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COMPARISON OF HYDROPHILIC ORTHODONTIC ADHESIVES TO A CONVENTIONAL HYDROPHOBIC ADHESIVE IN WET AND DRY FIELDS: AN IN-VITRO STUDY

Mohamed Mostafa Elgharabawy[1], Walaa Elsayed Elgameay[2], Ahmed Basiouny Abdel-Aal[3], Ahmed Abdelfattah Ramdan[4]

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ARI, Bonding, Contamination, Hydrophilic, SBS.

• E-mail address: mohamed.mostafaa@must.edu.eg

1. Demonstrator at Orthodontic department, Faculty of Dentistry, Misr University for Science and Technology.
2. Associate professor of Orthodontics, Faculty of Dentistry, Suez Canal University.
3. Associate professor of Orthodontics, Faculty of Dentistry, Misr University for Science and Technology.
4. Professor of Orthodontics, Faculty of Dentistry, Suez Canal University.

ABSTRACT

Introduction: Bonding is a technique sensitive procedure that greatly affects the success of orthodontic treatment. Moisture contamination is regarded as the most common cause of bond failure. In this study a comparison was made between hydrophobic and hydrophilic adhesives in both dry and wet fields.

Aim: The objective of this investigation was to assess the impact of moisture contamination on SBS of hydrophilic adhesives in comparison to that of a conventional hydrophobic adhesive in dry and wet fields. **Materials and methods:** Sixty sound premolars were split into three equal groups. Group I was bonded using conventional adhesive (Contec LC), Group II was bonded using hydrophilic adhesive (Transbond Plus Color Change), and Group III was bonded with hydrophilic RMGI (Meron Plus AC). Based on the bonding field, each group was thereafter separated into two subgroups (wet or dry). After bonding, a universal testing equipment was used to assess the SBS. **Results:** Although saliva affected Contec LC more than it affected Transbond Plus Color Change or Meron Plus AC, this was not statistically significant (P= 0.228). **Conclusion:** Hydrophilic adhesives did not provide any significant advantages over conventional adhesives in either wet or dry fields.

INTRODUCTION

Bonding in orthodontics is a fundamental and challenging task that greatly influences the efficacy as well as the length of treatment. It is widely acknowledged that moisture contamination is the leading factor in bond failure [(1)]. One second or longer of saliva contamination on etched enamel leaves a coating of saliva on the surface of the enamel that is resistant to rinsing [(2)]. Contamination plugs most of the pores created in enamel by acid etching resulting in reduced bond strength [(3)]. Conventional composite resins, which are commonly used during orthodontic bonding, have a hydrophobic nature, so a completely dry field of operation is required during bracket bonding from start to finish. Moisture control may be difficult in certain situations, such as during bonding in in accessible areas such as the gingival areas, impacted teeth or in patients with increased salivation [(4)]. Bonding failure is common in these circumstances, necessitating rebonding consuming more time and effort. To address moisture, glass ionomer cements (GICs) were evaluated as bonding material during orthodontic treatment because of their ability to sustain moisture. The introduction of resin modified glass ionomer (RMGIC) took place soon after through the addition of resin component to the composition of GIC to obtain better bond strength [5]. Unfortunately, the shear bond strength (SBS) of RMGI was reduced in comparison to of conventional composite resin adhesives [6,7]. To address the reduced SBS of RMGICs and at the same time preserve their ability to bond brackets in a moist field, manufacturers have developed hydrophilic adhesives containing hydrophilic components such as hydroxyethyl methacrylate (HEMA), which enhances wetting of enamel by the bonding agent[8]. These materials improve the SBS on moisture contaminated enamel surfaces [4]. Various investigations have assessed the SBS of hydrophilic adhesives despite that, the results are controversial regarding the effectiveness of these hydrophilic adhesives. Therefore, this research was performed to determine the impact of moisture contamination on the SBS of hydrophilic adhesives in comparison to that of a conventional high viscosity adhesive in dry and wet fields.

MATERIALS AND METHODS

Sample size calculation

The size of the sample was identified based on the methodology outlined by Daniel (1999) [9] and Charan and Biswas (2013) [10] using the following equation:

$$N = \frac{(Z\alpha)^2 * (S)^2}{(d)^2} = \frac{(1.96)^2 * (7.90)^2}{(2)^2} = 59.94\ ^{2} \simeq 60$$

N represents the total sample size. Zα denotes the standard normal variate, which is equal to 1.96 when the significance level is set at $P < 0.05$. SD refers to the standard deviation of the variable, while d indicates the absolute error or precision.

