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Original Research

A Comparative Evaluation of Adherence of Microorganism to Different Types of Brackets: A Scanning Electron Microscopic Study

E P Shashidhar[1], M Sahitya[1], T Sunil[2], Anup R Murthy[3], M S Rani[4]

Contributors:

[1]Lecturer, Department of Orthodontics, MR Ambedkar Dental College, Bengaluru, Karnataka, India; [2]Lecturer, Department of Orthodontics, VS Dental College, Bengaluru, Karnataka, India; [3]Reader, Department of Orthodontics, MR Ambedkar Dental College, Bengaluru, Karnataka, India; [4]Professor, Department of Orthodontics, VS Dental College, Bengaluru, Karnataka, India.

Correspondence:

Dr. Shashidhar EP. Department of Orthodontics and Dentofacial Orthopedics, M. R. Ambedkar Dental College, Bengaluru, Karnataka, India. Phone: +91-9448594124. Email: drshashidhara77@gmail.com

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Abstract:

Background: The purpose of this study was to evaluate and compare the adherence of microorganism to different types of brackets using the scanning electron microscope (SEM). A double-blinded study was undertaken to evaluate and adherence of microorganisms to different types of brackets using SEM.

Materials and Methods: At random, 12 patients reporting for treatment to the department of Orthodontics VS Dental College and Hospital were selected. Four types of brackets were included in the present study stainless steel, titanium, composite, and ceramic. Brackets were bonded to teeth of the patient on all the four quadrants. The teeth included for bonding were lateral incisor, canine, first premolar, and second premolar. The brackets were left for 72 h. After 72 h brackets were debonded, and they were evaluated by SEM for adherence of microorganism in the slot and tie wings surface. The SEM images were graded, and the adherence of microorganism to the brackets in the surfaces and the four different quadrants were recorded.

Results: There is a significant difference in adherence of microorganisms to the various types of brackets ($P < 0.001$) and the surfaces ($P < 0.05$) included in the study. However, there is no significance in the mean adherence of microorganisms in the different quadrants ($P > 0.05$) included in the study. The interaction of bracket/surface, bracket/quadrant, surface/quadrants was analyzed, there was no significance of comparison of bracket/surfaces/quadrant but the interaction of bracket/quadrant was found to be significant (<0.011). The interaction of bracket/surfaces/quadrant was also found to be significant (<0.003).

Conclusion: The maximum adherence of microorganisms was observed with the composite bracket material and the least adherence of microorganisms was observed with the titanium bracket material. The adherence of microorganisms is relatively more in the slot area, when compare to the tie wings surface maximum adherence of microorganism is observed in the upper left quadrant and least adherence of microorganism is observed in the lower right quadrant. There is a significant difference in adherence of microorganisms to various types of brackets and the surfaces included in the study. There is no significant difference in the adherence of microorganism to the bracket surfaces in the four quadrants included in the study.

Key Words: Adherence, brackets, ceramic, composite, microorganism, scanning electron microscope, stainless steel, titanium

Introduction

The traditional orthodontic patient was considered as a low-risk patient and orthodontic procedures were considered non-invasive for a long time. There is increased demand for orthodontic treatment of adult patients and the popularity of usage of the esthetic brackets-ceramic and composite.[1]

Orthodontic appliances frequently encroach on the gingival sulcus and act as an obstacle for maintaining the oral hygiene. Increase in gingival inflammation is noted immediately after placement of fixed orthodontic appliances. The level of oral hygiene during treatment has a direct influence on periodontal status. Even with excellent oral hygiene, the majority of patients usually develop moderate gingivitis within 1-2 months after placement of the appliances. These changes are generally transient and are reversible with no permanent damage to the periodontal tissues.[1]

The initial affinity of the bacteria to solid surfaces is mostly due to electrostatic and hydrophobic interactions.[2-4] The physiochemical properties of bacteria as well as of the solid surfaces contribute as mediators during the process of adherence to the hard surfaces.[5]

Recent studies indicate that patients who received orthodontic treatments were more susceptible to enamel white spot formation.[6,7] In particular, metallic orthodontic brackets have been found to induce specific changes in the buccal environment such as decreased PH, increased plaque accumulation,[8,9] and elevated *Streptococcus mutans* colonization.[10-13] Thus, metal brackets impose a potential risk for enamel decalcification.

