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Bracket bonding to polymethylmethacrylate-based materials for computer-aided design/manufacture of temporary restorations: Influence of mechanical treatment and chemical treatment with universal adhesives

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Objective: To assess shear bond strength and failure mode (Adhesive Remnant Index, ARI) of orthodontic brackets bonded to polymethylmethacrylate (PMMA) blocks for computer-aided design/manufacture (CAD/CAM) fabrication of temporary restorations, following substrate chemical or mechanical treatment. **Methods:** Two types of PMMA blocks were tested: CAD-Temp® (VITA) and Telio® CAD (Ivoclar-Vivadent). The substrate was roughened with 320-grit sandpaper, simulating a fine-grit diamond bur. Two universal adhesives, Scotchbond Universal Adhesive (SU) and Assure Plus (AP), and a conventional adhesive, Transbond XT Primer (XTP; control), were used in combination with Transbond XT Paste to bond the brackets. Six experimental groups were formed: (1) CAD-Temp®/SU; (2) CAD-Temp®/AP; (3) CAD-Temp®/XTP; (4) Telio® CAD/SU; (5) Telio® CAD/AP; (6) Telio® CAD/XTP. Shear bond strength and ARI were assessed. On 1 extra block for each PMMA-based material surfaces were roughened with 180-grit sandpaper, simulating a normal/medium-grit (100 μm) diamond bur, and brackets were bonded. Shear bond strengths and ARI scores were compared with those of groups 3, 6. **Results:** On CAD-Temp® significantly higher bracket bond strengths than on Telio® CAD were recorded. With XTP significantly lower levels of adhesion were reached than using SU or AP. Roughening with a coarser bur resulted in a significant increase in adhesion. **Conclusions:** Bracket bonding to CAD/CAM PMMA can be promoted by grinding the substrate with a normal/medium-grit bur or by coating the intact surface with universal adhesives. With appropriate pretreatments, bracket adhesion to CAD/CAM PMMA temporary restorations can be enhanced to clinically satisfactory levels.
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Key words: Bracket, Bonding, Adhesive, Prosthodontics

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INTRODUCTION

The growing interest in oral health and esthetic dentistry has increased the demand for adult orthodontic treatment.[1-4] In multidisciplinary treatments orthodontists are often required to bond brackets to teeth restored with temporary crowns.[2-5] Several materials and techniques are currently available to clinicians for fabricating temporary restorations.[2-8] However, if a patient is undergoing orthodontic therapy as a part of interdisciplinary treatment, materials that can provide satisfactory properties for an extended period of time are preferable.

In recent years, highly cross-linked prefabricated polymethylmethacrylate (PMMA) resin blocks have been marketed for use in computer-aided design/manufacture (CAD/CAM) systems. As they are industrially fabricated under standardized conditions, these CAD/CAM polymer materials exhibit improved mechanical and esthetic properties.[9-11] Thus, PMMA-based milled temporary restorations are particularly suitable for use in longer clinical services, such as interdisciplinary treatment strategies that involve an orthodontic phase. Nevertheless, the adhesive conditions offered in orthodontic bracket bonding by such a densely polymerized restorative substrate must be investigated. Industrially polymerized PMMA-based materials exhibit a high degree of conversion, and the amount of residual monomers or free radicals may be insufficient for co-polymerization with the monomers in the adhesive system.

The adhesion of a resin composite to highly cross-linked PMMA could benefit from chemically or mechanically pretreating the restorative substrate.

Regarding chemical treatment, universal adhesives have been claimed to successfully adhere to different restorative substrates,[12] as well as dental tissues, and have recently been proposed for several applications in dentistry.[13,14] In an *in-vitro* study, Hellak et al.[15] reported that Scotchbond Universal Adhesive (3M ESPE, St. Paul, MN, USA) provided satisfactory retention of orthodontic brackets to metal, porcelain, and composite substrates. Lately, Assure Plus (Reliance Orthodontic Products, Itasca, IL, USA), a one-step universal primer allegedly able to effectively bond orthodontic brackets to all intraoral surfaces, including restorative substrates, entered the market.[16-18] The bond strength of this new material to sound[16] and fluorosed[17] enamel, as well as to ceramic materials[18] has been tested. A chemical component common to most universal adhesives is the 10-methacryloyloxydecyl dihydrogenphosphate (10-MDP) monomer. This monomer may promote adhesion to PMMA by chemically reacting with methacrylate groups. However, the potential for universal adhesives to bond orthodontic brackets to polymer materials for CAD/CAM temporary restorations needs to be verified. Therefore, the aim of the first part of this study was to assess the influence of universal adhesives on bracket bond strength to PMMA-based CAD/CAM blocks. Specifically, the first tested null hypothesis was that two marketed universal adhesives did not significantly differ from each other or from a conventional orthodontic adhesive in their ability to bond metal brackets onto two types of PMMA-based CAD/CAM blocks.