Sample selection

Sixty extracted premolar teeth were collected based on the following criteria:

a. <u>**Inclusion criteria:**</u>

- Freshly extracted teeth.
- Premolars extracted for orthodontic purposes.
- Intact buccal enamel.
- Normal anatomy.

b. <u>**Exclusion criteria:**</u>

- Carious teeth.
- Attrited teeth.
- Defected enamel.
- Malformed teeth.

Sample grouping:

The teeth were categorized into three main groups in a random manner. The stratified randomization method was used to control the covariates of tooth number (1st or 2nd premolar) and tooth position (maxillary or mandibular). With these 2 covariates, possible block combinations total 4. Each tooth in block combinations was given a number. A simple randomization procedure (opaque numbered sealed envelopes) was used to equally allocate samples within each block to one of the treatment groups which were the following:

<u>Group I</u> was bonded using a high viscosity adhesive (Contec LC, Dentaurum, Ispringen, Germany).

<u>Group II</u> was bonded using a hydrophilic adhesive (Transbond Plus Color Change, 3M Unitek, Monrovia, CA, USA).

Group III was bonded using a hydrophilic self-adhesive resin-modified glass ionomer (Meron Plus AC, Voco, Cuxhaven, Germany).

Thereafter, each main group was subdivided into two equal subgroups:

Subgroup A: bonding was performed in a dry field.

Subgroup B: bonding was performed in a wet field.

Sample preparation:

The teeth underwent an extensive cleaning process using distilled water before being preserved in saline solution until bonding. All the teeth were mounted in a colour-coded dental stone.

Bonding

Bonding of Roth stainless-steel premolar brackets (Ortho Pro Dent LLC, Sarasota, FL, USA) was conducted adhered strictly to the guidelines provided by the manufacturer, which are as follows:

A. Dry field:

- Group I (Contec LC):

A 37% phosphoric acid (Contec LC) etching gel was used to treat enamel surfaces for a duration of 30 seconds then washed and dried, a uniform coat of Contec LC primer was rubbed against buccal surface and subsequently thinned using a stream of dry air. A small quantity of Contec LC paste was dispensed on the mesh of the bracket, which was set in place and firm pressure was applied on it to ensure proper fitting to the enamel surface. surplus adhesive was gently moved away before curing. The samples were then exposed to LED curing light for 20 seconds.

- Group II (Transbond Plus Color Change):

The Trans Plus Self-Etching Primer was rubbed against enamel surfaces of samples for 10 seconds and subsequently thinned using a stream of dry air. A small quantity of Transbond Plus Color Change adhesive paste was dispensed on the mesh of the bracket, which was set in place and firm pressure was applied on it to ensure proper fitting to the enamel surface. The surplus adhesive was moved away before curing. The samples were then exposed to LED curing light for 20 seconds.

Group III (Meron Plus AC):

Meron Plus AC capsules were mixed in the amalgamator (mixer) for 10 seconds. A little quantity of Meron Plus AC was dispensed on the bracket mesh, which was set in place and firm pressure was applied on it to ensure proper fitting to the enamel surface. The surplus adhesive was moved away before hardening.

B. Wet field:

The same procedures as in the dry field but with contamination applied before bonding. Artificial saliva was rubbed against the enamel surfaces for 10 seconds.

Evaluation methods:

A. Evaluation of SBS:

Samples were kept at room temperature for 24 hours then SBS was evaluated using an Instron universal testing machine (Fig. 1). An evaluation of SBS was conducted at a crosshead speed of 1 mm/min, and the results were calculated and recorded utilizing computer software. SBS was quantified in MPa.

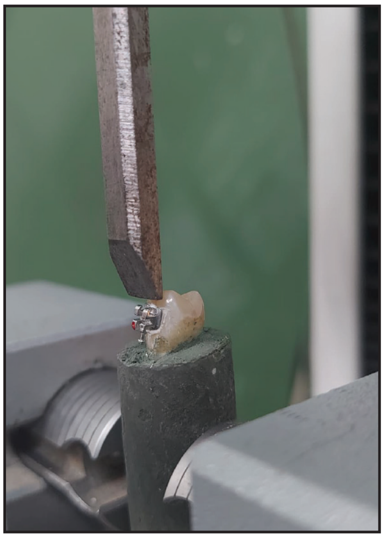

Fig. (1) Evaluation of the shear bond strength

B. Evaluation of the adhesive remnant index (ARI):

Following adhesive failure, no attempt was made to remove any adhesive remnants. Inspection of the enamel surfaces was conducted with a stereomicroscope set to 10X magnification. Excess resin outside bracket bases was not investigated. The evaluation of the adhesive residues was conducted using the ARI, as outlined by Årtun and Bergland (1984) [11].