One of the most common problems encountered in orthodontics is accidental dislodgement of orthodontic brackets. Rebonding of these brackets require more chair side time and is a clinical

nuisance.[14] It has been suggested that bond strengths of 5.88-7.85 MPa are adequate for orthodontic bonding.[15] Although ceramic and plastic brackets are relatively new in the orthodontic armamentarium, their bond strength, morphologic nature, and plaque retaining capacities have been studied extensively.[16-18] Chlorhexidine use prior to the bonding of polycarbonate brackets has no influence on the shear bond strength of the brackets.[19] There are many studies in the literature evaluating the adherence of microorganisms caused by the brackets made out of various materials.[20,21] Stainless steel, ceramic, and composite, which are commonly employed in orthodontics.

It is well known that the adherence of oral bacteria to enamel tooth surface and orthodontic material has a harmful effect on the teeth and periodontal tissues.

Hence, the present study was undertaken to assess the adherence of microorganism to the brackets made of different types of bracket material using the scanning electron microscope (SEM).

Materials and Methods

Materials

Twelve subjects with fair oral hygiene, no gingival inflammation, no missing teeth, and no previous orthodontic treatment were included in the study. The subjects with gingival pathology, poor oral hygiene, extracted teeth, congenital abnormality, fluorosis, and enamel hypoplasia were excluded from the study.

Brackets of four different materials were used such as stainless steel, titanium, composite, and ceramic. The lateral incisor, canine, first premolar, and second premolar on all the four quadrants were included in each patient.

Methods

Step I: Brackets are bonded to the teeth of the patients on all four quadrants. The patients are numbered from 1 to 12. The cases are taken up as they report department for orthodontic treatment. The brackets are bonded in the following pattern as shown in Table 1.

Step II: The brackets were left for 72 h. The patient was instructed to brush regularly. Bracket bonding pattern on the patient is shown in Figure 1.

Table 1: Pattern of bonding brackets and numbering of patients.

Pattern of bonding of brackets		Patient numbering
Stainless steel	Titanium	1, 5, 9
Composite	Ceramic	
Composite	Stainless steel	2, 6, 10
Ceramic	Titanium	
Ceramic	Composite	3, 7, 11
Titanium	Stainless steel	
Titanium	Ceramic	4, 8, 12
Stainless steel	Composite	

Step III: After 72 h brackets were debonded. The debonded brackets were carried in a sterilized Petri dish to the laboratory (Indian Institute of Science) as shown in Figure 2.

Step IV: The patients are numbered in the particular sequence as shown in Table 1. Later after debonding, the brackets are numbered, in serial order and are sent for SEM evaluation for adherence of microorganisms.

Step V: In the laboratory, each bracket was gold coated and was viewed under scanning electronic microscope, and the images were recorded as shown in Figures 3 and 4.

Step VI: Analysis of the images.

The numbered SEM images were submitted and were evaluated by the staff of Oral Pathology, VS Dental College and Hospital, Bengaluru for adherence of microorganisms.

Surfaces examined.
1. Slot
2. Tie wings

The images were graded as shown in Table 2 and Figure 5.

Figure 1: Different type of brackets bonded to four quadrants.

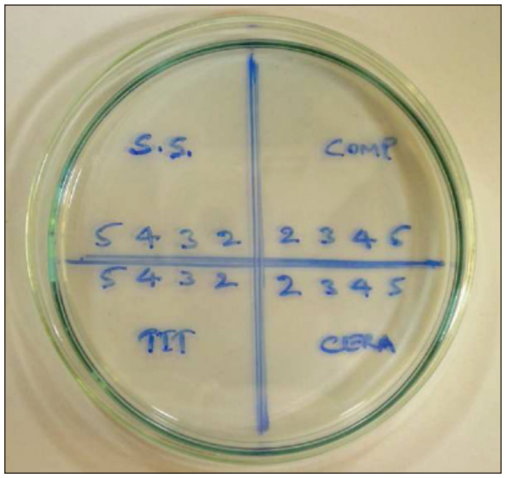


Figure 2: Sterilized Petri dish.

