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Nanoparticles and their Potential affect as Antimicrobials in dentistry

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Abstract

The aim of the current article is to evaluate the antiadherent and antibacterial properties of surfacemodified different orthodontic brackets with silver nanoparticles against Streptococcus mutans and Streptococcus sobrinus, using radiomarker. To measure the current study, a quantitative method was applied to the adherence of Streptococci to orthodontic brackets, 70 samples of orthodontic brackets were selected and classified in to 10 groups as follow: GVn (Radiance plus-Roth), GVI (InVu-Roth), GVII (SystemAlexanderLTS), GVIII (Gemini-Roth), GIX (NuEdge-Roth), GIIIn (Gemini-Roth), GIVn (NuEdge-Roth), GX (Radiance plus-Roth), GIn (InVu-Roth), and GIIn (SystemAlexanderLTS). The study focused on patients' gender while considering sample for the present article. To codify and measure the bacterium, a radioactive marker (3 H) was applied. The brackets were then immersed in a radiolabeled solution, and the radiation was measured. The ANOVA test (Sheffè post hoc) was used to calculate the statistical analysis. The findings revealed that there were substantial disparities between the groups. GIIIn was the lowest score for both bacteria, whereas GIX and GVI were the highest for Streptococcus mutans and Streptococcus sobrinus, respectively. In conclusion, the surface of orthodontic brackets can be modified with silver nanoparticles to reduce the accumulation of dental plaque and the development of dental caries during orthodontic treatment.

Keywords— Silver nanoparticles, Orthodontic brackets, White spot lesion, Dentistry

I. INTRODUCTION

One of the most serious issues in dental clinical care is the growth of white spot lesions (WSLs) on dental enamel during orthodontic treatment. This process is mostly caused by Streptococcus mutans metabolism, which produces low oral pH and lactic acid. Previous research has found an increase in bacterial growth at the interface of adhesive resins used to connect orthodontic implants to enamel. Furthermore, even with patient cooperation, mechanical plaque removal around orthodontic cariogenic difficulty (Balhaddad et al. 2020). Some important aspects of the oral cavity environment are necessary for the proliferation of bacteria that are capable of generating acids that demineralize the surface of tooth enamel (Sreenivasagan et al. 2020). The formation of a biofilm on the tooth surface is critical for the adherence of these microorganisms to the surface (Chandra et al. 2020). Enamel demineralization is caused by organic acids produced by various microorganisms, primarily Streptococcus mutans (S. mutans) and Streptococcus sobrinus (S. sobrinus), which have been identified as the primary pathogens in dental caries (Bapat et al. 2020).

The development of germs resistant to commercially available antimicrobial treatments has increased the demand for natural and harmless sources. The bactericidal activity of fluoride-releasing compounds decreased rapidly. In this regard, innovative materials aimed at reducing cariogenic streptococci adhesion to orthodontic adhesives for extended lengths of time are critical to preventing enamel demineralization (Yin et al. 2020).

Silver nanoparticles have been shown to have a greater antibacterial impact against S. mutans at lower concentrations than other antimicrobial compounds such as gold or zinc (Song & Ge, 2019). This enables significant clinical effects while reducing toxicity. Furthermore, Makvandi et al. (2020) found that adding AgNP to an adhesive had no effect on the cytotoxicity of human gingival fibroblast viability. As previously demonstrated20, the antibacterial activity of silver nanoparticles included into adhesive cement can be extended for up to 3 months

(Burdușel et al. 2018). Nonetheless, this causes the creation of voids, which weakens the polymeric matrix. As a result, a straightforward approach for promoting AgNP dispersion in an aqueous solution was recently disclosed (Jiao et al. 2019).

