Review Article

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Dentistry Section

A Systematic Review on Nano Coated Orthodontic Brackets and its Antibacterial Effects

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ABSTRACT

Introduction: Oral cavity is a natural habitat of bacteria which proliferates when an orthodontic appliance is placed which leads to enamel demineralisation or white spot lesions. In order to reduce the bacterial proliferation, the surface coating of brackets using nano particles came into existence.

Aim: To assess the different surface modifications using nano coating materials and to evaluate the antibacterial properties of these nano coated orthodontic brackets.

Materials and Methods: A systematic review was conducte in September 2021, analysing the microbial adhesion and antibacterial properties of orthodontic brackets after application of nano coating against uncoated brackets was conducted from the available electronic database during January 2000 to June 2021, which included PubMed, Embase, Google Scholar and Medical Literature Analysis and Retrieval System Online (MEDLINE). Due to less number of in-vivo studies, in-vitro studies were also included. An analysis on the microbial adhesion and antibacterial effects of various orthodontic brackets was done. The results were tabulated after performing risk of bias assessment for each study.

Results: Based on the inclusion and exclusion criteria, 13 studies were included in the study. Risk of bias was medium for majority of the selected studies. As per the previous literature, bacterial adherence of *Streptococcus mutans, Streptococcus sobrinus, Aggregatibacter actinomycetemcomitans, Lactobacillus acidophilus, Actinomyces viscous* and *Candida albicans* was reported lower in groups of brackets coated with silver nano particles than that in the groups of brackets without the addition of silver nano particles. The corrosion level on the silver or silver platinum (Ag-Pt) coated specimens was lower than that on the non coated specimens.

Conclusion: The stainless-steel orthodontic brackets coated with various nano coating materials like silver, silver-platinum, titanium, Zinc Oxide (ZnO) and Copper Oxide (CuO) exhibited adequate antibacterial effect. This shows that in orthodontic patients, especially the one susceptible to caries, the amount of plaque accumulation is significantly reduced when nano-coated orthodontic brackets are used. They reduce the microbial colony count, prevent enamel demineralisation and white spot lesions. Further clinical trials must be carried out on a large scale to confirm the results.

Keywords: Antibacterial properties, Microbial adhesion, Nano coating, Nano particles

INTRODUCTION

The oral cavity is a natural habitat for microorganisms like bacteria to proliferate and produce organic acids that demineralise the surface of tooth enamel thus leading to white spot lesions followed by dental caries [1]. When a fixed or removable orthodontic appliance is placed in patient's mouth, there will be variation in the microbial flora, decrease in the pH level followed by increased plaque accumulation. This occurs most commonly at tooth surface and bracket interface since these areas are very difficult to access using a toothbrush. There will be adhesion of bacteria and biofilm formation in these areas. The most common type of bacteria that produce significant amount of acid and lead to demineralisation include *Streptococcus mutans* and *Lactobacilli*. *Streptococcus sobrinus* and *Porphyromonas gingivalis* are also associated with demineralisation [2].

Orthodontic brackets can be classified as metallic and aesthetic brackets based on the material used. Stainless steel orthodontic brackets are the most commonly used metallic brackets in orthodontic treatment. However, there were reports of enamel demineralisation at the bracket-adhesive-enamel junction, White spot lesions (decalcification of enamel) and dental caries encountered while undergoing orthodontic treatment due to plaque accumulation around brackets [3]. Orthodontic brackets are ideal surface for increased plaque accumulation [4]. Because of their complex structure they do not prevent biofilm formation and microbial growth. This leads to decalcification which is the first step to cavity formation [5].

Hence, nano materials can be coated over the brackets to reduce enamel demineralisation, bacterial aggregation, surface roughness and friction [6]. Nitrogen doped Titanium dioxide (TiO_2), Silver (Ag), Gold (Au), Silica (SiO_2), Copper (Cu/CuO) and ZnO nano particles have been used as coating materials to reduce demineralisation. These coatings prevent the bacterial aggregation by changing the antibacterial properties of the metal surface of the appliance before application [3].