Results

Graph 1 shows the descriptive statistics of the mean adherence of microorganisms recorded to the different types of brackets included in the present study. Maximum adherence of microorganisms is observed with composite bracket material 1.83 ± 1.07, followed by ceramic 0.80 ± 0.96, stainless steel 0.69 ± 0.76, and least adherence of microorganisms was observed with titanium bracket material 0.40 ± 0.59.

Graph 2 shows the mean adherence of microorganisms to the slot and tie wings surface of the brackets included in the study. The adherence of microorganism is relatively more in the slot area 1.04 ± 1.02 when compared to the tie wings surface 0.82 ± 1.01 of the brackets.

Graph 3 shows the adherence of microorganisms to the brackets bonded in the various quadrants. Maximum adherence is observed in the upper left quadrant 0.98 ±1.05, followed by lower left quadrant 0.96 ± 1.04, upper right quadrant of 0.90 ± 1.02, and least adherence is observed in lower right quadrant 0.89 ± 0.98.

Figure 3: Fine coated brackets.

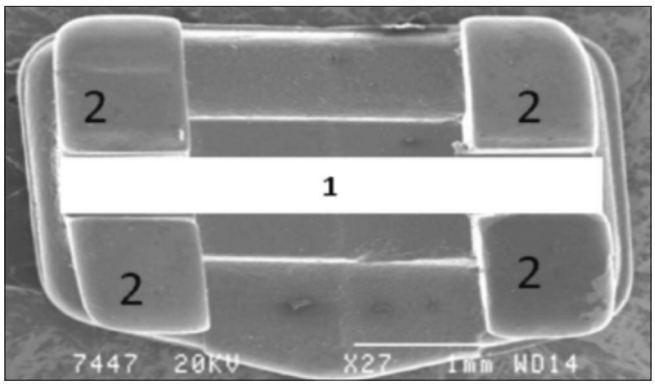


Figure 4: Scanning electron microscopic image of a bracket.

Table 2: Grading of adherence of microorganism in the SEM images.	
Adherence of microorganisms in the image	**Grading**
Nil	0
Low	1
Medium	2
High	3
SEM: Scanning electron microscope	

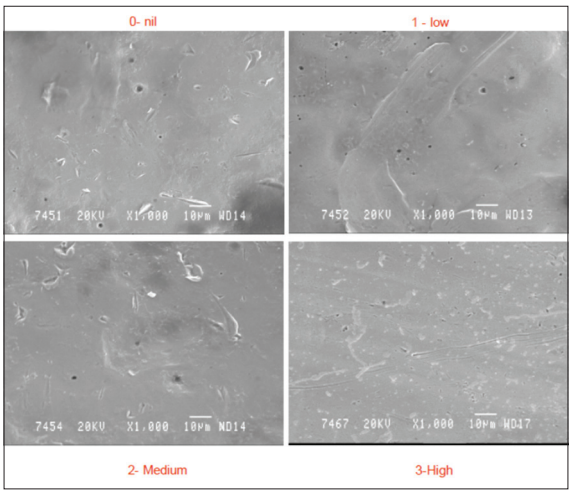
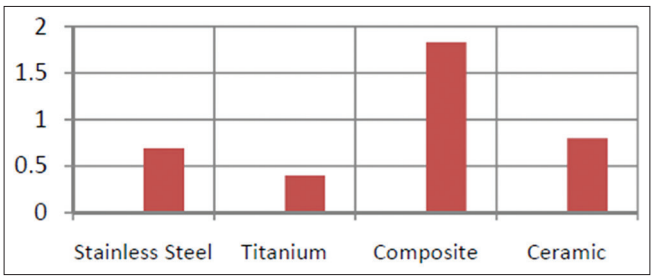
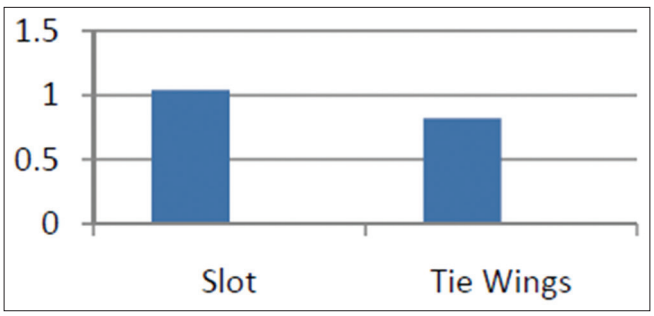