The presence of fixed appliances has a mild effect on the amount and quality of oral microbiota (Chambers et al. 2017). Furthermore, Luchese et al. reveal in their study that orthodontic equipment affect the oral microbiota by increasing the counts of S. mutans and Lactobacillus spp. as well as the percentage of potentially pathogenic gram-negative bacteria (Parnia et al. 2017). It has been suggested that 55 to 75% of patients having fixed orthodontic appliance therapy exhibited enamel demineralization (white spot lesions or cavities) around the brackets (Espinosa-Cristóbal et al. 2019). This has been widely publicized from the first month after the brackets were placed, with estimates ranging from 13.1 to 45 percent (Enan et al. 2021). The oral pH levels and other microorganisms generally present in the oral cavity may influence bacterial adhesion capacity, biofilm formation, which raises the risk of demineralization in enamel, and caries development, particularly in bracket material (Divakar et al. 2018). The earliest affinity of bacteria to solid surfaces is mostly caused by electrostatic and hydrophobic interactions. Surfaces with a high free energy attract bacteria more easily, such as S. mutans (Rodrigues et al. 2020). According to Lima et al. (2020), stainless steel has the highest critical surface tension and is likely to have a better plaque-retaining capacity. Metallic orthodontic brackets have been shown to cause particular changes in the oral environment, including decreased pH, increased plaque formation, and increased S. mutans and S. sobrinus colonization. Nonetheless, recent research on apparent changes in the initial affinity and adherence of bacteria on metal, ceramic, and plastic brackets over time has been unconvincing (Bhushan & Maini, 2019).

While this addition of water to the nonpolymerized resin may inhibit cross-linking formation, it increases the dispersion of silver nanoparticles and, as a result, improves the antibacterial activity. Previous research using silver ions release and a bacterial adhesion assay6 demonstrated growth suppression effects against S. mutans. However, ion release can cause polymer breakdown, whereas the bacterial adhesion assay on the adhesive surface does not account for bacterial colonization at the enamel-adhesive interface (Amiri et al. 2017). Furthermore, no antibacterial test was seen after the introduction of modest amounts of silver nanoparticles in studiesexamining the mechanical qualities of orthodontic adhesives. As a result, the goal of this work was to assess the antibacterial effect of different concentrations of silver nanoparticle solutions on liquid and solid media, as well as the physical (Takamiya et al. 2021)-chemical properties of an orthodontic adhesive system. The null hypothesis was that AgNP inclusion would improve antibacterial activity while not interfering with the physical-chemical features of the orthodontic bonding system (Vega-Jiménez et al. 2017).

The avoidance of white spot lesions, caries, and periodontal issues during orthodontic treatment is a major concern for both the practitioner and the patient. Many treatments, such as fluoride varnishes or mousses, various toothpastes, and mouth rinses, have been proposed and developed to mitigate these biological implications (Lboutounne, 2017). Unfortunately, only about 14% of orthodontic patients follow the instructions [22–24]. Aside from that, with the introduction of an antibiotic-resistant type of bacteria, some metals, particularly in nanoparticle form, have piqued the interest of researchers. Nanoparticles are insoluble particles with a diameter of less than 100 nm that can be utilized in combination with dental products or by covering the surface to minimize microbial adhesion and prevent caries (Talapko et al. 2020). Silver has long been known for its antibacterial effect against gram-positive and gram-negative bacteria, fungi, protozoa, and certain viruses, including antibiotic-resistant strains, among other metals. Silver is commonly utilized in burned areas, medical gadgets, textile fabric, and as a water filter due to these capabilities (Fathima et al. 2017). Silver surface coating can be generated using a variety of processes, including chemical, physical, and biological (Butrón Téllez Girón et al. 2020). Silver nanoparticles (AgNPs) have been added to traditional orthodontic adhesives and appliances; the essential issue is that the physical and chemical properties should not be harmed, resulting in optimal clinical performance. Furthermore, the antibacterial and antiadhesive capabilities of the novel nanoadhesives, as well as their safety, must be demonstrated over a therapeutically relevant time range (Makvandi et al. 2021). As a result, the goal of this study was to determine and compare the independent bacterial colonization of S. mutans and S. sobrinus in five various types of orthodontic bracket materials, as well as to validate the efficacy of AgNP incorporation in some of them (Ferrando-Magraner et al. 2020).