Another issue worthy of evaluation is whether adhesion to densely polymerized PMMA can be enhanced by mechanically roughening the substrate. In a recent *in-vitro* study, Wiegand et al.[19] measured the shear bond strength of a resin composite to different CAD/CAM polymer materials for the purpose of repairability. In the absence of any surface pretreatment, significantly weaker adhesion was established than when silica coating/silanization, aluminum oxide sandblasting, and mechanical roughening for simulating diamond bur abrasion were performed.[19] However, the influence of mechanically pre-treating PMMA blocks on the adhesion of orthodontic brackets has not yet been evaluated. Therefore, the aim of the second part of this study was to assess the effect on bracket bond strength of roughening the PPMA substrate with different abrasives. Specifically, the second formulated null hypothesis was that roughening the PMMA blocks surface with abrasives simulating a fine-grit or a normal/medium-grit diamond bur did not significantly change the adhesive conditions offered to orthodontic brackets. Throughout the study, the adhesive conditions were assessed by measuring the shear bond strength of bonded brackets, as well as the amount of adhesive remaining on the substrate after debonding.

MATERIALS AND METHODS

Chemical treatment of the substrate with universal adhesives

Two types of PMMA-based blocks for use in CAD/CAM systems were tested: CAD-Temp® (VITA Zahnfabrik, Bad Säckingen, Germany) and Telio® CAD (Ivoclar Vivadent AG, Schaan, Liechtenstein). The chemical composition of the two materials is presented in Table 1. The dimensions of the CAD-Temp® and Telio® CAD blocks were 15.5 × 19 × 39 mm and 15.4 × 19 × 39 mm, respectively. Up to 5 brackets could be bonded horizontally spaced on each longitudinal surface of the block (Figure 1). Thus, all the brackets in each experimental group ($n = 10$) were bonded to one same block.

The bonding surface of each block was roughened using wet 320-grit silicon carbide paper at 1.3 N for 8 seonds,[19] simulating the action of a fine-grit (40 μm) diamond bur. After roughening, the bonding surface was cleaned with ethanol and dried using an oil-free

Table 1. Chemical compositions of the tested PMMA blocks

	Manufacturer	Chemical composition
CAD-Temp®	VITA Zahnfabrik, Bad Säckingen, Germany	83–86% wt% PMMA, 14% wt% microfiller (silica), pigments (< 0.1%)
Telio® CAD	Ivoclar Vivadent, Schaan, Liechtenstein	99.5% wt% PMMA, no fillers, pigments (< 0.1%)

PMMA, Polymethylmethacrylate; wt%, percentage by weight.

Table 2. Chemical compositions of the tested adhesives

	Manufacturer	Chemical composition
Scotchbond Universal Adhesive	3M ESPE, St. Paul, MN, USA	10-MDP phosphate monomer, Vitrebond copolymer, HEMA, Bis-GMA, dimethacrylate resins filler, silane, initiators, ethanol, water
Assure Plus	Reliance Orthodontic Products, Itasca, IL, USA	Bis-GMA, ethanol, MDP, HEMA
Transbond XT Primer	3M Unitek, Monrovia, CA, USA	Bis-GMA, TEGDMA, 4-(dimethylamino)-benzeneethanol, camphorquinone, hydroquinone
Transbond XT Paste	3M Unitek, Monrovia, CA, USA	Silane treated quartz (70–80% in weight), bisphenol A diglycidyl ether dimethacrylate, bisphenol A bis(2-hydroxyethyl ether) dimethacrylate, silane treated silica, diphenyliodonium

10-MDP, 10-methacryloyloxydecyl dihydrogenphosphate; HEMA, hydroxyethyl methacrylate; Bis-GMA, bisphenol A diglycidyl methacrylate; TEGDMA, triethyleneglycol dimethacrylate.

