocatalytic activity, low toxicity, high stability, ^{20,21} antimicrobial properties and physiochemical properties. ²²	Used in orthodontics material due to its anticorrosion properties.
Fullerene like tungsten sulfide nanoparticles (IF - WS ₂)	Was first time described in 1992, varies in size 20 - 200nm ²³	Solid lubricant with reduced friction and wear properties ²⁴⁻²⁶	Coated on orthodontic archwire because of their reduced frictional properties.
Chitosan nanoparticles	200nm	Biodegradable, non-toxic, non - antigenic, strong anti-microbial properties ²⁷	Added in nano - composite ^{20,28} and dentifrice. ²⁷
Fluoride releasing nanoparticles	hexagonal and triangular single crystals vary in size of 25 - 350nm	Anticariogenic properties ²⁹	Fluoride releasing glass ionomer, resin - modified glass ionomer cements, polyacid modified composites (compomer), and composite ^{2,29,30}
Hydroxyapatite nanoparticles	Sizes varies between 50 and 1000 nm	Biocompatible and bioactive material, ^{2,31,32} anti - cariogenic properties. ³¹ antimicrobial properties. ³³	Incorporated in glass ionomer cement, ³¹ orthodontic adhesives ^{32,33}
Zinc nanoparticles	30 - 150nm	Anti - bacterial, antifungal and UV filtering properties. Low toxicity and good biocompatibility ^{2,34,10} reduced frictional properties. ^{35,36}	Coated on the orthodontic brackets ³⁴ , archwire, ^{35,36} and adhesives. ^{10,28}
Copper nanoparticles	1 to 100nm	Exceptional tensile strength, elastic modulus, electrical and thermal conductivity, and unique electronic, magnetic and optical properties. Antibacterial and antifungal properties ^{2,37,38}	Incorporated in orthodontic adhesives ^{37,38}
Magnesium nanoparticles	20 - 60nm	Improves bone regeneration, antibacterial and antimicrobial properties ^{37,39}	Incorporated in mini-implants, served as antibiotic ³⁹
Quaternary ammonia nanoparticles	100nm	Antimicrobial and antibacterial properties	Incorporated in dental resin based material ² , orthodontic cement. ⁴⁰

Table 2. Various Metal - Based Nanoparticles Used in Orthodontics and Their Properties

When coating the arch wire, it's important to look at the film's quality, corrosion behaviour, and how many ions are released, because free ions induce cytotoxicity.² By embedding hard alumina nanoparticles in polysulfone, nanoparticles are also employed to make brackets. These brackets are strong, have less friction, and are biocompatible, all while keeping the bracket's transparency¹. When a nano-coated elastomeric ligature is used, anti-cariogenic fluoride is released.⁴ Nanoparticles are also used on the surface of micro-implants to improve osseointegration and decrease the failure rate of TADs.⁴⁸

CONCLUSIONS

Despite widespread effectiveness, orthodontic therapy is limited by many issues, including friction, extensive treatment times, and consequences like tissue irritation, tooth decalcification owing to bacterial development, and root resorption. Nanoparticles bond strongly to other materials or each other due to their large surface free energy (agglomeration). The nano - coatings produced are either lubricants to reduce friction or antibacterial to minimize microbial counts and the issues that come with them, including cavities, periodontal illnesses, and decalcification around the bracket.⁵ The unique features of silver and gold nanoparticles can be used to give local anaesthetic, diagnose, and treat oral problems. Nanoparticles are employed in orthodontics because of their biocidal, anti-adhesive, and anti-biofilm properties, as well as their demineralization effect and friction reduction.^{9-15,49,16-19} Based on the coating substance, nanoparticles are biocompatible and less cytotoxic. Friction being the most important in fixed mechanotherapy for alignment and levelling, as well as space closure. Up to 60 % of the force is wasted as friction, reducing

the force available for tooth movement and necessitating the application of extra force to counteract the frictional force. Increased friction during orthodontic treatment can cause a variety of issues, including trouble with anchoring management and an increase in the length of orthodontic therapy. Several strategies have been developed to reduce friction and improve both the mechanical and biological properties of orthodontic wires, including changing the bracket design, using various types of alloys, surface treatment or coating of brackets using various techniques and materials, and modifying the surface of both the archwires and brackets. On stainless steel and NiTi wire, nanoparticles such as copper oxide,³⁷ inorganic fullerene - like nanoparticles of tungsten disulphide,^{48,28} and Co + fullerene - like WS₂ NPs,²⁴ silver - coated nanoparticles¹⁹ and zinc oxide nanoparticles on the orthodontic bracket and an archwire³⁵ showed a 50 % reduction in coefficient of friction. During orthodontic treatment, plaque collection on fixed and removable appliances is also a typical issue. Gingivitis, periodontitis, white spot lesions, increased caries risk, halitosis, superimposed infections, TAD failure, and delayed tooth movement are all possible repercussions of bacterial development. Nanoparticles as antibacterial agents can be included or put on bracket surfaces, resin composites, glass ionomer cement, and mini-implants to reduce these issues.⁵ Nanoparticles coated on bracket which showed excellent antibacterial effect and biocompatibility were silver NP,^{21,31,40,50} Titanium nitride,¹ Nitrogen - doped titanium oxide,^{21,22} CuO & ZnO NP.³⁷ Carbon nanoparticles were integrated into stainless steel wire.³⁸ Silver nanoparticles coated on mini-implants used as temporary anchorage devices have antibacterial properties, and are safe and prevent implant infection.^{44,51} Nano - composite showed a good antibacterial effect when incorporated with ZnO NP and Chitosan NP,^{20,28} titanium oxide NP,⁴⁵ nitrogen doped titanium oxide NP,²⁹ hydroxyapatite NP^{20,32} and fluoride

releasing nano- composite to prevent demineralization. Nanosized fluorapatite (NFA) or fluorohydroxyapatite (NFHA) particles at a concentration of 25 %, ^{31,52} silver nanoparticles, ^{53,54} magnesium oxide, ⁵⁵ and quaternary ammonium nanoparticles have all been used to improve GIC. ⁴⁰

Nanotechnology is widely used in our day-to-day life including its use in medicine. In 21st century based on its economic and scientific potential, nanotechnology holds promise in many areas like advanced diagnostics, targeted drug delivery and biosensors. It has several applications in dentistry as well, from diagnosis of pathological conditions to local anaesthesia, orthodontic tooth movement and periodontics. In the field of orthodontics, nano-coating on the orthodontic archwire, brackets, bands, elastomeric ligatures, orthodontic power chains, mini-implants are used for its reduced friction properties, excellent corrosion resistance, and good antimicrobial property, fluoride- releasing nano-filled composite (FN) reduces the caries lesion development around the brackets and nanoparticles can be used as agents for remineralization of decalcified enamel.

This present reviewed article summarized the most significant innovation of nanotechnology in the field of orthodontics and reviewed the most recent literature comparing with different research studies and focusing the attention on the application of new nanoparticles and their benefits. The nanomaterials have introduced many advantages in the field of orthodontics, especially with improved mechanical and antimicrobial properties. The future in orthodontic treatment will benefit enormously through nanotechnology should all the current attempts succeed in its clinical application at a reasonable cost to the orthodontist and patients.

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