International Journal of Advanced Biotechnology and Research (IJBR)
ISSN 0976-2612, Online ISSN 2278–599X,
Vol-8, Issue-2, 2017, pp868-874
http://www.bipublication.com

Research Article

Evaluation of Static Friction and Effect of Anti S. Mutans of Metal Brackets Coating by Silver Nanoparticles by Physical Vapor Deposition (PVD)

Morteza Ghaderiehsanpour[1]* and Behzad Houshmand[2]

[1]D,D,S private practice, Tehran, Iran.
[2]Professor at Periodontics
Department at Shahid Beheshti University, Dental School, Tehran, Iran.
*Corresponding author:Morteza Ghaderiehsanpour
Tel: +989122033252 E mail: Qaderi.dds@gmail.com

ABSTRACT

Background and objective: Because silver is known for its anti-bacterial properties.The aim of this study was to evaluate the performance of antibacterial and static friction of steel orthodontic brackets coating by silver nanoparticles.

Materials and Methods: 48 pcs stainless steel brackets into three groups of 16brackets uncoated, coated with silver 60nm and 100 nm. Coatingvia Pvd method was performed.3 brackets for friction testing of each group was randomly selected and tested.AFM and SEM method to check the adequacy of the coating process was performed on the coated brackets.Antibacterial tests used include disk diffusion test and had direct contact which was measured using Streptococcus mutans. Colonies were counted after 3,6,24 and 48 hours. Results via Software 18SPSS v and test Krus kalwalis and repeated measures ANOVA and Mann Whitney U test were analyzed.

Findings:The friction values of the control group, silver -60and silver -100 respectively 0.55 ± 0.14,0.77 ± 0.08,$0.82 \pm 0.11$and there is no significant difference was observed between the control group and groups coating with silver ($p = 0.07$)in disk diffusion test in agar environment no significant difference between case and control groups was observed. While the direct contact test brackets coated with silver, significantly reduced the growth of bacteria ($P < 0.05$) but in brackets without covering a number of bacteria increased sharply.

Conclusion: steel brackets coating via silver by PVD method, anti-bacterial ability to make direct contact with the bacteria Streptococcus mutans is not significant and increasing friction.

Key words: steel brackets, PVD, Streptococcus mutans, friction, sliding

INTRODUCTION

Enamel decalcification is one of the common side effects of orthodontic treatment.Studies report high incidence of demineralization and after treatment compared with the control group (1).

Demineralization clinical presentations are just as white spot, and in extreme cases of cavitation (2).To avoid microbial adhesion and enamel demineralization in orthodontic treatment widely two strategies is used. One composition of the nanoparticles, such as nano-fillers, silver, Tio2, Sio2, hydroxyapatite, fluorapatite and hydroxyapatite packing adhesive/cement or orthodontics acrylic resins and other coating surfaces with nanoparticles is an orthodontic appliance (for example, cover the surface with a thin layer of brackets (nitrogen doped Tio2) (3).Streptococcus mutans has been identified as the cause of dental caries and is alpha-hemolytic streptococci of type (1).

Demineralization of enamel around the brackets are produced by organic acids caused by Streptococcus mutans and orthodontic treatment results and undermine the ecological changes in the oral environment are undergoing orthodontic treatment, reducing the acidity of the environment, increase retention sites and increase food particles stuck to Streptococcus mutans noted which may lead to an increase in the proportion and absolute number of Streptococcus mutans in saliva.Such a change in oral floramay increase and decalcification of tooth enamel is often seen during orthodontic treatment (22).In the meantime, orthodontic brackets, including the most common appliance that bacteria play a significant role in the accumulation of plaque (4).Studies on the adhesion of micro-organisms to a variety of brackets have been inconsistent.

Because the most common form of steel brackets used in orthodontic bracket now, examining ways to prevent the buildup of cariogenic microorganisms is very important.Currently, the most common approach to prevent demineralization of enamel used during treatment with fixed orthodontic appliances advice patients to control microbial plaque. Using a fluoride toothpaste and mouthwash and flossing teeth are fluoridated.Silver has strong antibacterial properties and the antibacterial mechanism of silver, because silver nanoparticles bind to microbial cells and change their membrane (5).Silver particles at very low concentrations, have shown significant antibacterial effects. (6).