Figure 1. Experimental set-up for bracket shear bond strength testing.

air spray. The adhesives Scotchbond Universal Adhesive (3M ESPE), Assure Plus (Reliance Orthodontic Products), and Transbond XT Primer (3M Unitek, Monrovia, CA, USA), all in combination with Transbond XT Paste (3M Unitek), were used to bond the brackets to the PMMA-based materials. Transbond XT primer is considered to be a standard adhesive in orthodontics and served as the control material. The chemical compositions of the tested adhesives are reported in Table 2. Six experimental groups were formed: group 1, CAD-Temp®/Scotchbond Universal Adhesive; group 2, CAD-Temp®/Assure Plus; group 3, CAD-Temp®/Transbond XT Primer; group 4, Telio® CAD/Scotchbond Universal Adhesive; group 5, Telio® CAD/Assure Plus; and group 6, Telio® CAD/Transbond XT Primer. Sixty stainless steel brackets for upper incisors (Victory Series; 3M Unitek) were randomly selected and assigned to the 6 experimental groups. The average bracket base surface area reported by the manufacturer was verified by measuring with a digital caliper (Mitutoyo, Kawasaki, Japan). The area of 10 randomly chosen brackets was recorded and the mean value of the measured areas was calculated to be 11.02 mm^2. In the bonding procedure, the adhesive was applied to the substrate with a brush and thinned with a gentle stream of air. Photopolymerization of the adhesives Assure Plus and Transbond XT Primer is not recommended by the respective manufacturers. As there were no specific manufacturer's guidelines for the use of Scotchbond Universal Adhesive in bracket bonding, in order to standardize the bonding procedure for all experimental groups, light-curing was omitted also for this adhesive. It should be noted that the manufacturer of Scotchbond Universal Adhesive recommends avoiding light-curing when using this adhesive for veneer luting (http://multimedia.3m.com/mws/media/754751O/scotchbond-universal-adhesive-technical-product-profile.pdf). Thereafter, a small amount of Transbond XT Paste was applied to the bracket base, and the bracket was firmly seated to the substrate using a scaler instrument. Excess resin composite was removed from the periphery of the bracket base with the scaler, and light-curing was perfomed with an LED curing light (Ortholux Luminous; 3M Unitek; output: 1,600 mW/cm^2), positioning the tip for 12 seconds on the mesial and 12 seconds on the distal side of the bracket. All brackets were placed by the same operator (GDB). The bonded specimens then underwent thermocycling from 5–55°C for 2,000 cycles, with a dwell time of 30 seconds.[20] For debonding, a steel rod with a flattened end was attached to the crosshead of a universal testing machine (Controls; Milano, Italy). Specimens were secured to the lower jaw of the machine to ensure that the bonded bracket base was parallel to the shear force direction. The flat-end steel rod acted on the bracket to apply a force at the bracket-substrate interface (Figure 1).[21] Specimens were stressed in the occlusal-gingival direction at a crosshead speed of 1 mm/min. The load necessary to debond the bracket from the block was recorded in Newtons, and the bond strength was expressed in MegaPascals by dividing the load at failure in Newtons by the surface area of the bracket in mm^2. After debonding, the bracket bases and enamel surfaces were examined under an optical microscope at a magnification of 20×. The Modified Adhesive Remnant Index (ARI) proposed by Ostby et al.[21] was used to assess the amount of adhesive remaining on the enamel surfaces. This index ranges from 0 to 5, and the scores are defined as follows: score 1, all of the adhesive remained on the tooth; score 2, over 90% of the adhesive remained on the tooth; score 3, 10% to 90% of the adhesive remained on the tooth; score 4, less than 10% of the adhesive remained on the tooth; score 5, no adhesive remained on the tooth.[21]

Mechanical substrate treatment

To assess the influence of mechanical substrate treatment on bracket adhesion, the surface of one additional block per PMMA-based material was roughened with a wet 180-grit silicon carbide paper at 1.3 N for 8 seconds,[19] simulating the action of a normal/medium-grit (100 μm) diamond bur. The bonding surface was then cleaned with ethanol and dried with an oil-free air spray. Using Transbond XT Paste in the same way as described above, brackets were bonded to the substrates, 10 on a CAD-Temp® block (group 7) and 10 on a Telio® CAD block (group 8). Thermocycling, bracket debonding, and ARI assessment were conducted following the same protocol for testing the influence of chemical treatment. The collected data were compared with those of experimental groups 3 and 6, that had been recorded on blocks roughened with a finer-grit silicon carbide paper.

Statistical analysis

All statistical analyses were conducted using SigmaPlot ver. 11.00 for Windows (Systat Software, Inc., San Jose, CA, USA).

