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Comparison of Surface Roughness of Silver Nanoparticle Coated Orthodontic Bracket and Conventional Stainless Steel Bracket – A Scanning Electron Microscope Study

[1]Dr. Deenadayalan Purushothaman, Associate Professor, Department of Orthodontics, SRM Kattankulathur Dental College

[2]Dr. Dhinahar.S, Professor and Head, Department of Orthodontics, SRM Kattankulathur Dental College.

[3]Dr. Akshaya Raj, Post Graduate student, Department of Orthodontics, SRM Kattankulathur Dental College

[4]Dr. Dhivya Dilip kumar, Associate Professor, Department of Orthodontics, SRM Kattankulathur Dental College.

[5]Dr. Akshay Tandon, Assistant Professor, Department of Orthodontics, SRM Kattankulathur Dental College

Corresponding Author: Dr. Akshaya Raj, Post Graduate student, Department of Orthodontics, SRM Kattankulathur Dental College

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Abstract

This study was aimed to evaluate the surface characteristic features of Silver nanoparticle coated orthodontic brackets under Scanning Electron Microscope (SEM). 8 metal brackets were coated with Silver nanoparticles using E-Beam coating method. The coated surface was compared with conventional uncoated stainless steel bracket. The surface roughnesses of coated and uncoated brackets were evaluated using meta analysis. The meta analysis showed a higher entropy value (7.63) for thicker coated brackets and lower entropy value (5.52). The higher entropy value indicates smoother surfaces while the lesser value indicates rougher surfaces. Hence coating of brackets reduce the surface roughness which helps in reduction of frictional resistance between the archwire and bracket interface resulting in better orthodontic treatment outcome.

Keywords: Silver nanoparticles, frictional resistance, surface roughness.

Introduction

Friction is stated as the force that resists relative motion between two bodies when in contact[1]. The frictional resistance experienced during sliding mechanics has been well recognized in the orthodontic literature, and it consists of complex interactions between the archwire, bracket and ligation method. Orthodontic tooth movement is in cognate with sliding mechanics has been mentioned as short steps in series, involving oscillating tooth tipping and uprighting, rather than a continuous, smooth, gliding process[1-3]. When points of contacts are established between the arch wire and edges of the bracket, the angle between them overreach the critical amount and binding occurs. Archwire, bracket binding, friction and notching of archwire are the combination of resistance to sliding in orthodontics[4].

The amount of force transmitted for the tooth movement is decreased, as the friction in between the bracket – archwire interface is increased resulting in less efficient orthodontic tooth movement.[2] Therefore, orthodontic forces of higher level would be essential to overcome resistance to sliding and achieve the appropriate tooth movement. Such excessive forces can increase the risk of anchorage loss, undesirable tooth movement and root resorption.

There are several contributing factors for resistance to sliding including bracket and wire material and surface characteristics. Studies have shown that ceramic brackets show more friction when compared to stainless steel brackets[1]. Beta-titanium wire resulted in less sliding due to increased friction and also increase in archwire dimension resulted in increased frictional resistance. Rectangular archwires have high friction when compared to round archwires.

Nickel Titanium wires generate a light force in a greater range of action and are considered to be the ideal orthodontic archwire for treatment in the initial stage of comprehensive orthodontic treatment. However, the main drawback of Nickel Titanium wire is the high friction coefficient and surface roughness which results in elevated frictional resistance.

Resistance to sliding is affected by several factors including the use of different surface treatment, alloys, altering shape and size of the bracket and coating with different materials such as Teflon, inorganic fullerene-like nanoparticles (NP) of tungsten disulfide and carbon nitride film[5-7].

Orthodontic brackets and wires also provide additional sites for microorganisms to adhere and colonize. Loss of integrity of enamel structure and formation of white spot lesions has been frequently reported during the fixed orthodontic treatment.

To overcome these drawbacks, there have been few inventions which have been made on to the surfaces of the bracket and archwire. Coating the surfaces of archwires and brackets with certain materials like Teflon, NP coating improves the surface characteristic feature and hence contributing to reduced frictional resistance. Both antibacterial activity and reduction in friction have been reported for wires and brackets with Zinc Oxide NP coating. Hence this study was done to evaluate the surface roughness of the brackets coated with Ag NP.