II. METHOD

The study used 70 orthodontic brackets, the total of 70 groups were divided into 10 sub-groups and each group has 10 sample. As mentioned earlier that the present article used 70 orthodontic brackets in total; all samples were cleaned ultrasonically for a while to remove contaminants before being dried. Only half of the samples in each group that did not contain silver nanoparticles were sterilized with ethylene oxide gas, whereas the other half contained silver nanoparticles (AgNPs). The samples were kept in a humidity-free area to avoid contamination. At 37 °C for 2 hours, in continual movement, the orthodontic brackets were separated from their caps and immersed in 150 ml of S. mutans radiolabeled fluid and 150 ml of S. sobrinus radiolabeled fluid, respectively, before being removed from the mold. The brackets were removed from the glass mold and washed three times with PBS in order to eliminate the bacteria that did not adhere to them. It was necessary to collect the tagged bacteria that had stuck to the brackets with the help of an automatic sample combustion device. A liquid scintillation counter (LSC-900, Aloka) was used to assess tritium radioactivity [33–35]. Tritium was recovered as H2O in Aquasol-2 (Packard), and radioactivity was quantified using a liquid scintillation counter. The results were recorded in terms of disintegration per minute (dpm); as a result, the average of greater radiation levels was proportional to the average of higher levels of bacterial colonization in the samples. Additionally, after being submerged for 2 hours at 37 degrees Celsius in a solution containing cultivated microorganisms with continuous stirring, several representative samples were examined under a scanning electron microscope at magnifications of 2500 and 5000 for qualitative examination. The samples were chemically pretreated with glutaraldehyde and fixed with osmium tetroxide before being dehydrated with an escalating sequence of ethanol and freeze-dried before being seen under a scanning electron microscope.

Statistical analysis

The information was entered into a database and reviewed with the help of statistical analysis tools (SPSS version 23). Using a one-way analysis of variance (ANOVA) with a Scheffé test for multiple comparisons, the researchers examined the differences in measured values among the orthodontic brackets. A probability of less than 0.05 for similarity of distribution was regarded statistically significant in the case of similarity of distribution.

III. FINDINGS

A statistically significant difference existed between the groups in the adhesion of S. mutans radiolabeled to orthodontic brackets (p 0.05). The results were reported in decimal minutes per minute (dpm), as indicated in Table 1. Based on the dpm results, orthodontic brackets with stronger adherence of S. mutans were categorized as group GVI (3153.83 dpm), followed by group GVIII (2203.94 dpm), and finally group GIX (2186.23 dpm). Silver nanoparticles were not introduced to any of the brackets in this group. The groups that had the lowest bacterial adhesion, in addition, were those that had a coaggregation of silver nanoparticles; these groups are as follows: group GVn (687.33 dpm), followed by group GIIn (599.13 dpm), and group GIIIn (687.33 dpm), respectively (563.01 dpm).

Table 1 Quantitative test to S. mutans by radiolabeled (3 H)

Bracket	**DPM**	**SD**	**Sheffe test**
Glln Alexander Ag	591.18	(259.78)	A
Gln In Vu Ag	703.92	(263.31	A
GVn Radiance Ag	671.29	(279.39)	B
GIVn Nu-Edge Ag	769.81	(511.53)	B
Gllln Gemini Ag	559.29	(291.01)	B
GVI In Vu	321.11	(1001.29)	C
GIX Nu-Edge	2014.12	(499.71)	C
GVIII Gemini	219.28	(871.25)	C
GVII Alexander	2033.17	(871.22	D
GX Radiance	1699.28	(401.22	C, D

SD= Standard Deviation

DPM = Disintegration/Min

A significant difference (p 0.05) was seen in the adhesion of S. sobrinus radiolabeled to orthodontic brackets between the two groups. The results were reported in decimal minutes per minute (dpm), as seen in Table 2. For the dpm values, the orthodontic brackets with the greatest adherence of S. sobrinus were divided into three groups: group GIX (8197.32 dpm), group GVIII (7518.39 dpm), and group GVI (7256.29 dpm). Silver nanoparticles were not included in any of these groups for the dpm values. Group GVn (1085.70 DPM), group GIVn (1084.31 DPM), and group GIIIn (1084.31 DPM) were the groups with the lowest bacterial adhesion, while the groups with the highest bacterial adhesion were those with a coaggregation of silver nanoparticles (1044.08 dpm).

Table 2 Quantitative test to S. sobrinus by radiolabeled (3 H)

Bracket	**DPM**	**SD**	**Sheffe test**
Glln Alexander Ag	1422.97	(799.82)	A
Gln Vu Ag	1844.25	(1121.29)	A
GVn Radiance Ag	991.57	(287.25)	B, C
GlVn Nu-Edge Ag	879.28	(399.52)	B, C
Glln Gemini Ag	784.58	(299.58)	B, C
GlX Nu-Edge	7944.11	(2363.21)	D
GVl In Vu	4977.52	(911.28)	D
GVl Radiance Ag	6881.25	(1008.29)	D
GVll Alexander	4599.52	(1352.22)	E
GX Radiance	5771.25	(1356.21	D, E

SD= Standard Deviation

DPM = Disintegration/Min

Samples (pictures) of the bracket materials taken with a scanning electron microscope (SEM) and obtained after 2 hours of immersion in mutans and sobrinus solutions are presented in Figs. 1 and 2. According to the quantitative analysis, the qualitative observation made in SEM is congruent with the quantitative analysis. According to the dpm values, the bacterial adherence of both microorganisms was lower in all of the bracket groups that had silver nanoparticles (AgNPs) added than it was in the bracket groups that did not have silver nanoparticles added.