One of the main bracket fixed orthodontic appliance components that transmit force to the teeth. Article brackets needs to be health, non-toxic and resistant kerogen.In addition, it can withstand the forces exerted by wire or occlusal forces should be affordable as well (7).Initial brackets to teeth with the emergence of adhesive resin strap but today they are used as binding. The types of brackets available include stainless steel, ceramic and plastic brackets.Plastic brackets can be easily absorbs water changed color and the forces applied to the teeth torque at high doses, the form was changed.Ceramic brackets are fragile and during separate the bracket from the tooth, the enamel layer is bonded with adhesive, ceramic brackets tend to separate along.The most important substance used in the manufacture of metal brackets are fixed orthodontic appliances, metal orthodontic brackets have properties which are ideal accepted, are closer (8).One of the major problems of the friction between the wire and bracket braces can be noted(9).To overcome this problem, the surge as much as 60% -40% is required.Also, the surge increases the risk of tooth root resorption (10). There are many methods to deal with this problem is presented and the use of nanoparticles with spherical structure in the 1990s as lubricants hard (solid lubricant) were made, to reduce friction between metal surfaces is taken into consideration (11, 12). Coating techniques, ways to enhance the quality of coating properties, extend the service life cover and its compatibility with the environment and some of these methods were used in orthodontics to improve the surface properties of some materials (13).Some of these coverage levels using Physical Vapor Deposition (PVD).In physical evaporation method or PVD, coatings on solid surfaces through condensation elemental composition of the gas phase are produced. Evaporation as the most common method of preparation of highly pure layer under conditions relatively controlled. (13)

Lkhagvajav et al(2011)have conducted a study entitled the antibacterial activity of silver colloidal nanoparticles, the results showed that the antimicrobial activity against all microorganisms tested with very low concentrations of silver nanoparticles (2-4 µg/ml) (14).Kao et al(2011)have conducted a study to compare the frictional force between the metal brackets with titanium nitride coatings kerogen and without kerogen and concluded that with or without kerogen, brackets with titanium nitride coating could reduce the frictional force (17) Cao et al in 2013, in a study of brackets with a thin layer of nitrogen-doped Tio2-xNy covered and have studied its antibacterial effect and the results

showed that the brackets against oral bacterial pathogens showed high antibacterial properties (15). According to this information, in this study, we decided to cover the brackets by silver nanoparticles, its anti-bacterial properties against Streptococcus mutans examined and the effect of the silver coating on the metal brackets examined the coefficient of friction.

MATERIALS AND METHODS

In this experimental study, the study population consisted of steel brackets premolars in the standard system 22(022, standard premolar, american, USA) coated and uncoated silver particles and wires SS 19 × 25 in direct form (dentarum).48 tooth steel brackets standard system 22(022, standard premolar, american, USA) in this studywas used.In this study, based on the criteria considered in the context of significant changes in positive clinical characteristics brackets, the metal coating, coating capabilities at the nanometer scale and economic issues, using physical vapor deposition (pvd)for the silver coating on the surface of the bracket selected. Brackets into 3 to 16groups were divided: the first group brackets covered with thick 60 nm, Group II brackets covered with thick nm 100and Group III bracket without cover. To obtain an appropriate level of coverage, the work of cleaning the substrate coating (the coating on the surface of the bracket is applied) that should be done with care and sensitivity. Good adhesion of the coating to the substrate when the result was favorably and the substrate surface was perfectly clean and proper.

Surface preparation operations brackets were:

1. Surface cleaning solution brackets with alcohol and acetone in one step by Ultrasonic Cleaning for 15 minutes.
2. Clean the surface with a solution of water and soda brackets Ultrasonic Cleaning method during a stage for 20 minutes.
3. Clean the surface with a solution of distilled water as ultrasonic cleaning brackets in two stages, each lasting 15 minutes.
4. Drying air exposed surface of the bracket.Silver coating by heat treatment was performed with tungsten crucibles with two thick nm60 and 100 nm. After the coating process, brackets for determining the adequacy of the coverage, AFM and SEM were under trials.AFM by the School of Babol and SEM by the Tarbiat Modarres University in Tehran were evaluated. 5Brackets coated for AFM and SEM were used. In order to test the friction brackets were divided into 3 groups of 3 (uncoated, silver-60, -100silver) a metal plate was prepared.It passed to the wire in the slot bracket is not in contact with the metal plate on the bottom of the page, other board with the same thickness and the same width but with less, cemented.To evaluate the anti-bacterial samples, Streptococcus mutans strains of Gram-positive bacteria 1683PTCC standard was used.