RESULTS

Table 1 shows the mean SBS in each subgroup in MPa. The conventional hydrophobic adhesive (Contec LC) exhibited the greatest SBS in the dry field. Conversely, the analysis revealed no statistically significant differences in SBS among the various adhesives in the wet field (P = 0.228), nor between the dry and wet fields for each adhesive. Table 2 indicates the ARI among the subgroups, variations observed was statically non-significant (P = 0.0527).

Table (1) *SBS of different groups in dry and wet fields*.

Group	Field (Subgroup)	Mean (MPa)	SD	Mean difference	T test	P value
I. Contec LC	(A) Dry field	15.37	4.94	2.31	0.946	0.357 ns
	(B) Wet field	13.06	5.91			
II. Transbond Plus Color Change	(A) Dry field	12.27	6.69	4.58	1.66	0.113 ns
	(B) Wet field	16.85	5.54			
III. Meron Plus AC	(A) Dry field	9.11	3.29	3.52	1.596	0.128 ns
	(B) Wet field	12.63	6.14			

Test used: independent sample T test at P<0.05. *ns: means no-significant difference*

Table (2) *Frequencies of ARIs for different groups in dry and wet fields.*

Group	Subgroup	n	ARI score				Chi square (χ^2)	P value
			0	1	2	3		
Contec LC	A. Dry	10	0 (0%)	9 (90%)	1 (10%)	0 (0%)	1.052	0.3049 ns
	B. Wet	10	0 (0%)	10 (100%)	0 (0%)	0 (0%)		
Transbond Plus Color Change	A. Dry	10	0 (0%)	6 (60%)	3 (30%)	1 (10%)	3.0909	0.3778 ns
	B. Wet	10	2 (20%)	5 (50%)	3 (30%)	0 (0%)		
Meron Plus AC	A. Dry	10	0 (0%)	9 (90%)	1 (10%)	0 (0%)	1.052	0.3049 ns
	B. Wet	10	0 (0%)	10 (100%)	0 (0%)	0 (0%)		
Chi square (χ^2)	24.79							
P value	0.0527 ns							

**ns=nonsignificant*

DISCUSSION

As our findings indicate, the differences in the SBS of Contec LC adhesive between dry and wet fields was not statistically significant. These results agree with that found by **Kumar *et al.*** (12), as their results revealed no significant differences in the SBS of hydrophobic adhesives among dry and wet conditions. Conversely, research conducted by **Rossouw et al.** (13), **Santos *et al.*** (4), **Robaski *et al.*** (14), and **Shaik *et al.*** (15) demonstrated that contamination by saliva had a detrimental effect on SBS of conventional adhesives. The variations in findings can be attributed to the specific adhesives employed in those studies compared to the Contec LC adhesive used in this research. Although Contec LC is hydrophobic in nature, it is free of BisGMA and TEGDMA, which necessitate a completely dry field for effective bonding because of their hydrophobic characteristics (12). The SBS of the Transbond Plus Color Change adhesive did not exhibit a statistically significant difference when comparing dry and wet fields. These findings are consistent with the research conducted by **Santos *et al.*** (4), **Robaski *et al.*** (14), and **Primo *et al.*** (16), but they contradict the findings obtained by **Shaik *et al.*** (15) and **Rameez *et al.*** (17), who concluded that SBS of Transbond Plus Color Change adhesive in dry field was significantly greater than that of adhesives exposed to contamination before bonding. Variations in contamination protocols, including the application of either artificial or human saliva, the extent of salivary contamination, and the specific primer utilized, may account for the observed differences. Effective bonding created by the Transbond Plus Color Change adhesive in wet field could be attributed to the hydrophilicity of the adhesive and application of its corresponding self-etching primer. This explanation agrees with those of **Zeppieri *et al.*** (18) and **Kapoor *et al.*** (19), who found that salivary contamination did not affect SBS of self-etching primers when they were utilized with a conventional adhesive. The difference in the SBS of Meron Plus AC between dry and wet fields was statistically non-significant. The conclusions drawn are in line with the work of **Jobalia *et al.***[20], **Shammaa *et al.***[7] and **Evangelina *et al.*** [21], who reported that moisture did not influence SBS of RMGI. Furthermore, it is noted that moisture is essential for achieving optimal adhesion of GIC to the dental substrate.