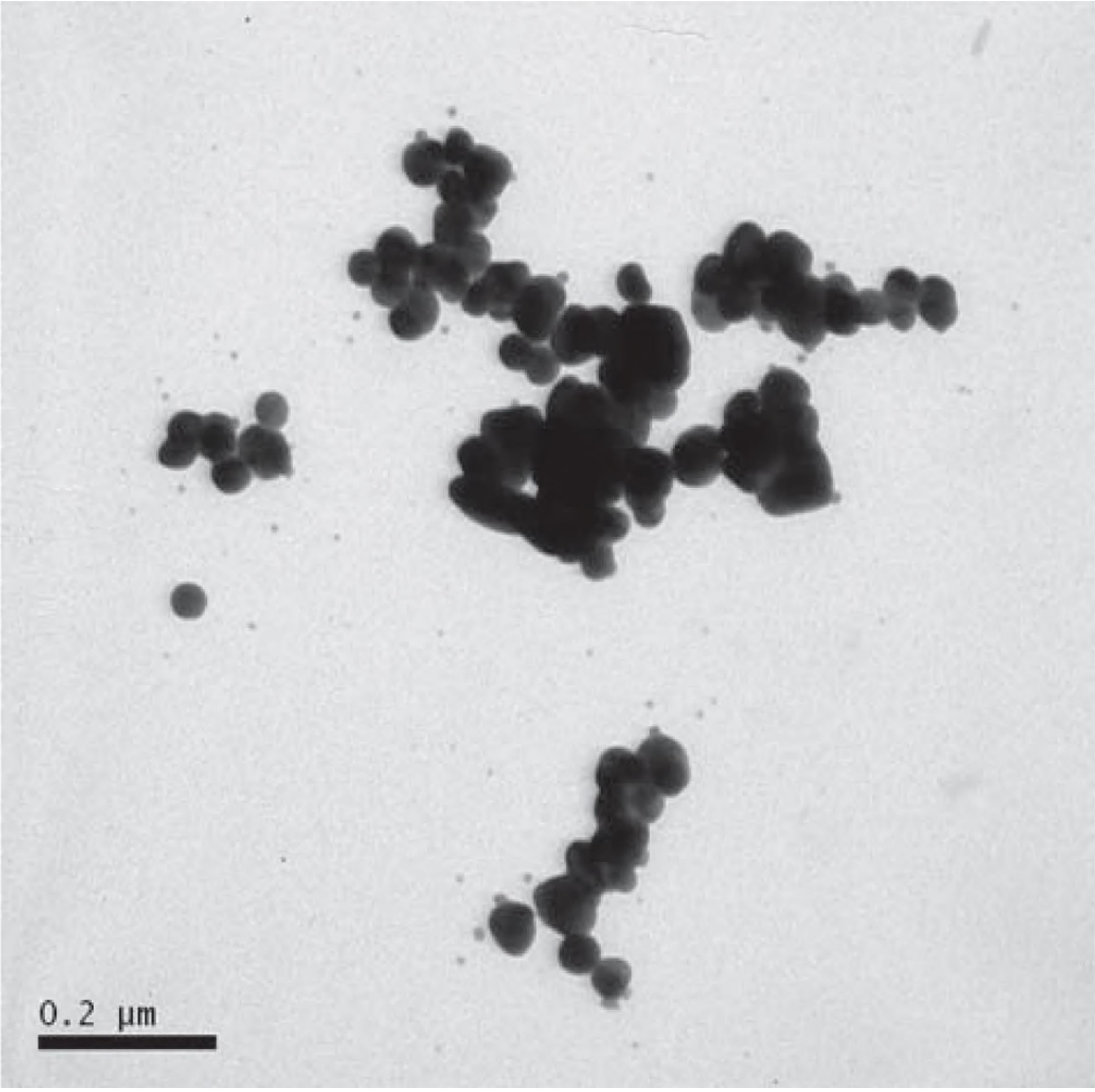

Fig.1-Oval and rhomboid shapes of silver nanoparticles measuring 25-100 nm

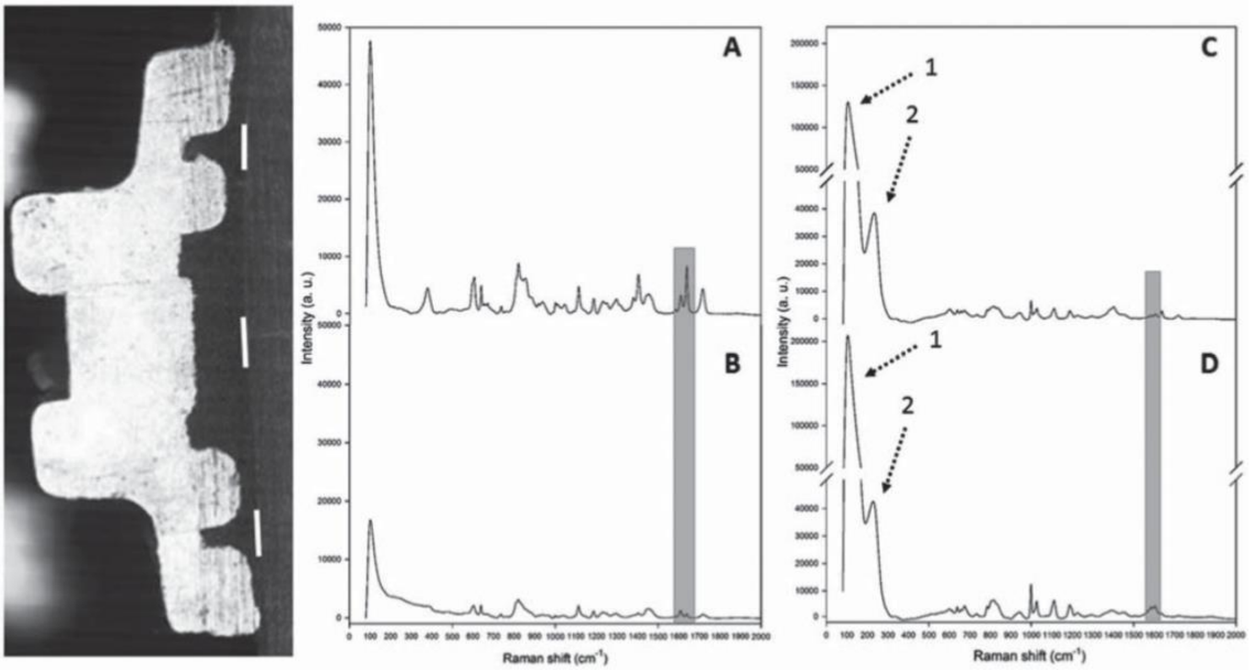

Fig.2-Half of a metal bracket used to analyze degree of conversion

Half of a metal bracket used to analyze degree of conversion (DC) in situ (three lines) before (A) and after (B) polymerization of 0% AgNP; and, before (C) and after (D) polymerization of 0.33% AgNP [highlight of the peaks corresponding to aromatic (1610 cm-1) and aliphatic (1640 cm-1) double bonds]. Arrows show the characteristic Raman peaks of silver compounds: (1) Higher intensity compared with 0% AgNP is due to the Ag lattice vibrational mode (114, 140, 146, and 158 cm-1) and (2) Ag-O stretching/bending modes from AgO2 (230-248 cm-1) and AgCH3COO (258 cm-1)

Silver has been shown to have an inhibiting effect on both Gram-positive and Gram-negative bacteria in earlier studies. A reaction against the denaturation effects of silver ions causes the DNA molecules to condense and lose their ability to replicate, resulting in the loss of replication skills. Furthermore, silver ions bind with thiol groups in proteins, resulting in the deactivation of the bacterial proteins as a result of the interaction. Using an Ag benzoate (AgBz)-based resin mix, Noori & Kareem, (2019) demonstrated halo inhibition against S. mutans following addition of 0.2 and 0.5 percent Ag benzoate (AgBz). We found that the antibacterial action of TransbondTM XT primer after incorporation of silver nanoparticles was due to direct contact with streptococci rather than silver ion release, which was consistent with our findings. After 48 hours of incubation, there was no evidence of an inhibitory halo around the disks in this investigation. The releasing property has the potential to reduce the lifespan of a bond and cause adhesive weakening. Furthermore, the non-releasing features of the adhesive allow the antibacterial action of the glue to be maintained for a longer period of time.