Antibacterial tests for this study include disk diffusion test and direct contact test.The friction test and antibacterial test, obtained data were analyzed using 18 SPSS software.Then Krus Kalwalis repeated measures ANOVA test and Mann Whitney U test were analyzed.

Findings

The friction values of the control group, silver -60 and silver -100 respectively 0.14 ± 0.55, 0.08 ± 0.77, 0.11 ± 0.82.And no significant difference was observed between the control group and groups with silver coating (p = 0.077) (Table 1)

Table 1: Mean, minimum, maximum, standard deviation Static friction in the study groups (each group n=3)

Group	Friction force (N)	Minimum (N)	Maximum (N)	**P-Value***
Group I (without any covers)	0.14 ± 0.55	0.41	0.69	0.07
Group II (silver-60nm)	0.08 ± 0.77	0.69	0.85	
Group III (silver 100nm)	0.11 ± 0.82	0.71	0.93	

*

Using Krus Kalwalis (p =0.0004) in both groups (brackets that were tested immediately and those who stayed three months in saline), no cover brackets have not reduced the number of bacteria (in this group, the number of bacteria increased sharply).But in the other two groups has decreased the number of Streptococcus mutans.According to the test, ANOVA, the number of bacteria in 48 hours in both the first and second groups (those who remained three months in saline) were similar (both p =0.0001) all colonies in control group (uncoated brackets) were more than 1250 in the fourth period (P>0.05).In each of the two groups, the first period was clearly more than 1250 (0.05‧ P).Silver in the -60, the second period was not significantly different from 1250 (0.05 ‧P) but on the colony counts in the third and fourth periods decreased in 1250 (0.05‧P). -100silver in the last three periods,Clooney was counting on 1250 (0.05‧ P).Mann Whitney U test to compare each of the periods in the first experiment with the same period in the second experiment (on the bracket that three months were kept in saline) was used.This test is a significant difference between the two test periods at first (3 hours. P =0.015), second (6 hours P =0.017) and third (24hours P=0.049) showed.

But the 48-hour period were similar (P =0.604).This remarkable series of analyzes, after removing the effect of the control group both groups was repeated. Mann Whitney test showed that after removing the groups without coverage, there is significant differences between the second section (P =0.002) and third (P=0.013) but between time periods thirds (P =0.06) and fourth (P=0.54) was found. So the difference was significant. The mean number of bacteria in the group who were kept in saline was 3 months. Tables 2 and 3.

Table 2: The mean ± SD number of bacteria in the case and control groups in the study periods (each group n=3)

Group Time	Uncoated	60 nm Silver	100 nmSilver	P value*
3 Hour	5.3332‧±1696.6	65.5743 ± 172‧	94.5163± 1483.3	0.007
6 Hour	4‧ ± 176‧	16.2583 ± 88.6‧	1‧25.64 ± 83.6‧	> 0.001
24Hour	‧64‧/65 ±1933.3	26.5141± 553	15.5349 ± 329	> 0.00
48Hour	311.9294 ± 1251‧	27.8388 ± 522	19.5192 ± 299	> 0.001

* By using the repeated measures ANOVA (p <0.05)

Table 3: Mean ± SD and p value the number of bacteria in the groups studied intervals, three months after storage in saline (group n =3)

Group Time	Uncoated	6‧ nm Silver	1‧‧ nmSilver	P value
3Hour	81.4452 ±1943.3	95.3939 ± 1730	1.9267‧6 ±1573.3	0.007
6Hour	256.58 ± 2383.3	102.5004±1027.6	39.8497±936	> 0.001
24Hour	171.5614± 2733.3	98.8534±638	35.5715 ± 448.6	> 0.001
48Hour	416.3332±12666.6	71.2834±472.6	33.9558 ± 331	> 0.001

* By using the repeated measures ANOVA (p <0.05)

The results of disk diffusion test showed no inhibition of bacterial growth, none of the test and control groups is created.This means that silver coated brackets, not penetrated the agar medium.

DISCUSSION AND CONCLUSION

In this study of silver nanoparticles for antibacterial surface coating brackets to assess the performance effectiveness of the coating used on friction ad our observations suggest the lack of friction between samples with and without silver lining as well as significant antibacterial activity groups were covered with silver.Several studies, such as the effect level for various purposes covered brackets (16, 17, 15, 18, 19).Our coating method (PVD) was used.