Commonly, Ag coatings are used due to its non toxicity and its antimicrobial effect. Silver has superior antibacterial and antibiotic characteristics [5]. The antimicrobial effects of silver ion or salts are known well since ancient times. Silver nano particles can be used as antibacterial agents because of their different chemical and physical properties [2]. During the silver (Ag) coating process of orthodontic brackets, addition of Palladium (Pd) is done to increase the hardness and wear resistance which will prevent the corrosion caused by chewing food [5].

Titanium coatings are used due to its biocompatibility properties [5]. The bracket coated with the $TiO_{2-x}N_y$ thin film strongly prevents the adherence of *S. mutans*. It shows high antimicrobial activity against *S. mutans*, *L. acidophilus*, *A. viscous*, and *C. albicans*. Enamel demineralisation and gingivitis occurring during orthodontic treatment can also be prevented effectively. Nano titanium films are not suitable for friction reduction [6,7]. Studies showed that the brackets coated with ZnO and CuO nano particles have excellent antimicrobial properties and after a period of time the bacterial count was reduced to zero [8-11]. Orthodontic brackets coated

with Silver (Ag) and Platinum (Pt) also provide antimicrobial property and prevent the biofilm formation [3]. Nano coating process was done by using physical vapour deposition system [1].

The aim of this systematic review is to assess the different surface modifications using nano coating materials and to evaluate the antibacterial properties of these nano coated orthodontic brackets.

MATERIALS AND METHODS

This systematic review was done in SRM Dental College, Ramapuram, Chennai in the month of September 2021, using four investigators under the registration ID SRMU/M&HS/SRMDC/2021/S/032 (SRM Dental College). A computerised search of the database was done from January 2000 to June 2021. The following databases were searched: Pubmed; Google Scholar, MEDLINE, MEDLINE In-process, Embase using the keywords like Microbial Adhesion; Nano coating; Nano Particles; Orthodontic Brackets and the articles were included in the systemic review based on the search criteria.

PICO Question: Population, Intervention, Comparison and Outcome

Can the incorporation of nano particle coating increase the antibacterial properties of orthodontic brackets and reduce the occurrence of dental caries?

PICO Analysis

Population (P): Orthodontic brackets

Intervention (I): Brackets coated with Nano particles

Comparison (C): Uncoated brackets

Outcome (O): Increase or decrease in the antimicrobial properties and its effect on enamel demineralisation or dental caries.

Inclusion criteria: Those publications of studies in English language with full text articles and studies on nano coated brackets and their antibacterial properties, from the year 2000 were included in the review.

Exclusion criteria: Articles published in language other than English, those studies which do not assess antibacterial properties of nano coated brackets and case reports were excluded from the review.

Data Extraction and Synthesis

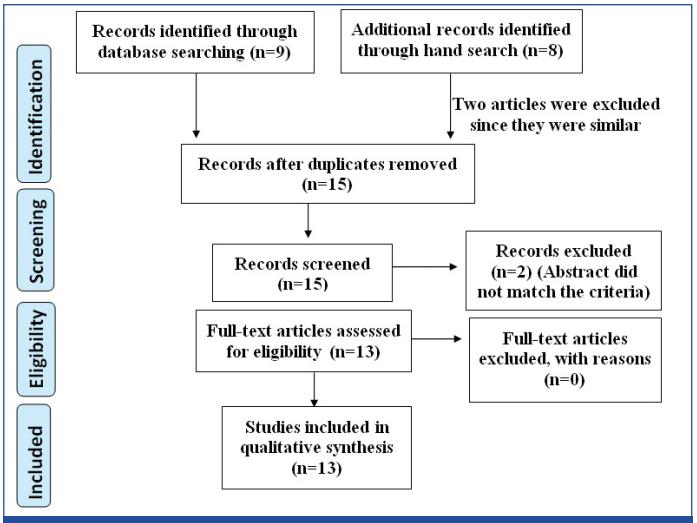
Articles abstracts were read thoroughly to determine the eligibility of articles. Two researchers independently completed the selection process. If a discrepancy arose, a third researcher helped in making the final decision. Articles for which the abstracts did not present enough relevant information to make a final decision regarding their inclusion were rejected. The reference lists of the selected articles were also searched for additional relevant publications that may have missed in the database searches.