With increasing quantities of silver nanoparticles in situ, DC in situ decreased. Nonetheless, values of DC in the range of 85 to 90 percent are associated with significant cross-linking densities of dental polymers, as shown in the table. A prior investigation confirmed that the DC range achieved with its hardness data was equivalent to the one obtained with this analysis. The SFE values decreased as a result of the integration of 0.18 and 0.33 percent AgNP, respectively. This could have occurred as a result of a reduced interaction between the dispersive liquid and the presence of water (polar liquid) in the specimens, as previously stated. It is well known that the molecular interaction dipole x generated dipole forces between polar liquids and dispersive liquids are quite weak. The interface interaction between the enamel and the adhesive primer can be reduced by using lower SFE values, which results in lower SBS values. Lower quantities of SFE, on the other hand, may limit bacterial colonization at the bracket base since plaque accumulation around the bracket base has been associated with sticky rough surface texture, as demonstrated elsewhere. According to a prior study, the inclusion of water into dental adhesives in amounts more than 5 vol percent may interfere with the creation of an orderly polymer network, hence reducing the physical qualities of the adhesive. Although the SBS values decreased after the integration of AgNP solution, they remained higher than the clinically acceptable values between 6 and 8 MPa in this investigation, despite the use of an aqueous solution up to 3 vol percent. Given that the immediate binding strength to the tooth substrate is a function of the mechanical properties of the adhesive layer, higher mechanical characteristics are necessary for more permanent bonding to the dental substrate to be achieved. The SBS values found in this investigation are compatible with those found in the literature, as a result of which The shift in failure pattern that occurs following the inclusion of AgNP may help to protect enamel from potential harm. The loss of the adhesive bond between the enamel and the adhesive increases the likelihood of the enamel tissue's surface being damaged. Contrary to the reports that the pre-bonding application of an adhesive resin can be skipped during metal bracket bonding4, a specific indication of adhesive resin should be employed as an antimicrobial promoter to protect enamel from germs during the bonding process. Because the adhesive resin comes into close touch with the enamel surface, the introduction of antimicrobial agents within the resin may be considered a more appropriate technique in this case. In a recent study, it was discovered that different adhesive types had larger rates of microleakage at the adhesive-enamel contact. Increased dispersion and penetration of antimicrobial agents into the enamel surface are made possible by the decreased viscosity and wettability of this material when compared to orthodontic composites.

IV. DISCUSSION

White spot lesions are connected with enamel demineralization surrounding fixed orthodontic appliances, which is why they are called "white spots." Orthodontic appliances play a significant role in the demineralization of enamel because they increase the retention of biofilm, provide more surfaces for bacterial adhesion, and their complex design prevents adequate tooth surface during cleaning (Stewart et al. 2018). Orthodontic appliances are also associated with increased tooth sensitivity. Numerous bacterial species have a role in the creation of dental biofilms, which are white spots lesions caused by organic acids secreted by cariogenic bacteria and created by cariogenic bacteria. S. mutans and S. sobrinus have been identified as the primary causal organisms of dental caries (Tüzüner et al. 2019), with S. mutans being the most common. Going back to Gorelick's report, enamel demineralization begins to develop within one month of the insertion of fixed appliances, and it is estimated that the prevalence of white spot injury in the enamel of orthodontically treated patients ranges from 13 to 55% (Anandaradje et al. 2020). Currently, there is little information available about which orthodontic brackets are most vulnerable to adhesion of cariogenic streptococcus. The bacteria Streptococcus mutans and Streptococcus sobrinus are the most common cause of dental caries. In light of the increasing popularity of plastic brackets in recent years, which can be attributed to an increased demand for superior esthetics during orthodontic treatment, the goal of this study was to identify possible variations in the adhesion patterns of S. mutans and S. sobrinus on different bracket materials in order to reduce the risk of possible side effects, such as the development of white spot lesions during orthodontic treatment. The findings revealed that there was a statistically significant difference in the level of adhesion between the two bacterial species (Tables 1 and 2). In general, the adhesion of Streptococcus sobrinus to the materials studied was greater than that of Streptococcus mutans to the materials tested. Another study found that S. mutans adhered more strongly to orthodontic brackets than S. sobrinus and that each species of cariogenic streptococci had a distinct level of adhesion (Al-Ansari et al. 2021). A study published in the journal Orthodontics reported the bacterial adhesion of different types of orthodontic composites, the fact that these resin retain biofilm, and the discovery that the Blugloo resin produced by the Ormco brand had the highest level of bacterial adhesion and that S. mutans and the S. sobrinus bacteria were more likely to cause white spot injury (Allaker & Yuan, 2019). In addition, it has been reported that the adhesion of cariogenic streptococcus to orthodontic attachments, such as orthodontic composites, elastomeric chains, and brackets, is caused by the manufacturing materials used in their manufacture and the complexity of their design. Van der Waals forces, electrostatic interaction, and hydrophobic interaction have all been implicated in the adhesion of cariogenic streptococcus to orthodontic attachments. It is possible that these may retain a greater amount of biofilm that is strongly colonized by S. mutans and S. sobrinus surrounding the fixed appliances, and that the bacteria will grow on the tooth surfaces and cause dental caries. In this study, the goal was to correctly measure the amount of S. mutans and S. sobrinus bacteria that adhered to the orthodontic brackets and wires. When these microbes are cultivated and evaluated independently, it is discovered that they are both directly related to dental caries and that they are also the largest producers of acid, which causes demineralization (Arya et al. 2019). An in vitro study (Noronha et al. 2017) found that surface modification of stainless steel orthodontic and NiTi alloy wires with AgNPs resulted in antibacterial favorable findings against the bacteria Lactobacillus acidophilus when tested against the bacteria.