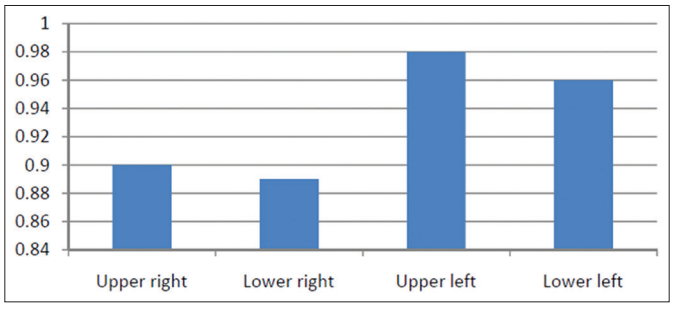
Figure 5: Graded scanning electron microscope images.



Graph 1: The mean adherence of microorganisms to different types of the bracket material.



Graph 2: The adherence of microorganisms in the slot and to tie wings surface.



Graph 3: The adherence of microorganisms in various quadrants.

Graph 4 shows the adherence of the microorganisms recorded in different surfaces of the brackets included in the study. Maximum adherence of microorganisms is observed with slot surface of composite brackets 1.92± 0.96 followed by tie wings surface of composite bracket, slot surface of ceramic brackets, tie wings surface of ceramic brackets, slot surface of stainless steel brackets, tie wings surface of stainless steel brackets, tie wings surface of titanium, and the least adherence is observed with slot surface of titanium brackets 0.35 ± 0.5.

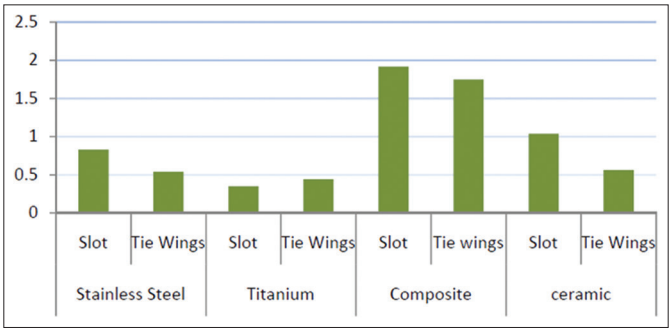
Graph 5 shows the adherence of microorganisms recorded to the different surfaces of brackets in all the four quadrants included in the study. The adherence of the microorganisms in slot surface is more or less similar in all the four quadrants included in the study. Whereas in the tie wings surface relatively more adherence of microorganisms is seen on the upper left and lower left quadrants compared to the upper right and lower right quadrants.

Graph 6 shows the adherence of microorganisms to different types of bracket materials in the four quadrants included in the study. The adherence of microorganisms is relatively more in all the four quadrants of composite bracket material and least adherence is observed with titanium brackets in all the four quadrants.

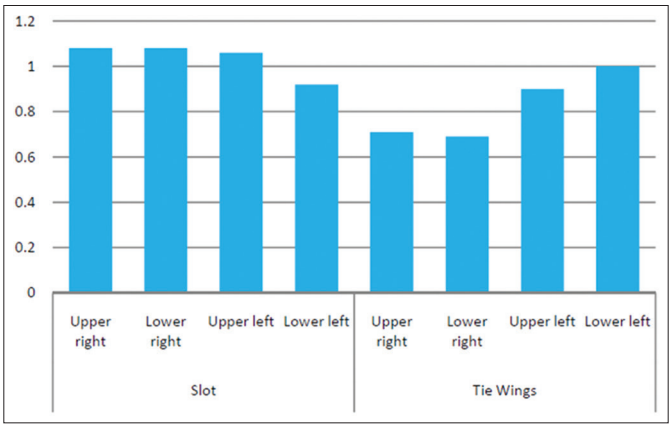
Graph 7 shows the adherence of microorganisms observed in different bracket materials in different surfaces and in all the four quadrants included in the study. The adherence of microorganisms recorded in different materials at the different surface is maximum in composite brackets and minimum in titanium brackets.