All the articles from the selected abstracts were evaluated independently and conclusion regarding which articles included in the review was drawn. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart of article selection is given in [Table/Fig-1].

RESULTS

Google Scholar and PubMed had the greatest diversity of abstracts. All of the selected abstracts from PubMed were included in Google Scholar and vice versa. After completing the review of the selected abstracts, the reference lists of the selected articles were included are displayed in [Table/Fig-2] [1-13].

Based on quality analysis; (National Institute of Health (NIH) quality assessment tool for risk of bias} [14], the quality of research and methodology was low for only one study, medium for eleven studies and high for one study [Table/Fig-3].



[Table/Fig-1]: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Flow chart.

DISCUSSION

When orthodontic treatment is done using fixed appliances, occurrence of plaque and microbial accumulation followed by white spot lesions around the bracket base area is very common. This will lead to frequent debonding of the brackets or bracket failure and also gingival inflammation because of increased bacterial count. In order to avoid this, the surface of the brackets is coated with different nano coatings [15]. The main objective of this systematic review was comparison of different nano-coated brackets with uncoated brackets to prevent the bacterial accumulation and antimicrobial property.

The different microorganisms that are present in the oral cavity will lead to the formation of enamel demineralisation by releasing certain acids. The most commonly associated bacteria with enamel demineralisation are *Streptococcus mutans* and *Lactobacilli*. These bacteria release lactic acid into the oral cavity thus leading to the formation of white spot lesions. The other bacteria that are associated include *Streptococcus sobrinus*, *Porphymonas gingivalis* and *Aggregatibacter actinomycetemcomitans*. The orthodontic brackets do not have the ability to prevent plaque accumulation or formation of white spot lesions because of its complex structure. An idea of nano coatings on orthodontic brackets has been introduced to prevent enamel demineralisation. The various coating materials that are used include Nitrogen doped Titanium dioxide (TiO_2), Silver (Ag), Gold (Au), Silica (SiO_2), Copper (Cu/CuO) and ZnO nano particles [16].

Jasso-Ruiz I et al., had concluded that the nano silver coated orthodontic brackets exhibit significant antibacterial properties against microorganisms and reduce their colony count. There is less adherence of microorganisms (*Streptococcus mutans*) to the brackets that were nano silver coated [1]. A study was done by Ryu HS et al., to compare the antibacterial properties and corrosion level of Silver-Platinum (Ag-Pt) coated orthodontic brackets with uncoated brackets. It was found out that the bacterial growth was significantly reduced in coated brackets (approximately 60%). Level of corrosion was also lower in Ag-Pt brackets when compared to the uncoated brackets [3].

A report by Ghasemi T et al., on the brackets coated with nano films of silver and titanium oxide coating was done. The four coated groups with silver and titanium oxide reduced the *S. mutans* count. Another important requirement during orthodontic treatment is the biocompatibility of the appliance. It has been found out that Nano costed Ag/TiO_2 brackets have good biocompatibility other than the antibacterial effects [6]. A study was done by Fatani EJ et al., to compare the antibacterial and antiadherent properties of Titanium oxide mixed with silver coated brackets against the

