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RESEARCH ARTICLE
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THE INFLUENCE OF ORTHODONTIC BRACKET BASE DIAMETER AND MESH SIZE ON BOND STRENGTH

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Abstract
Introduction- To enhance the retention of the adhesive to the metal base of orthodontic brackets, various chemical and mechanical retentive designs have been suggested.
Methodology- A total of 40 extracted human molars were collected and stored in a solution of 0.1% (wt/vol) thymol. The criteria for tooth selection included intact buccal enamel, no history of any pretreatment with chemical agents, eg, hydrogen peroxide, no cracks due to the presence of the extraction forceps, and no caries. Two types of brackets were used in this study. Twenty Ovation metal bracket series with a double-mesh base (Super-mesh) and an 81.50 gauge.
Results- The descriptive statistics for the two bracket types compared are presented in Table 2. The mean shear bond strength was 5.2 ± 3.9 MPa for the double-mesh brackets and 5.8 ± 2.8 MPa for the single-mesh brackets. The *t*-test comparisons indicated that these values were not significantly different from each other. The ARI scores comparison indicated that both bracket types had similar bracket failure modes and were not significantly different from each other.
Conclusion- The results indicated that the single- and double-mesh bracket bases evaluated in this study provided comparable shear bond strengths and bracket failure modes.

Keywords- Metal Base, Bracket Base Diameter, Bond Strength

Introduction

Numerous chemical and mechanical retentive designs have been proposed to improve the adhesive's retention on the metal base of orthodontic bracket. Mechanical retention was improved by adding undercuts to the cast bracket bases, welding various mesh wires of varied diameters to the bracket base, and adding various designs to the mesh structure. Other cutting-edge techniques to increase retention involved laser-structured bases, metal plasma-coated bracket bases, fusing metallic or ceramic particles to the bases, and employing laser-structured bases.[3] Orthodontic brackets with 80- and 100-gauge mesh bases (0.123 and 0.154 inches, respectively) as well as micro and standard-size bases were examined by Cucu et al[4] for their in vitro shear bond strength. Researchers discovered no appreciable variations in any of the brackets' shear bond strengths. Machine integrated bases were more retentive than foil-mesh bases, according to Regan and van Noort[5]. Comparing mesh-base and metal-base brackets, however, Thanos et al.[6] discovered that mesh-base brackets are more tensile in tension while metal-base brackets are more tensile in shear.

Sandblasting bracket base mesh surfaces, decreasing base surface area, and etching enamel with different kinds of acids were all examined by MacColl et al[7]. Researchers discovered that micro-etching and sandblasting of foil-mesh bases strengthened the shear bond. Additionally, they discovered that the shear bond strength of bracket base surface areas between 6.8 and 12.4 mm^2 did not vary significantly from each other but reduced when the surface size was 2.4 mm^2.

Smith and Reynolds[8] assessed the effectiveness of undercut, rough, and fine mesh bracket bases. They discovered that the fine-mesh base outperformed the coarse-mesh base in terms of performance and had a greater tensile bond strength.

Middleton et al.9 and Knox et al.10 assessed the impact of changing the bracket base geometry, considering introducing single- and double-mesh designs, utilising a validated model of the finite element method of stress analysis for the bracket-cement-tooth combination. When contrasted to the single-layer design, the combination of mesh layers produced a rise in the stresses observed in the deepest (fine) mesh layer and a decline in the stresses recorded in the most superficial (coarse) mesh layer. Researchers also discovered that altering the mesh wire's width and spacing had an impact on the measured stress's amplitude and distribution. Knox et al[11] evaluated different bracket base designs including 60-, 80-, and 100-gauge (0.093, 0.123, 0.154 inches, respectively) single-mesh bases, a double-mesh base, and integrated metal base. They concluded that the bonding agent significantly affects the shear bond strength and that particular base designs may allow improved adhesive penetration or improved penetration of the curing light.

Considering the impact of adopting various retentive bracket base designs on the shear bond strength, the literature has contradicting findings. The use of a single- or double-mesh bracket base and whether it influences the shear bond strength of orthodontic brackets were other subjects of debate. In this research, two metallic orthodontic brackets—one with a single-mesh bracket base and the other with a double-mesh base—were tested for their shear bond strengths.