Table 3 gives the results of ANOVA comparison of adherence of microorganisms to different brackets, surfaces, and quadrants. It also gives the comparative adherence of bracket and surfaces, bracket and quadrant, surface and quadrant, and bracket/surface/quadrant.

Table 4 gives the multiple comparisons of Bonferroni. The results show that there is a significant difference in adherence of microorganisms to the various types of brackets ($P < 0.001$) and the surfaces ($P < 0.05$) included in the study. However, there is no significance in the mean adherence of microorganisms in the different quadrants ($P > 0.05$) included in the study. The interaction of bracket/surface, bracket/quadrant, surface/quadrants was analyzed, there is no significance of comparison of bracket/surfaces/quadrant but the interaction of bracket/quadrant was found to be significant (<0.011). The interaction of bracket/surfaces/quadrant was also found to be significant (<0.003).



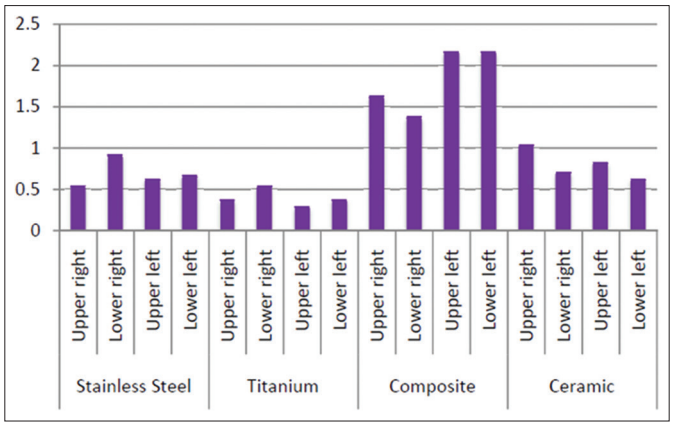
Graph 4: The adherence of microorganisms recorded in different types of bracket materials in the slot and tie wing surfaces.



Graph 5: The adherence of microorganisms in different surfaces and quadrants of the brackets.

Discussion

The result of our study are in accordance of the Brusca *et al.*[1] who studied that the adherence of *S. mutans* and *Candida albicans*

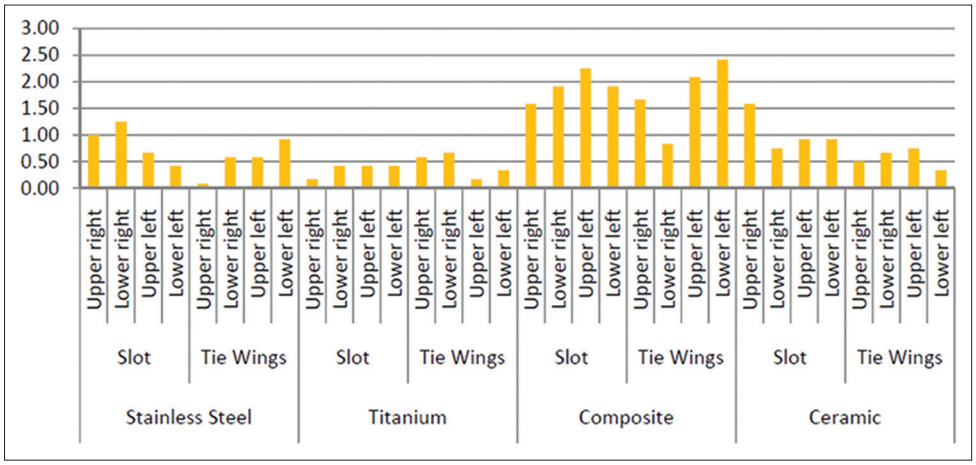


Graph 6: The adherence of microorganisms to different types of bracket materials in different quadrants.