Author	Year of publication	Number of samples	Type of coating	Results
Jasso-Ruiz I et al., [1] (In-vitro study)	2020	A total of 300 commercial orthodontic brackets were used (n=30 per group) and classified into ten groups of orthodontic brackets (five groups with silver nano particles and five groups without silver nano particles).	Nano silver coating	Bacterial adherence of both *Streptococcus mutans* and *Streptococcus sobrinus* was lower in groups of brackets coated with silver nano particles than that in the groups of brackets without the addition of silver nano particles.
Metin-Gürsoy G et al., [2] (In-vivo study)	2017	12 male Wistar rats (four months old) were used (divided randomly into two groups of six rats each). One group consists of brackets coated with nano silver coating and the other group was a control group.	Nano silver coating	The nano silver coated bracket group exhibited significantly lower *S. mutans* counts compared to the control group.
Ryu HS et al., [3] (In-vitro study)	2012	Stainless steel was cut into 15 mm–diameter, 2 mm–thick samples. One group of cleaned specimens was coated with Ag and the other group with Ag-Pt.	Silver-Platinum coating	The level of bacterial growth of *Streptococcus mutans* and *Aggregatibacter actinomycetemcomitans* on the Ag-Pt coated specimens was reduced significantly (approximately 60%). The corrosion level on the Ag or Ag-Pt coated specimens was lower than that on the non coated specimens.
Baby RD et al., [4] (In-vitro study)	2017	A total sample size of 115 brackets was taken. A 68 of these brackets underwent the TiO_2 coating procedures. For the antibacterial study, there were four groups: group 1: 13 stainless brackets coated with the anatase phase of TiO_2; group 2: 13 stainless steel brackets coated with the rutile phase of TiO_2; group 3: 13 uncoated stainless steel brackets (positive control); and group 4: 13 uncoated stainless steel brackets (negative control).	Titanium dioxide coating	Both groups 1 and 2 brackets showed significant antibacterial activity, and group 2 had the greatest activity against *Streptococcus mutans*.
Fatani EJ et al., [5] (In-vitro study)	2017	Study comprised of four groups each with 35 samples. Group 1 included the Ag coated brackets. Group 2 included the TiO_2 coated brackets and group 3 included Ag+TiO_2 coated brackets. The samples with uncoated brackets were considered as control groups.	Ag coating, Titanium oxide coating, Titanium oxide mixed Ag coating	Bacterial Adhesion of *Streptococcus mutans* and *Porphyromonous gingivalis* was found more in non coated stainless brackets compared to others and significantly less adhesive in brackets coated with Ag+TiO_2 irrespective of the bacterial species.
Ghasemi T et al., [6] (In-vitro study)	2017	Total 55 stainless steel brackets were used for the study. These brackets were divided into five groups of 11 brackets each: uncoated brackets, brackets coated with 60 µm silver, 100 µm silver, 60 µm titanium, and 100 µm titanium.	Nano silver and Nano titanium oxide coatings	In the uncoated bracket group, the number of bacteria increased tremendously within 48 hours. However, the four coated groups reduced the *S. mutans* count.
Cao B et al., [7] (In-vitro study)	2013	A bracket coated with a Nitrogen-doped (N-doped) $TiO_{2-x}N_y$ thin film was prepared using the Radio Frequency (RF) magnetron sputtering method.	Nitrogen-doped TiO_2-xNy coating	Fewer bacteria were adherent to the surface of the bracket coated with the N-doped $TiO_{2-x}N_y$ thin film. They showed high antimicrobial activity against *Streptococcus mutans*, *Lactobacillus acidophilus, Actinomyces viscous, and Candida albicans.*
Ramazanzadeh B et al., [8] (In-vitro study)	2015	Sixty brackets were coated with nano particles of ZnO (n=20), CuO (n=20) and CuO-ZnO (n=20). Twelve uncoated brackets constituted the control group.	ZnO and CuO coating	In CuO and ZnO-CuO groups, bacterial population reduced to zero within two hours. The ZnO group, in comparison with the control group was effective in decreasing the number of *S.mutans* colonies, but had less antimicrobial effect compared with the two former groups.
Meyer-Kobbe V et al., [9] (In-vivo study)	2019	An occlusal splint equipped with differently silver modified test specimens based on stainless steel bracket material was prepared for a total of 12 periodontally healthy patients and was worn in the mouth for 48 hour.	Nano silver coating	Compared to untreated stainless steel bracket material, the antibacterial effect against *Streptococcus mutans* of the the Plasma Immersion Ion Implantation and Deposition (PIIID) silver modified surface was just as significant with regard to reducing the biofilm volume and the surface coverage as the galvanically applied silver layer and the Physical Vapor Deposition (PVD) silver coating.
Arash V et al., [10] (In-vitro study)	2016	Total 40 standard metal brackets were divided into two groups of 20 cases and 20 controls. The brackets in the case group were coated with Ag particles using an electroplating method.	Nano silver coating	The bacterial counts of *Streptococcus mutans* in the Ag-coated brackets were, in general, significantly lower (p-value <0.001) than those of their non coated counterparts.
Zhang R et al., [11] (In-vitro study)	2015	Lyophilized strains of anabiotic bacteria were incubated on blood agar plate for 48 hours under anaerobic condition. Then they were centrifuged, rinsed by PBS (Phosphate-Buffered Saline) buffer solution and finally diluted with water to achieve 1×106 CFU/mL. A volume of 0.2 mL bacterial culture broth was added on nano Ag/TiO_2 thin film and the control sample stainless steel 17-4.	Nano Ag/TiO_2 coating	Nano Ag/TiO_2 coating bracket not only has antibacterial effect against *Streptococcus mutans* but also has good biocompatibility, therefore, it can satisfy the clinical request of orthodontic treatment.
Salehi P et al., [12] (In-vitro study)	2018	A total of 40 stainless steel pre-adjusted premolar brackets were equally divided into two groups; namely the control group (n=20, uncoated brackets) and the experimental group (n=20, coated brackets).	Nitrogen-doped titanium dioxide (N-doped TiO_2) coating	The orthodontic brackets coated with the N-doped TiO_2 thin film showed a significant Colony-Forming Units (CFU) reduction of *Streptococcus mutans* compared to the uncoated brackets.
Shah AG et al., [13] (In-vitro study)	2011	This study was done on 120 specimens of stainless steel Pre-Adjusted Edgewise Appliance (PEA) orthodontic brackets. The specimens were divided into four test groups. Each group consisted of 30 specimens. Groups 1 and 3 containing uncoated brackets acted as a control group. Groups 2 and 4 included brackets coated with photocatalytic titanium oxide (TiO_2) thin film.	Photocatalytic titanium oxide (TiO_2) coating	Orthodontic brackets coated with photocatalytic TiO_2 showed an antiadherent effect against *L. acidophilus* compared with uncoated brackets. The bacterial mass that was bound to the TiO_2-coated brackets was less when compared with the uncoated brackets. Furthermore, TiO_2- coated brackets had a bactericidal effect on *L. acidophilus*, which causes dental caries.