Methodology

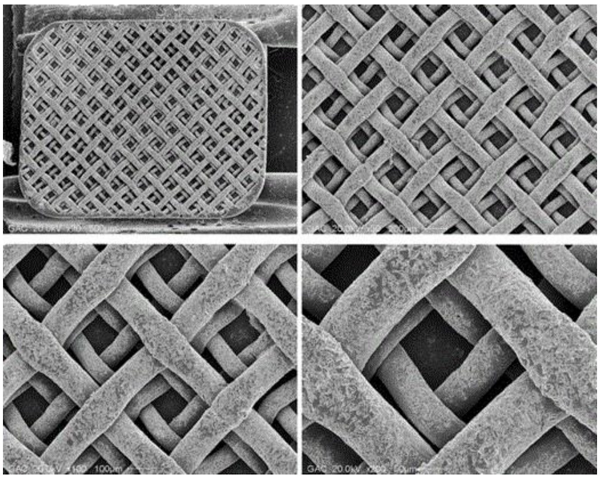
A solution containing 0.1% (wt/vol) thymol was used to preserve a total of 40 removed human molars. The criteria used to select for teeth required complete buccal enamel, no history of chemical pretreatment, such as hydrogen peroxide, no splits from the extraction forceps, and no cavities. After using pumice and rubber prophylactic cups to clean and polish the teeth for 10 seconds, water was used to rinse them. All brackets were bonded to the teeth using the Transbond XT adhesive method from 3M Unitek in Monrovia, California.

Brackets used

In this investigation, two different kinds of brackets were employed. Twenty Ovation metal bracket series with a double-mesh base (Super-mesh) and an 81.50 gauge (0.126 inches) were utilised. The Ovation bracket's surface area was estimated to be 13.9 mm2. 20 metal brackets from the Victory series from 3M Unitek with a tiny single-mesh base were utilised. It was determined that the bracket base surface area was 11.8 mm2. For the maxillary left central incisors, all brackets were used.

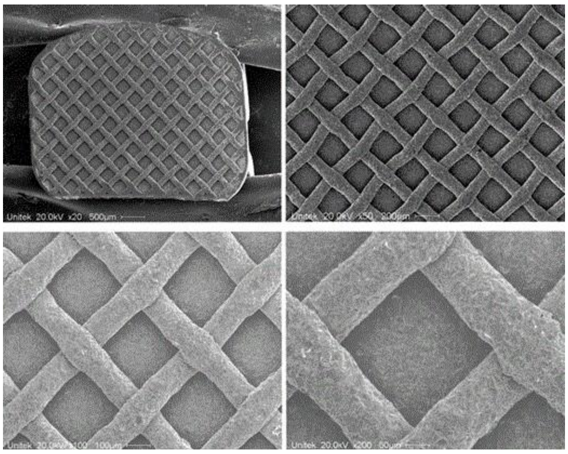
Figures 1 and 2, correspondingly, show scanning electron microscopy images at various magnifications (from 20 to 200) for the Ovation double-mesh and Victory single-mesh bracket bases in the "as received" state.

Figure 1.



SEM photographs at different magnifications (from ×20 to ×200) for the Ovation double-mesh bracket bases, in the “as received” condition

Figure 2.



SEM photographs at different magnifications (from ×20 to ×200) for the Victory single-mesh bracket bases, in the “as received” condition

When evaluating mesh performance, Matasa[12] identified a number of variables that need to be considered, including

- Mesh number, ie, the number of openings per lineal inch measured from the center of wire to the center of wire.
- Wire diameter: If it is too thin it will break. If it is too thick it will limit the penetration of the adhesive.
- Size of the aperture (open area): The higher the percentage of the open area the better is the penetration of the adhesive.

Bonding procedure

On the buccal side of every tooth, a 37% phosphoric acid gel was administered for 15 seconds. Following a 30-second water rinse, the teeth were dried with an oil-free air source for 20 seconds, resulting in the buccal surfaces of the etched teeth looking powdery white. On the etched surfaces, the sealer was used. Each bracket base was covered in Transbond XT glue. The bracket was then placed on the tooth correctly and given a 300 g force. Sharp scaler was used to get rid of extra glue.