Materials and Methodology

The effect of changes in surface characteristics of Silver nano coated orthodontic stainless steel bracket was studied using 8 metal brackets (3M Unitek Gemini). The stainless steel brackets were coated with Silver NP in different thickness using E-bean coating. Before coating the brackets were cleaned using acetone to make the brackets free from any impurities. After preparation these brackets were placed onto a disc with a help of two sided tape and secured, the disc was then placed in the vacuum chamber of the E-Beam coating equipment.

Results

Figure1: 3 minutes coated – 110 nm

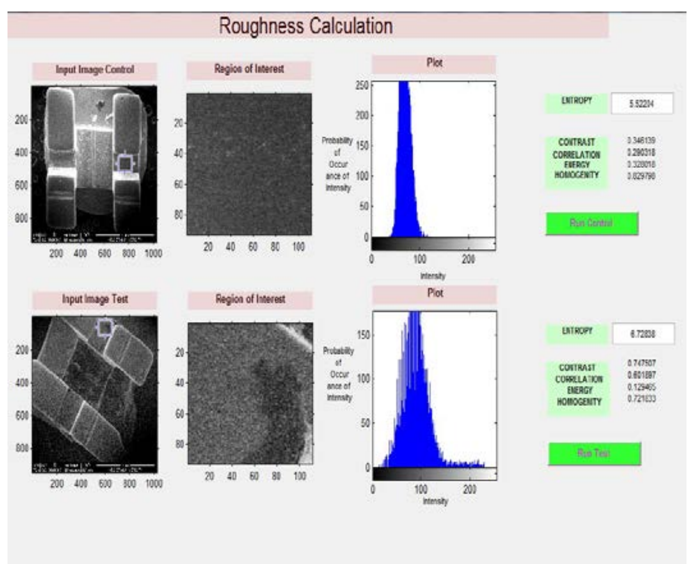


Figure2: 3 minutes coated with variation in intensity 125 nm

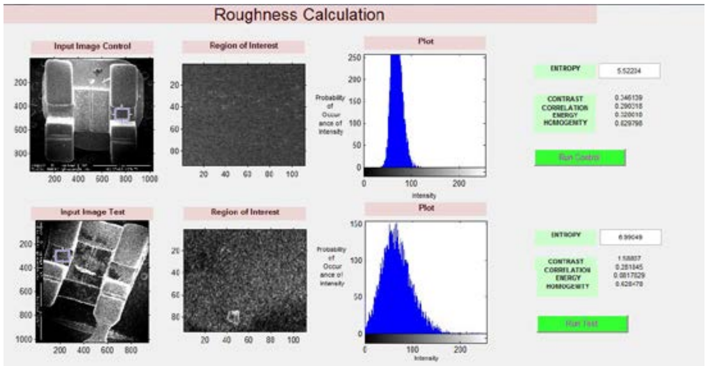


Figure 3: 5 minutes coated – 160 nm

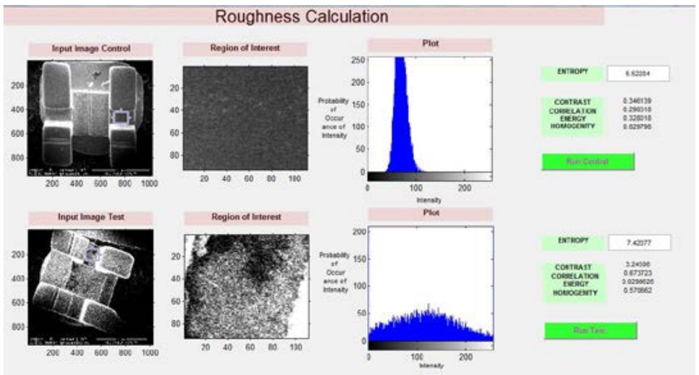
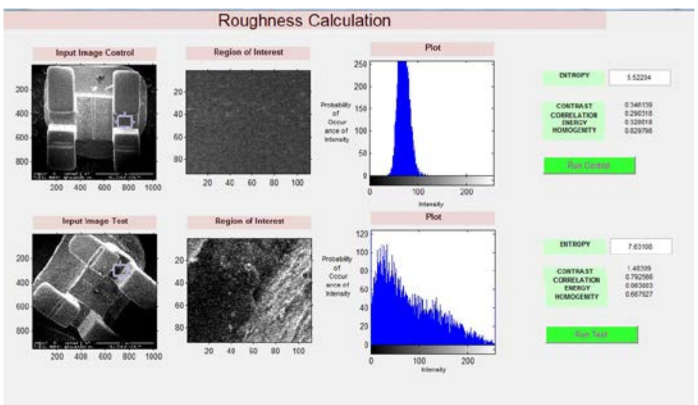