[Table/Fig-2]: Summary of the studies included [1-13].

Author	Sample size calculation	Bracket randomisation	Control group	Surface coating procedure	Antibacterial assessment	Classification
Jasso-Ruiz I et al., [1]	No	No	Yes	Yes	Yes	Medium quality
Metin-Gürsoy G et al., [2]	Yes	Yes	Yes	Yes	Yes	High quality
Ryu, HS et al., [3]	No	No	Yes	Yes	Yes	Medium quality
Baby RD et al., [4]	Yes	No	Yes	Yes	Yes	Medium quality
Fatani EJ et al [5]	No	No	Yes	Yes	Yes	Medium quality
Ghasemi T et al., [6]	No	Yes	Yes	Yes	Yes	Medium quality
Cao B et al., [7]	Yes	No	Yes	Yes	Yes	Medium quality
Ramazanzadeh B et al., [8]	No	No	Yes	Yes	Yes	Medium quality
Meyer-Kobbe V et al., [9]	No	No	Yes	Yes	Yes	Medium quality
Arash V et al., [10]	No	No	Yes	Yes	Yes	Medium quality
Zhang R et al., [11]	No	No	No	Yes	Yes	Low quality
Salehi P et al., [12]	No	No	Yes	Yes	Yes	Medium quality
Shah AG et al., [13]	No	No	Yes	Yes	Yes	Medium quality