After that, the bracket underwent a 20-second light cure. The acrylic teeth were set on phenolic rings and imbedded in acrylic. The labial side of the teeth was aligned to the applied force throughout the shear test by using a mounting jig to align the facial surfaces perpendicular to the bottom of the mould.

Shear bond strength testing

To roughly match the timing of binding the initial archwires to the teeth, the teeth were debonded within 30 minutes of the initial bonding. The bracket was subjected to an occluso-gingival stress, creating a shear force at the bracket-tooth interface. The flattened end of a steel rod that was mounted to the crosshead of a Zwick test device was used to achieve this. The Zwick test machine electronically attached computer recorded the results of each test in mega-Pascals (MPa). At a crosshead speed of five millimetres per minute, shear bond strengths were assessed.

Modified adhesive remnant index

Accompanying debonding, the enamel surface was examined at a magnification of 10 to assess how much leftover adhesive was still attached to the tooth using the following scale: One indicates that all of the composite was still present on the tooth, two indicates that more than 90% of it was, three indicates that more than 10% but less than 90% of it was, four indicates that less than 10% was, and five indicates that no composite was present on the tooth.

Statistical analysis

For the two bracket kinds investigated, descriptive statistics such as the mean, standard deviation, minimum and maximum values were computed. The two groups were contrasted using the Student's t-test. The scores for the adhesive remnant index (ARI) for the two bracket types were compared using the chi-square (2) test. The ARI ratings for groups 1 and 2 as well as groups 4 and 5 were combined for the statistical analysis. All statistical tests have a preset significance level of P .05.

RESULTS

Shear bond strength

The descriptive statistics for the two bracket types compared are presented in Table 2. The mean shear bond strength was 5.2 ± 3.9 MPa for the double-mesh brackets and 5.8 ± 2.8 MPa for the single-mesh brackets. The *t*-test comparisons ($t = 2.09$) indicated that these values were not significantly different from each other ($P = .157$).

ARI scores

The failure modes of the two types of brackets are presented in Table 3. The ARI scores comparison indicated that both bracket types had similar bracket failure modes and were not significantly different from each other ($y^2 = 2.0$, $P = .5$). More specifically, at the time of debonding, most of the adhesive remained on the enamel surface. Theseresults indicated that in general, in the first half hour, there was more adhesive attached to the enamel surface than the bases of both types of brackets (ARI scores of 1 and 2).

Table 1- Mesh-Base Specifications of the Two Brackets Compared in this Study as Described by Matasa[13]

Brackets	Pad$x$[a]	Diameter (inch)[b]	Aperture μ[c]	Open Area (%)[d]
Ovation	Super-mesh 200	0.0021	75	34
Victory	Single-mesh 80 mesh	0.0055	180	31.5

[a] Mesh number (x) = number of openings per lineal inch from thecenter of the wire to the center of the wire.

[b] Diameter of the mesh wire.

[c] Aperture, size of the mesh aperture in micrometers.

[d] Open area, total area available for the adhesive to penetrate.

Table 2. Descriptive Statistics in Megapascals (MPa), and theResults of the Student's *t*-Test Comparisons of the Shear Bond Strengths of the Brackets Testeda

Brackets	**n**	**x¯**	**SD**	**Range**
Single mesh	20	5.8	2.8	1.0–11.2
Double mesh	20	5.2	3.9	1.0–13.8
t-Test	2.09			
P	.157			

Table 3. Frequency Distribution and y2 Comparisons of the Modified Adhesive Remnant Index (ARI) Scores of the Two Groups

				ARI Scores[a]		
Brackets	N	1	2	3	4	5
Single mesh	20	10	10	—	—	—
Double mesh	20	12	5	3	—	—
y2				2.0		
P				.50		

[a] 1, all the composite remained on the tooth; 2, more than 90% of the composite remained on the tooth; 3, more than 10% but less than 90% remained on the tooth; 4, less than 10% remained on the tooth; 5, no composite remained on the tooth.