After analyzing the free surface energy and the work of adhesion of various raw materials, Bapat et al. (2018)

identified stainless steel as a surface material with a higher potential for microbial attachment after comparing it with polycarbonate and ceramic materials. In contrast, the findings of Balhaddad et al. (2020) indicate that S. mutans has a weaker in vitro affinity for metallic brackets than for plastic brackets, which is consistent with the findings of (Sreenivasagan et al. 2020), who conducted multiple in vitro comparisons of cariogenic adhesion amounts on stainless steel, plastic, ceramic, and titanium brackets in their study. Aside from finding statistically significant differences in the adhesion patterns of distinct cariogenic strains, their findings revealed that cariogenic streptococci adhered more strongly to plastic brackets than they did to the other four types of brackets.

The samples for this study were not coated with saliva because earlier investigations (Chandra et al. 2020) have shown that saliva coating does not significantly alter the adherence of S. mutans and S. sobrinus to surfaces. This study is consistent with other experiments, which have demonstrated that the saliva coating has no substantial effect on the adhesion of Streptococcus to the underlying substrates (Bapat et al. 2020). Orthodontics is one of the most frequently sought treatments by patients; nevertheless, as previously said, because of the complexity of its attachments, it results in increased bacterial colonization and the development of white spot lesions in the mouth. Despite the fact that fluor has been employed as a preventive strategy, it has not been effective in preventing its recurrence (Yin et al. 2020). As a result, it is currently required to insert antibacterial chemicals, such as silver, into the product through the use of nanotechnology at this time. Nanotechnology has been widely applied in the biomedical field for a variety of applications ranging from diagnosis and therapy to medication delivery and the coating of medical devices as well as personal health care products. In light of the increased use of nanoparticles in the medical field, it is imperative to gain a better understanding of the mechanisms of NPs' biological interactions and potential toxicity, in addition to the unique physiochemical properties of NPs, such as their ability to exert antibiotic, antifungal, and antiviral activity, as well as their anti-inflammatory activity (Song & Ge, 2019). A great deal of attention has been focused recently on the extraordinary antibacterial characteristics of metal nanoparticles such as silver, copper, gold, titanium, and zinc. Each metal nanoparticle exhibits a distinct set of properties and activation spectrum, which has sparked a great deal of curiosity. Silver has been used as a bacteriostatic agent for many years, and as a result, it has been discovered to have a wide range of applications in the field of human health. Silver nanoparticles are nanostructured materials with a silver salt as their starting point. It has a variety of biomedical applications because of its strong antibacterial properties, as well as the fact that it has no toxicity in human tissues when used in low concentrations. As a result, it is widely used in medical fields such as covering materials, wound dressings, bone cement, food supplements, and catheters, and in dentistry, they are used in some dental materials such as pastes, cement, adhesives, resorcinol, and other resorcinol-containing products.