Figure 4: 10 minutes coated – 190 nm



E = entropy (I) returns E, a scalar value representing the entropy of grayscale image I.

Entropy is a statistical measure of randomness that can be used to characterize the texture of the input image.

The entropy and homogeneity value is less in thinner layer as compared to thick layer deposition.

Figure 1; indicates an entropy value of 6.72 of a NP coated bracket of thickness 110 nm, where as the entropy value of uncoated bracket surface is 5.52, which indicates the surface is notably less rough in coated bracket than uncoated bracket.

Figure 2; indicates an entropy value of 6.99 in NP coated bracket of thickness 125 nm. In this the exposure time was as same as bracket in Fig. 1 but the variation is in the intensity of deposition.

Figure 3; indicated an entropy value of 7.42 in NP coated bracket of thickness 160 nm. The thickness of deposition was increased by increasing the timing of deposition from 3 minutes to 5 minutes.

Figure 4; indicated an entropy value of 7.63 in NP coated bracket of thickness 190 nm. The exposure time was increased to 10 minutes.

Discussion

The different thickness NP coated brackets shows different entropies. The variation in thickness is due to variation in the timing of exposure and intensity of exposure. The E value represents the entropy, which is a statistical measure, employed to determine the characteristic feature of a surface. Higher the entropy indicates smoother surface. Likewise, increased homogeneity, lesser is the surface roughness. The results indicate that the higher thickness coating revealed a lesser rough surface when compared to thin layer of deposition of NP. The uncoated bracket in the control group shows entropy of 5.52 where as thicker NP coating bracket shows entropy of 7.63. This indicates a significant reduction in the surface roughness in coated brackets than uncoated brackets. Adding up to the point higher thickness yields even smoother surface when compared to thin layer.

Previous studies revealed that the ZnO nanocoating significantly reduced the surface roughness of Niti wires. Surface quality is an important influence in determining the effectiveness of archiwre-guided tooth movement. It has been reported that ZnO NP coatings , have stable chemical and physical properties and higher oxidation action with strong corrosion protection[5]. Next to NiTi wires, TMA wire is said to have increased friction among all orthodontic wires. Ion implantation and Teflon coating on wire has effectively reduced the roughness of TMA wire[6].

Fewer nano-particles like Silver, Zinc Oxide, Copper Oxide, Titanium Oxide, etc., have an additional property i.e antibacterial property which helps in reducing the colonization of microorganisms. The antimicrobial action of silver salts or ions is very well known since ancient times. An assessment of ion release and antibacterial property of nanosilver coated orthodontic brackets were done to compare the adhesion of Streptococci and to provide information on prevention on white spot lesion in comparison with conventional orthodontic brackets[7]. Stainless steel wire coated with photocatalytic Titanium Oxide anti-adherent and anti-bacterial property against Lactobacillus acidophilus. It is suggestive of that surface modification of orthodontic brackets with photocatalytic TiO can be used to avoid the accumulation of plaque and dental caries during orthodontic treatment.

Conclusion

NP coated orthodontic brackets showed smooth surfaces than uncoated conventional stainless steel brackets. The higher thickness coated brackets were found to have the smoothest surface than the thin coated surfaces. The smooth surface in the bracket does not only contribute in reducing the friction between archwire and bracket but also contributes in anti-adherent property by repulsing the bacteria from bracket surface.

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