Shear bond strength

Having excluded through a linear regression that the PMMA block *per se* was an influential factor for the measured bond strengths, the bracket was considered as the statistical unit. Normality of the data distribution (Shapiro-Wilk test) and homogeneity of the group variances (Levene test) were confirmed, then the Two-Way Analysis of Variance (ANOVA) was applied with bond strength as the dependent variable, substrate and adhesive type or substrate and substrate treatment as factors. The Tukey test was utilized for *post-hoc* comparisons as needed. In all the analyses the statistical significance level was set at $p < 0.05$.

Adhesive Remnant Index score

To assess the statistical significance of the between-group differences in the amount of adhesive remaining on the substrate, the Kruskal–Wallis ANOVA was applied to the ARI scores, followed by the Dunn's multiple range test for *post-hoc* comparisons. In all tests the level of statistical significance was set at $p < 0.05$.

RESULTS

Chemical treatment of the substrate with universal adhesives

Shear bond strength

The descriptive statistics of the shear bond strength data are reported in Table 3. The Two-Way ANOVA demonstrated that the type of polymeric material for CAD/CAM fabrication of temporary restorations had a significant influence on bracket adhesion *per se* ($p = 0.02$). Particularly, CAD-Temp® offered significantly more favorable bonding conditions than Telio® CAD. Also, the type of adhesive proved to be a significant factor for bracket retention ($p < 0.001$). Specifically, with the use of Transbond XT Primer, significantly weaker bonds were established than after the application of Scotchbond Universal Adhesive and Assure Plus ($p < 0.05$), which achieved comparable bond strengths ($p > 0.05$). The substrate-adhesive interaction was not statistically significant ($p = 0.311$).

Adhesive Remnant Index score

The descriptive statistics of the ARI scores are presented in Table 4. The Kruskal–Wallis test demonstrated statistically significant differences in the ARI scores amongst the experimental groups ($p < 0.001$). In particular, the Dunn's multiple range test indicated that a significantly smaller amount of resin composite remained on the substrate in specimens that received Transbond XT Primer, in comparison with those treated with Scotchbond Universal Adhesive or in comparison with CAD-Temp® blocks coated with Assure Plus ($p < 0.05$).

Table 3. Descriptive statistics of the shear bond strength data following the chemical treatment of the substrate

PMMA-based material	Adhesive	Number	Mean (MPa)	Standard deviation
CAD-Temp®[A]	Scotchbond Universal Adhesive	10	7.51	1.40
	Assure Plus	10	8.15	1.89
	Transbond XT Primer	10	5.95	1.37
	Total	30	7.20	1.78
Telio® CAD[B]	Scotchbond Universal Adhesive	10	7.28	1.21
	Assure Plus	10	6.66	1.58
	Transbond XT Primer	10	5.23	1.10
	Total	30	6.39	1.59
Adhesive	Scotchbond Universal Adhesive[a]	20	7.40	1.21
	Assure Plus[a]	20	7.41	1.58
	Transbond XT Primer[b]	20	5.59	1.26

Two-Way Analysis of Variance, Tukey test for *post hoc* comparisons.
[A,B]The different upper-case superscript letters indicate a statistically significant difference in the bond strengths provided by the two polymethylmethacrylate (PMMA)-based materials, regardless of the adhesive used ($p < 0.05$). [a,b]The different lower-case superscript letters show the statistically significant differences in the bond strengths achieved by the adhesives, irrespective of the substrate ($p < 0.001$).

Table 4. Descriptive statistics of the Adhesive Remnant Index scores

Group	Number	Median	Interquartile range (25–75%)	Significance $p < 0.05$
CAD-Temp®/Scotchbond Universal Adhesive	10	3	1–3	A
CAD-Temp®/Assure Plus	10	3	3–3	A
CAD-Temp®/Transbond XT Primer	10	5	5–5	B
Telio® CAD/Scotchbond Universal Adhesive	10	3	1–3	A
Telio® CAD/Assure Plus	10	3	3–5	AB
Telio® CAD/Transbond XT Primer	10	5	5–5	B

Kruskal–Wallis Analysis of Variance, Dunn's multiple range test for *post hoc* comparisons. In the significance column, the different letters indicate the statistically significant differences amongst the experimental groups.