These nanostructured agents have an antibacterial action that is linked to the high surface area of the nanoparticles, which allows for a greater presence of atoms on the surface, allowing for the greatest possible contact with the surrounding environment (Makvandi et al. 2020). Moreover, according to Garcia and colleagues' findings in their study (Burdușel et al. 2018), the small size of these particles allows penetration through cell membranes simpler (resulting in an inhibition of ADN synthesis). Recent studies have revealed that the positive charges of metal ions are crucial for the antibacterial activity of the nanoparticles, as they allow electrostatic interaction between the negative charge of the bacteria's cell membrane and the positive charge of the nanoparticles (Jiao et al. 2019). Different synthetic AgNPs approaches result in a wide range of sizes, forms, morphologies, and even stability when compared to one another. For the most part, these techniques can be divided into three major categories: physical syntheses, chemical syntheses, and biological (or "green") syntheses. Tanusheree Bala made the suggestion for the chemical approach employed in this study in their publication (Chambers et al. 2017), which was afterwards adopted. The use of equipment and methodology, such as the automatic sample combustion machine and the liquid scintillation counter device for measuring 3 H, which have been extensively described by Parnia et al. (2017 and Espinosa-Cristóbal et al. (2019), as well the results expressed and recorded in dpm, are all discussed in greater detail below. In this respect, a larger value of dpm indicates a higher level of radioactivity, and as a result, a higher level of adhesion of a radiolabeled microbe is discovered. Lower values of dpm, on the other hand, imply that the radiolabeled microbe adheres to the surface less effectively.

S. mutans and S. sobrinus radiolabeled to orthodontic brackets were found to adhere significantly differently between groups (p 0.05) in this study, as shown in the results (Tables 1 and 2) of this investigation. As a whole, the cariogenic streptococcus attached much less to the orthodontic brackets including silver nanoparticles than it did to the orthodontic brackets containing no silver nanoparticles. Among the S. mutans strains, group GIIIn (563.01 dpm) has the lowest bacterial adherence, while group GIIIn (1044.08 dpm) has the lowest bacterial adherence for S. sobrinus. The maximum bacterial adherence was observed in groups GVI (3153.83 dpm) and GIX (8197.32 dpm) in the same mode of operation. Overall, the level of bacterial adhesion to the materials examined was higher for S. sobrinus than it was for S. mutans, and this was true for both species. Another point to mention is that group GIIIn (Gemini Roth) demonstrated the lowest bacterial adhesion for both species; it is speculated that this could be due to a variety of causes. First and foremost, as can be seen in the SEM images, this group, in particular, has a smoother surface with a better finish, whereas the rough surface increases the surface area and niches, which are conducive to bacterial adhesion (Enan et al. 2021). Second, the rough surface increases the surface area and niches, which are conducive to bacterial adhesion. According to literature, positive charges on metal ions repel negative charges on bacterial membranes, and this is supported by experimental evidence. The reason for this could be due to the highest coaggregation of AgNPs, which explains why it has the highest antibacterial potential. Additionally, because of its significant reduction of microorganism adhesion, it has become an excellent option for orthodontic treatments, with a high likelihood of avoiding dental caries and the development of white spot lesions.

V. CONCLUSIONS

Nanotechnology has been widely used in the biomedical industry for a wide range of applications, including diagnosis and therapy, pharmaceutical administration, and the coating of medical devices and personal health care goods. Given the increased use of nanoparticles in the medical field, it is critical to gain a better understanding of the mechanisms of NPs' biological interactions and potential toxicity, as well as the unique physiochemical properties of NPs, such as their ability to exert antibiotic, antifungal, antiviral, and anti-inflammatory activity. Because the silver coating inhibited the attachment of both S. mutans and S. Sobrinus to the orthodontic brackets, it demonstrated the antibacterial capabilities of the silver coating. The use of silver nanoparticles to change the surface of orthodontic brackets can help to prevent the formation of dental plaque and the development of dental caries while a patient is receiving orthodontic therapy. Recently, much emphasis has been placed on the exceptional antibacterial properties of metal nanoparticles such as silver, copper, gold, titanium, and zinc. Each metal nanoparticle has a unique set of characteristics and activation spectrum, which has piqued the public's interest. For many years, silver was utilized as a bacteriostatic agent, and as a result, it was discovered to have a wide range of applications in the field of human health. Silver nanoparticles are nanostructured materials that begin with a silver salt. Because of its powerful antibacterial activity and lack of toxicity in human tissues at low concentrations, it has a wide range of biomedical applications. As a result, it is widely utilized in medical disciplines such as covering materials, wound dressings, bone cement, food supplements, and catheters, and in dentistry, it is used in pastes, cement, adhesives, resorcinol, and other resorcinol-containing goods.

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