[Table/Fig-3]: NIH quality assessment tool for risk of bias [1-13].

uncoated brackets. The type of bacteria that was used in the study included *Streptococcus mutans* and *Porphyromonas gingivalis*. It was concluded that the antiadherent and antibacterial properties of coated brackets was significantly higher than that of uncoated brackets [5].

Many studies have reported on the antimicrobial assessment of brackets coated with nitrogen doped titanium dioxide coating. The studies showed that the N-doped $TiO_{2-x}N_y$ surface coated bracket have significantly higher antimicrobial activity because of fewer bacterial adherence. Since the bacterial count was less, there was a reduction in colony forming units. The bactericidal effects of TiO_2 coated brackets against *L. acidophilus*, which cause dental caries was also significant [4,7,12,13]. In a study done by Ramazanzadeh B et al., 4 groups were compared for the antibacterial properties against *Streptococcus mutans*. Group 1 included brackets coated with CuO, Group 2 included ZnO brackets, Group 3 included CuO-ZnO coated brackets and Group 4 included uncoated brackets. They found that the coated brackets have significant antibacterial properties than uncoated brackets [8]. In groups with CuO, coated brackets and CuO-ZnO coated brackets, the bacterial count was reduced to zero within two hours. But in ZnO coated brackets group, the antimicrobial properties were less when compared to other two groups.

Limitation(s)

Even though there are many studies to prove that the nano coated brackets have antibacterial properties, 11 out of 13 studies were only in-vitro studies. Only 2 out of 13, studies were in-vivo which accounts to about 15% of total studies. It might seem logical to think that the results of in-vitro studies would be more reliable, since it is done under controlled environment without the factors affecting the interpretation of results. But the in-vitro studies have its own drawbacks such as the variability encountered during the human experiments/in-vivo studies and it is impossible to replicate the exact intraoral environment such as medium, temperature and pH, etc. [17]. Further in-vivo studies are required to check the reliability of the results.

CONCLUSION(S)

The stainless steel orthodontic brackets coated with various nano coating materials like silver, silver-platinum, titanium, ZnO and CuO were evaluated, and they exhibited adequate antibacterial effect by decreasing the adherence of *Streptococcus mutans* on the orthodontic brackets. This indicates that in patients susceptible to dental caries and undergoing orthodontic treatment, there was a significant reduction in plaque accumulation when nano coated brackets are used. They reduce the microbial colony count, prevent enamel demineralisation and white spot lesions. Further clinical trials must be carried out on a large scale to confirm the results.

REFERENCES

[1] Jasso-Ruiz I, Velazquez-Enriquez U, Scougall-Vilchis RJ, Morales-Luckie RA, Sawada T, Yamaguchi R. Silver nanoparticles in orthodontics, a new alternative in bacterial inhibition: In vitro study. Progress in Orthodontics. 2020;21(1):01-08.

[2] Metin-Gürsoy G, Taner L, Akca G. Nanosilver coated orthodontic brackets: In vivo antibacterial properties and ion release. European Journal of Orthodontics. 2017;39(1):09-16.

[3] Ryu HS, Bae IH, Lee KG, Hwang HS, Lee KH, Koh JT, et al. Antibacterial effect of silver-platinum coating for orthodontic appliances. The Angle Orthodontist. 2012;82(1):151-57.