Ryu et al andEwald et al studies and similar to our study concluded the success of an anti-bacterial coating on the surfaces to be compatible with the current study (18 and 20).

Our results in relation to the antimicrobial properties of nanoscale silver were in line with previous studies. Ryu et al in 2012 and

biocompatible coatings, antibacterial effects of silver- platinum assess and report on the bracket positive antimicrobial activity without toxic effects on fibroblasts reported (18).

In the present study, colony counting in direct contact test showed that the brackets coated, Mutans bacteria from growing significantly in their level, they prevented. The general trend growth of bacteria in 3, 6, 24 and 48 hours, is increasing. But the silver lining in the bracket with the average growth of bacteria in all three repeats, garlic almost uniformly. This phenomenon stamp of approval the antibacterial properties of silver in the cover bracket because over time the number of bacteria in the control group was growing increasingly and one of the factors that increase the friction of the surface hardness (23,22,21).

However, despite increased friction, surface samples with silver coating 100, in most cases, to investigate the SEM and AFM, were softer. But 60 micron silver samples did not change in hardness and the control group was at the same level. Other studies showed the appliance with silver coating (21) can improve surface hardness. This is more subjective and less reliable SEM, AFM is safe (21-24). Perhaps due to increased friction is closing the distance between the bracket and arch wire.However, other factors need to be involved, otherwise, should a similar increase in thickness of 100 microns was observed regardless of the type of metal. Further studies required levels more samples in each group were analyzed.In this study, these results were due to direct contact test results and the brackets coated with antimicrobial silver had its best the day.

Kuo et al in 2013 in a study, brackets with a thin layer of nitrogen-doped Tio2-xNy covered and have studied its antibacterial effect. The results showed that the brackets against oral bacterial pathogens, showed high antibacterial properties (15). Ronghe et al in 2015 in a study, brackets with 2 nano-Ag / Tio covered and anti-bacterial properties and biocompatibility are studied in orthodontic treatment. The results showed brackets coated with 2nano Ag / Tio not only had antibacterial effects but also had good biocompatibility (16).There was no significant increase in friction brackets with nanosilver coating and therefore not be concluded. This needs more study.Kao et al in 2011 in a study compares the frictional force between the metal brackets via titanium nitride with or without kerogen and have not kerogen and concluded that with or without kerogen, brackets with titanium nitride coating could reduce the frictional force (19). Arash et al in 2015 in a study, orthodontic steel bracket covered by electroplating with silver ions and his work on the coefficient of friction and shear bond strength tested. The results showed that silver lining electroplating method has no effect on bond strength to enamel bracket in addition to reducing friction in sliding mechanics is not effective (21).In clinical applications, silver ions can be used to cover brackets without covering the tracks to be used to reduce bacteria.

Young L et al in a study in 2010 to examine the antibacterial properties of silver-coated titanium surfaces, the results showed that bacteria coated surfaces less than the control group (which contains titanium was unwrapped) stick (25).Yusuke et al in a study in 2014, fixed orthodontic retainer covered with silver ions and its effect on the growth of pathogenic bacteria in the mouth showed the wire coated with silver ions compared to uncoated wire, showed significant antibacterial activity and the radial diffusion test, area around them resistant to bacterial growth than 2mm in diameter.Silver ion release 24hour 0.05 ± 0.043ppm which showed no cytotoxicity (2).

REFRENCE:

1. Chang HS, Walsh LJ, Freer TJ. Enamel demineralization during orthodontic treatment. Aetiology and prevention. Australian dental journal. 1997;42(5):322-7.
2. Ahmed I, Saif ul H, Nazir R. Carious lesions in patients undergoing orthodontic treatment. JPMA The Journal of the Pakistan Medical Association. 2011;61(12):1176-9.