No statistically significant differences in SBS were found between the conventional hydrophobic adhesive (Contec LC) and the hydrophilic adhesive (Transbond Plus Color Change). These findings agree with that found by **Santos *et al.*** [4], **Robaski *et al.***[14] and **Primo *et al.***[16]. However, these findings contrast with those of **Shaik et *al.*** [15], who reported that the Transbond Plus hydrophilic adhesive had better SBS than the Transbond XT conventional adhesive in a dry field. This may be due to differences in the conventional adhesive used or the etching time. Differences observed in SBS between the hydrophilic adhesive (Transbond plus Color Change) and RMGI (Meron Plus AC) in the dry field was statistically non-significant. This aligns with the conclusions drawn by **Bishara *et al.*** [22]. The SBS of the conventional hydrophobic adhesive (Contec LC) was greater than that of RMGI (Meron Plus AC). This observation aligns with the research conducted by **Shammaa *et al.*** [7], **Marković *et al.*** [23] and **Knaup *et al.*** [24], which indicated that the SBS of conventional resins was better than that of RMGI in dry fields. However, these findings contrast with those of **Jobalia *et al.*** [20] **and Komori and Ishikawa** [25], who found comparable bond strength between RMGI and conventional adhesives in a dry field. This may be due to the different adhesives used. Differences in SBS among the three groups in the wet field were statistically non-significant. This agrees with **Santos *et al.*** [4], who reported no significant differences between conventional hydrophobic adhesive and hydrophilic adhesive (Transbond Plus Color Change) in wet field. However, the results contrasted with that obtained by **Robaski *et al.*** [14] and **Shaik *et al.*** [15], who concluded that the Transbond Plus hydrophilic adhesive provided a higher SBS than the Transbond XT conventional adhesive in wet conditions. Such differences may arise from variations in experimental design, including the type of conventional adhesive, etching time, utilization of either artificial or natural saliva, and the level of salivary contamination. **Shammaa *et al.*** [7] found that the conventional adhesives had higher SBS than RMGI in wet fields, contrary to our results. This could be due to the different adhesives used in their study. Findings from the current research indicate that each of the three adhesives tested achieved SBS that is considered clinically acceptable according to the optimal bond strength determined by **Rossouw** [13], **Su *et al.*** [26] and **Hellak *et al.*** [27], so they can be used safely for orthodontic bonding under either dry or wet conditions.

This study revealed greater cohesive failure than adhesive failure, with most of the failed brackets falling under an ARI of 1. Although the Transbond Plus color change showed different scores from those of Contec LC and Meron Plus with more adhesive remnants on teeth surfaces, The analysis revealed no statistically significant differences among the different adhesives used under either condition (dry or wet). These findings are consistent with the research conducted by **Bishara *et al.*** [22], which indicated similar ARIs for both Transbond Plus Color Change and resin-modified glass ionomers. Furthermore, the outcomes are in agreement with the observations documented by **Knaup *et al.*** [24], who revealed similar ARIs between Meron Plus AC and conventional adhesive, noting that a majority of the adhesive remained on the bracket bases. Additionally, no statistically significant difference was found in the ARI between the subgroups in each group. The findings are consistent with the research conducted by **Shammaa *et al.*** [7], whose results demonstrated that the ARI of RMGI did not show any significant variation between dry and wet conditions and the majority of the adhesive material was retained on the mesh of the bracket.

CONCLUSIONS

From the obtained results, the impact of moisture on the SBS of different adhesives used and the ARI after bond failure can be summarized as follows:

1. Regarding the effect on SBS:

- The conventional hydrophobic adhesive (Contec LC) had the highest SBS in the dry field.
- No statistically significant variation in SBS was seen among the various adhesives utilised in the wet field.
- No statistically significant variation in SBS was seen between dry and wet fields for each adhesive.

2. Regarding the ARI:

- No statistically significant variation in the ARI was seen between the different adhesives used in this study in either field.
- No statistically significant variation in the ARI was seen between dry and wet fields for each adhesive.

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