[4] Baby RD, Subramaniam S, Arumugam I, Padmanabhan S. Assessment of antibacterial and cytotoxic effects of orthodontic stainless steel brackets coated with different phases of titanium oxide: An in vitro study. American Journal of Orthodontics and Dentofacial Orthopedics. 2017;151(4):678-84.

[5] Fatani EJ, Almutairi HH, Alharbi AO, Alnakhli YO, Divakar DD, Alkheraif AA, et al. In vitro assessment of stainless steel orthodontic brackets coated with titanium oxide mixed Ag for anti-adherent and antibacterial properties against Streptococcus mutans and Porphyromonas gingivalis. Microbial Pathogenesis. 2017;112:190-94. Doi: 10.1016/j.micpath.2017.09.052. Epub 2017 Sep 29.

[6] Ghasemi T, Arash V, Rabiee SM, Rajabnia R, Pourzare A, Rakhshan V. Antimicrobial effect, frictional resistance, and surface roughness of stainless steel orthodontic brackets coated with nanofilms of silver and titanium oxide: A preliminary study. Microscopy Research and Technique. 2017;80(6):599-607.

[7] Cao B, Wang Y, Li N, Liu B, Zhang Y. Preparation of an orthodontic bracket coated with an nitrogen-doped TiO_2-xNy thin film and examination of its antimicrobial performance. Dental Materials Journal. 2013;32(2):311-16.

[8] Ramazanzadeh B, Jahanbin A, Yaghoubi M, Shahtahmassbi N, Ghazvini K, Shakeri M, et al. Comparison of antibacterial effects of ZnO and CuO nanoparticles coated brackets against Streptococcus mutans. Journal of Dentistry. 2015;16(3):200.

[9] Meyer-Kobbe V, Doll K, Stiesch M, Schwestka-Polly R, Demling A. Comparison of intraoral biofilm reduction on silver-coated and silver ion-implanted stainless steel bracket material. Journal of Orofacial Orthopedics/Fortschritte der Kieferorthopädie. 2019;80(1):32-43.

[10] Arash V, Keikhaee F, Rabiee SM, Rajabnia R, Khafri S, Tavanafar S. Evaluation of antibacterial effects of silver-coated stainless steel orthodontic brackets. Journal of Dentistry (Tehran, Iran). 2016;13(1):49.

[11] Zhang R, Zhang W, Bai X, Song X, Wang C, Gao X, et al. Discussion on the development of nano Ag/TiO^2 coating bracket and its antibacterial property and biocompatibility in ortho-dontic treatment. Pakistan Journal of Pharmaceutical Sciences. 2015;28(2 Suppl):807-10.

[12] Salehi P, Babanouri N, Roein-Peikar M, Zare F. Long-term antimicrobial assessment of orthodontic brackets coated with nitrogen-doped titanium dioxide against Streptococcus mutans. Progress in Orthodontics. 2018;19(1):01-06.

[13] Shah AG, Shetty PC, Ramachandra CS, Bhat NS, Laxmikanth SM. In vitro assessment of photocatalytic titanium oxide surface modified stainless steel orthodontic brackets for antiadherent and antibacterial properties against Lactobacillus acidophilus. The Angle Orthodontist. 2011;81(6):1028-35.

[14] Ma LL, Wang YY, Yang ZH, Huang D, Weng H, Zeng XT. Methodological quality (risk of bias) assessment tools for primary and secondary medical studies: What are they and which is better? Military Medical Research. 2020;7(1):01-01.

[15] Khoroushi M, Kachuie M. Prevention and treatment of white spot lesions in orthodontic patients. Contemporary Clinical Dentistry. 2017;8(1):11.

[16] Loesche WJ. Microbiology of dental decay and periodontal disease. Medical Microbiology. 4th edition. 1996.

[17] Kokich VG. In vitro vs in vivo materials research. American Journal of Orthodontics and Dentofacial Orthopedics. 2013;143(4):S11.

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- Manual Googling: Dec 13, 2021
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