3. Borzabadi-Farahani A, Borzabadi E, Lynch E. Nanoparticles in orthodontics, a review of antimicrobial and anti-caries applications. Acta odontologica Scandinavica. 2014;72(6):413-7.
4. B KF. Effectiveness of Mouth Washes on Streptococci in Plaque around Orthodontic. ISRN Dentistry. 2010:1-4.
5. DE KWAADSTENIET M, BOTES M, CLOETE TE. APPLICATION OF NANOTECHNOLOGY IN ANTIMICROBIAL COATINGSIN THE WATER INDUSTRY. Nano. 2011;06(05):395-407.
6. Hernandez-Sierra JF, Ruiz F, Pena DC, Martinez-Gutierrez F, Martinez AE, Guillen Ade J, et al. The antimicrobial sensitivity of Streptococcus mutans to nanoparticles of silver, zinc oxide, and gold. Nanomedicine : nanotechnology, biology, and medicine. 2008;4(3):237-40.
7. nanda RS. Biomechanics in orthodontics. In: 1, editor. Biomechanics in orthodontics. 1. china: quintpub; 2010. p. 56
8. KeunTO, SungUC, KwangMK , KyoungNK. A stainless steel bracket for orthodontic application. European journal of orthodontics. 2005(27):237–44.
9. Chen WX, Tu JP, Xu ZD, Tenne R, Rosenstveig R, Chen WL, et al. Wear and Friction of Ni-P Electroless Composite Coating Including Inorganic Fullerene-WS2 Nanoparticles. Advanced Engineering Materials. 2002;4(9):686-90.
10. Thorstenson GA, Kusy RP. Resistance to sliding of self-ligating brackets versus conventional stainless steel twin brackets with second-order angulation in the dry and wet (saliva) states. American journal of orthodontics and dentofacial orthopedics : official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics. 2001;120(4):361-70.
11. Wei S, Shao T, P D. Study of CNx film on 316L stainless steel for orthodontic application. Diamond And Related Mater. 2010;19(5-6):648-56.
12. Goto M, Kasahara A, M T. Reduction in frictional force of Zno coatings in a vacuum. Jpn J Applied Phys. 2008;47(12):8914-6.
13. Arango S, Peláez-Vargas A, García C. Coating and Surface Treatments on Orthodontic Metallic Materials. Coatings. 2013;3(1):1.
14. N.Lkhagvajav, I.Yasa, E.Celik, M.Koizhaiganova, O.Sari. Antimicrobialactivity of colloidal silver nanoparticles prepared by sol-gel method. 2011;6:149-54.
15. Cao B, Wang Y, Li N, Liu B, Zhang Y. Preparation of an orthodontic bracket coated with an nitrogen-doped TiO(2-x)N(y) thin film and examination of its antimicrobial performance. Dental materials journal. 2013;32(2):311-6.
16. Zhang R, Zhang W ,Bai X, Song X, Wang C, Gao X, et al. Report: Discussion on the development of nano Ag/TiO2 coating bracket and its antibacterial property and biocompatibility in orthodontic treatment. Pakistan journal of pharmaceutical sciences. 2015;28(2 Suppl):807-10
17. Kim YJ, Lee DY, Lee JY, Lim YK. The effect of silver ion-releasing elastomers on mutans streptococci in dental plaque. Korean journal of orthodontics. 2012;42(2):87-93.
18. 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):151-7.
19. Kao CT, Guo JU, Huang TH. Comparison of friction force between corroded and noncorroded titanium nitride plating of metal brackets. American journal of orthodontics and dentofacial orthopedics : official publication of the American Association of Orthodontists, its constituent societies, and

the American Board of Orthodontics. 2011;139(5):594-600.
20. Ewald A, Glückermann SK, Thull R, Gbureck U. Antimicrobialtitanium/silver PVD coatings on titanium.BioMedical Engineering On Line. 2006;**5**:22.
21. Arash V, Anoush K, Rabiee SM, Rahmatei M, Tavanafar S. The effects of silver coating on friction coefficient and shear bond strength of steel orthodontic brackets. Scanning. 2015;37(4):294-9.
22. Arash V, Rabiee M, Rakhshan V, Khorasani S, Sobouti F. In vitro evaluation of frictional forces of two ceramic orthodontic brackets versus a stainless steel bracket in combination with two types of archwires. Journal of orthodontic science. 2015;4(2):42-6.
23. Amini F, Rakhshan V, Pousti M, Rahimi H, Shariati M, Aghamohamadi B. Variations in surface roughness of seven orthodontic archwires: an SEM-profilometry study. Korean J Orthod. 2012;42(3):129-37.
24. Khosravanifard B, Nemati-Anaraki S, Nili S, Rakhshan V. Assessing the effects of three resin removal methods and bracket sandblasting on shear bond strength of metallic orthodontic brackets and enamel surface. Orthodontic Waves. 2011;70(1):27-38.
25. Liao Juan, Zhu Zhimin, Mo Anchun, Li Lei, Jingchao Z. Deposition of silver nanoparticles on titanium surface for antibacterial effect. Int J Nanomedicine. 2010;5:261–7.