Table 5. Descriptive statistics of the shear bond strength data following the mechanical treatment of the substrate

PMMA-based material	Abrasive	Number	Mean (MPa)	Standard deviation
CAD-Temp®	180 grit[a]	10	7.98	1.21
	320 grit[b]	10	5.95	1.37
	Total	20	6.96	1.63
Telio® CAD	180 grit[a]	10	8.99	0.95
	320 grit[b]	10	5.23	1.10
	Total	20	7.11	2.17
Total	180 grit[a]	20	8.48	1.18
	320 grit[b]	20	5.59	1.26

Two-Way Analysis of Variance, Tukey test for *post hoc* comparisons.
[a,b]The different superscript letters indicate a statistically significant difference in the bonding conditions achieved by roughening with the two abrasives, regardless of the type of polymethylmethacrylate (PMMA)-based material ($p < 0.001$).

Table 6. Descriptive statistics of the Adhesive Remnant Index scores

Group	Number	Median	Interquartile range (25–75%)	Significance $p < 0.05$
CAD-Temp®/180 grit	10	3	3–4	A
CAD-Temp®/320 grit	10	5	5–5	B
Telio® CAD/180 grit	10	3	3–4	A
Telio® CAD/320 grit	10	5	5–5	B

Kruskal–Wallis Analysis of Variance, Dunn's multiple range test for *post hoc* comparisons. In the significance column, the different letters indicate the statistically significant differences amongst the experimental groups.

Mechanical treatment of the substrate

Shear bond strength

The descriptive statistics of the shear bond strength data are presented in Table 5.

The Two-Way ANOVA revealed that the type of polymeric material was not an influential factor for bracket adhesion *per se* ($p = 0.686$). Regardless of the type of substrate, roughening with a coarser abrasive increased significantly bracket adhesion ($p < 0.001$). Furthermore, the substrate-abrasive interaction was statistically significant ($p = 0.026$): both CAD-Temp® and Telio® CAD had their retentive potential significantly enhanced by roughening with the coarser silicon carbide paper, reproducing a normal/medium-grit diamond bur ($p < 0.05$).

Adhesive Remnant Index score

The descriptive statistics of the ARI scores are presented in Table 6. The Kruskal–Wallis test reported statistically significant differences in the ARI scores amongst the experimental groups ($p < 0.001$). In particular, the Dunn's multiple range test indicated that a significantly smaller amount of resin composite remained on the surfaces roughened with the finer abrasive ($p < 0.05$).

DISCUSSION

The study's outcome led to rejection of both formulated null hypotheses.

Regarding the influence of chemical substrate treatment on bracket retention, the first interesting finding was that, regardless of the adhesive type, CAD-Temp® was more receptive to bonding than Telio® CAD. The difference between the two PMMA-based materials was not notable in absolute terms, but significant from a statistical viewpoint (Table 3). By considering the chemical composition of the two materials (Table 1), it is evident that CAD-Temp® contains some silica microfillers, while Telio® CAD is made almost completely of PMMA. It can be speculated that the silica filler of CAD-Temp® contributed positively to adhesion. However, this hypothesis would need further verification.

More remarkable was the effect of the universal adhesives. Coating the substrate with either Scotchbond Universal Adhesive or Assure Plus resulted in a significant increase in bracket bond strength, in comparison with the use of Transbond XT Primer (Table 3). Distinctive ingredients of the universal adhesives, compared with the conventional bonding system, are hydroxyethyl methacrylate (HEMA) and 10-MDP (Table 2). While the role of these monomers in adhesion to enamel and dentin, as well as to zirconia has been clarified,[12,13,22,23] the literature presents no information regarding the mechanism by which the same monomers could promote adhesion to methacrylates. It can therefore only be speculated that HEMA contributed by reducing the adhesive solution viscosity, in comparison with the bisphenol A diglycidyl methacrylate based adhesive Transbond XT Primer, while 10-MDP purportedly provided a chemical bond with the methacrylates of the substrate.

The bracket bond strengths recorded on Transbond XT specimens roughened with the finer abrasive were below the threshold of clinical acceptability established by Reynolds (6–8 MPa).[24] However, Finnema et al.,[25] having conducted a systematic review and meta-analysis of *in-vitro* orthodontic bond strength testing, questioned the use of the threshold values proposed by Reynolds, and stated that whether 6–8 MPa is a sufficient *in-vitro* bond strength for clinical use has never actually been tested.[26,27] Furthermore, Eliades and Bourauel[28] warned against the risks of extrapolating from the absolute bond strength values and relating them to a 'clinically acceptable' limit. In fact, the bond strengths measured in a test are related to the experimental conditions of the trial and do not necessarily apply to other testing environments.