Discussion

Several investigators found machine integral bases to be more retentive than foil-mesh bases when examining the effectiveness of the bracket base retention,5 while others discovered opposite results.7,8 The technique of finite element analysis was used to examine both single- and double-mesh designs, and it was discovered that the stresses varied depending on the thickness of the adhesive layer.9,10 Similar shear bond strength values and bracket failure mechanisms were obtained in this work using single- and double-mesh designs. Maijer and Smith14 used scanning electron micrographs to analyse various bracket pads and identified a number of factors and observations that might affect the bond strength of brackets, such as (1) weld spots might prevent decrease the retentive area, (2) weld spurs could decrease bond strength with foil-mesh brackets, (3) weld spots on the edges of the connections should be avoided to enhance the resin-mesh seal, (4) bracket bases should be designed to prevent air entrapment, and (5) weld.

Knox[11] proposed that the intrusions for the adhesive and light-curing materials need to be im- proved in the bracket base design. On the contrary, Matasa[12] noted that the bracket pad has historically received more attention from the manufacturer's attempts to increase bonding strength than the adhesive and enamel conditioner. As an outcome, despite significantly affecting bond strength, the bonding pad and bracket base have evolved over time to include a perforated mesh, mesh, grooves, dents, and pegs. Since metals are hydrophilic, Matasa[13] proposed that using a good primer would assist moisten the surface and encourage the adhesive to pass through the mesh in order to enhance bracket performance. Either mesh silanation or polymer coating can do this. In the absence of such a treatment, pressing the bracket after it has been positioned on the tooth is essential in order to push the adhesive through the mesh layer(s) and reduce air pockets that could weaken the connection.

Conclusion

The findings showed that the shear bond strengths and bracket failure modes offered by the single- and double-mesh bracket bases examined in this study were comparable. It remains to be seen whether these findings will hold up 24 hours following the first bonding or after thermocycling.

Reference

1. Sorel O, El Alam R, Chagneau F, Cathelineau G. Comparison of bond strength between simple foil and laser-structured base re- tention brackets. *Am J Orthod Dentofacial Orthop.* 2002;122: 260–266.
2. Droese V, Diedrich P. The tensile bonding strength of metal plas- ma-coated bracket bases. *Fortschr Kufer Orthop.* 1992;53:142– 152.
3. Smith DC, Maijer R. Improvements in bracket base design. *AmJ Orthod.* 1983;83:277–281.
4. Cucu M, Driessen CH, Ferreira PD. The influence of orthodontic bracket base diameter and mesh size on bond strength. *Swed Dent J.* 2002;57:16–20.
5. Regan D, van Noort R. Bond strength of two integral bracket base combinations: an in vitro comparison with foil-mesh. *Eur J Orthod.* 1989;11:144–153.
6. Thanos CE, Munholland T, Caputo AA. Adhesion of mesh-base direct-bonding brackets. *Am J Orthod.* 1979;75:421–430.
7. MacColl GA, Rossouw PE, Titley KC, Yamin C. The relationshipbetween bond strength and orthodontic bracket base. *Am J OrthodDentofacial Orthop.* 1998;113:276–281.
8. Smith NR, Reynolds IR. A comparison of three bracket bases: an in vitro study. *Br J Orthod.* 1991;18:29–35.
9. Middleton J, Hubsch P, Kralj, Knor J, Jones ML. Numerical in- vestigation of fixed orthodontic brackets. Proceedings of the In- stitution of Mechanical Engineers. Part II. *J Eng Med.* 2000;214: 311–323.
10. Knox J, Kralj B, Hubsch P, Middleton J, Jones ML. An evaluationof the quality of orthodontic attachment offered by single and double mesh bracket bases using finite element method of stress analysis. *Angle Orthod.* 2001;71:149–155.
11. Knox J, Hubsch P, Jones ML, Middleton J. The influence of bracket base design on the strength of bracket-cement interface. *J Orthod.* 2000;27:249–254.
12. Matasa CG. In search of a better bond: state of the art. *The Or- thodontic Materials Insider.* 2003;15:1–3.
13. Matasa CG. Do adhesives and sealants really seal the bracket’s pad? II. Surface tension. *The Orthodontic Materials Insider.* 2003;15:4–10.
14. Maijer R, Smith DC. Variables influencing the bond strength of metal orthodontic bracket bases. *Am J Orthod.* 1981;79:20–34.