Table 3: Results of ANOVA.

Source	df	SS	Mean SS	*F*	*P* value
Bracket	3	112.945	37.648	55.546	<0.001*
Surface	1	4.378	4.378	6.459	0.011*
Quadrant	3	0.612	0.204	0.301	0.825
Bracket*Surface	3	4.008	1.336	1.971	0.118
Bracket*Quadrant	9	15.836	1.760	2.596	0.007*
Surface*Quadrant	3	3.591	1.197	1.766	0.153
Bracket*Surface*Quadrant	9	17.148	1.905	2.811	0.003*
Error	352	238.583	0.678	-	-
Total	383	397.102	-	-	-

*Denotes significance. SS: Sum of squares



Graph 7: The adherence of microorganisms recorded in different materials at different surfaces and in different quadrants.

Table 4: *Post-hoc* test - Bonferroni.

Dependent variable: Adherence of microorganisms						
(I) Bracket material	(J) Bracket material	Mean difference (I-J)	Standard error	Significance	95% Confidence interval	
					Lower bound	Upper bound
Stainless steel	Titanium	0.29	0.119	0.088	−0.02	0.61
	Composite	−1.15*	0.119	0.000	−1.46	−0.83
	Ceramic	−0.11	0.119	1.000	−0.43	0.20
Titanium	Stainless steel	−0.29	0.119	0.088	−0.61	0.02
	Composite	−1.44*	0.119	0.000	−1.75	−1.12
	Ceramic	−0.41*	0.119	0.004	−0.72	−0.09
Composite	Stainless steel	1.15*	0.119	0.000	0.83	1.46
	Titanium	1.44*	0.119	0.000	1.12	1.75
	Ceramic	1.03*	0.119	0.000	0.72	1.35
Ceramic	Stainless steel	0.11	0.119	1.000	−0.20	0.43
	Titanium	0.41*	0.119	0.004	0.09	0.72
	Composite	−1.03*	0.119	0.000	−1.35	−0.72

Based on observed means. *The mean difference is significant at the 0.05 level

together which varied according to the bracket materials with decreasing order as composite, ceramic, and metallic.

The results are in accordance to Fournier *et al.*,[9] who concluded metal brackets presented a lower potential for bacterial accumulation than the plastic and ceramic bracket.

The results are in accordance to van Gastel *et al.*,[22] who concluded orthodontic brackets serve as different loci for biofilm formation. Significant differences between the different bracket types in terms of biofilm formation were found. The adherences of the microorganism are less with metallic brackets when compared to ceramic brackets.

Ahn *et al.*[23] found that adhesion of microorganisms is highest with plastic brackets and lowest in monocrystalline sapphire brackets. This study suggests that the adhesion amount of cariogenic streptococci to brackets is strongly influenced by the surface characteristics of the brackets, rather than a bacterial strain or saliva coating.

Papaioannou *et al.*[24] found no significant difference in the adherence to stainless steel, ceramic or plastic brackets.

Anhoury *et al.*[25] also found no significant difference between metallic and ceramic brackets with respect to caries inducing *S. mutans* and *lactobacillus acidophilus* spp. count

The low adherence of microorganism shows in the titanium brackets in the study are in accordance to Leonhardt and Dahlen,[6] who concluded titanium could not be demonstrated to have a similar antibacterial effect such as copper and amalgam.

Conclusion

1. Maximum adherence of microorganisms is observed with the composite bracket material, and the least adherence of microorganisms was observed with the titanium bracket material.
2. The adherence of microorganisms is relatively more in the slot area when compare to the tie wings surface.
3. Maximum adherence of microorganisms is observed in the upper left quadrant and least adherence of microorganisms is observed in lower right quadrant.
4. Maximum adherence of microorganisms is observed with slot surface of composite brackets and least adherence is observed with slot surface of titanium brackets.

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