In this perspective, with reference to a previous *in-vitro* study[29] following the same protocol and using the same testing equipment as in the present investigation, it is noteworthy that, after treating the surface of the PMMA with the universal adhesives, the achieved bracket bond strengths were similar to those established on enamel by a self-etching adhesive with proven satisfactory clinical performance.[30] Expectedly, in the absence of any PMMA substrate pretreatment, the adhesion levels achieved by Transbond XT Primer were lower than those achieved by

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the same adhesive on etched enamel in the mentioned previous study with the same design.[29] The two universal adhesives proved comparably effective at enhancing bracket adhesion to the PMMA-based materials. Assure Plus was recently introduced to the orthodontic market as an 'all-surface bonding resin', claimed to be able to increase bracket retention to all the dental hard tissues, including teeth with fluorosis or deciduous enamel and cement, as well as to metallic, ceramic, and polymeric restorative substrates.[16-18] Scotchbond Universal Adhesive has long been available to dental clinicians for several purposes.[12,13] Mainly utilized in general dentistry for bonding of direct and luting of indirect restorations, Scotchbond Universal Adhesive was recently satisfactorily tested as a bracket-bonding agent.[14,15] In this regard, as already pointed out by Hellak et al.,[14,15] the choice of this material also by the orthodontist may be convenient in terms of office inventory costs. In other words, it is useful to know that Scotchbond Universal Adhesive, possibly already in use in the office for its various applications in restorative dentistry, can also be safely employed for 'all surface' bonding in orthodontics, thereby eliminating any need to stock an alternative material for this purpose. The versatility is an advantage of universal adhesives that is expected to be appreciated also by orthodontists, and no limitation to the routine use of such bonding agents in orthodontic practice can currently be seen.

Regarding ARI score evaluation, the observations were in line with the results of the bond strength tests. As expected, lower bond strengths were associated with lower amounts of adhesive retained on the substrate. A relevant finding was that in the totality of the specimens treated with the control adhesive, bond failure occurred at the interface between composite resin and substrate (Table 4), confirming that PMMA surfaces, if left untreated, offer poor conditions for bonding.

Mechanical pretreatment has traditionally been advised to increase bracket retention to polymer-based restorations, from composite fillings to provisional crowns.[2-8] The protocol for PMMA surface roughening followed in the present investigation was defined with reference to the only one study available in the literature on bonding resin composite to CAD/CAM PMMA.[19] In the study by Wiegand et al.[19] roughening simulating bur abrasion, air abrasion, and silica coating were assessed as the most common types of substrate pretreatment. Among them in the present investigation it was decided to perform roughening simulating bur abrasion as this method does not require any specific equipment. In the study by Wiegand et al.[19] surfaces were ground with a 40 μm diamond disc. In the present investigation 320-grit silicon carbide paper was utilized, which is considered to roughen the surface in a manner similar to that of a 40 μm fine-grit diamond bur. Nevertheless, it emerged from the collected data that higher bond strengths were obtained by roughening PMMA surfaces with an abrasive replicating a normal/medium-grit diamond bur (Table 5). Interestingly, the adhesion levels reached through roughening with the coarser abrasive were about the same as those obtained by pretreatment with the universal adhesives. As a clinical indication, it can therefore be inferred that the adhesion of orthodontic brackets to PMMA-based substrates can be equivalently enhanced by grinding with a normal/medium-grit diamond bur or by coating the intact surface with a universal adhesive, such as Scotchbond Universal Adhesive or Assure Plus.

The bond strength data corresponded well with the ARI scores. The surfaces roughened with the coarser abrasive retained various amounts of bonding material, while the specimens that were more finely abraded appeared free of any residual adhesive after debonding (Table 6). In this regard, it is also worth mentioning that, being provisional restorations designed for limited service, the possibility that grinding with a normal/medium-grit bur may affect the superficial aspect of the crown is not a clinically relevant concern. Even if the need to keep the provisional restoration beyond the end of orthodontic treatment should arise, the bur-roughened area previously covered by the bracket could easily be polished for improved esthetics.

CONCLUSION

Based on the results of this investigation, it can be concluded that the adhesion of orthodontic brackets to commercial PMMA-based CAD/CAM materials for temporary restorations can be enhanced to reach levels compatible with the clinical service by first grinding the substrate with a normal/medium-grit bur or by coating the intact surface with contemporary universal adhesives. The new CAD/CAM materials, which prosthodontists may prefer due to their favorable mechanical and esthetic properties, can therefore be safely used when the overall treatment strategy also involves an orthodontic phase with fixed appliances.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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