CHAPTER IV

RESULTS

The results of this study are presented in two parts as follows:

1. Shear bond strengths
2. Failure modes

Failure modes are described as follows: the failure sites and the amount of residual adhesives on debonded enamel surfaces

1. Shear bond strengths

Shear bond strengths of three self-etching (Xeno® III, ED PRIMER® and AdheSE®) and one conventional phosphoric acid etching adhesive systems are presented as follows:

1.1 Determination of the shear bond strengths

Shear bond strengths of three self-etching (Xeno® III, ED PRIMER® and AdheSE®) and one conventional phosphoric acid etching adhesive systems were described by means, standard deviations and minimum to maximum values which are shown in table 4.1. The amounts of shear bond strengths were recorded in MegaPascals (MPa) which was recommended by Fox *et al*. (1994).

Table 4.1 Means, standard deviations and minimum to maximum values of shear bond strength at the point of bond failure of three self-etching (Xeno® III, ED PRIMER® and AdheSE®) and one conventional phosphoric acid etching adhesive systems

Adhesives	Number	Shear bond strength (MPa)		
		Mean	Standard deviation	Min.-Max.
37% H_3PO_4	32	9.45	2.97	3.79-15.31
Xeno® III	32	1.48	1.39	0.01-5.37
ED PRIMER®	32	3.98	2.50	0.05-9.83
AdheSE®	32	1.74	1.66	0.01-5.60

The means and standard deviations of shear bond strengths of three self-etching (Xeno® III, ED PRIMER® and AdheSE®) and one conventional phosphoric acid etching adhesive systems were 1.48 ± 1.39, 3.98 ± 2.50, 1.74 ± 1.66 and 9.45 ± 2.97 Mpa respectively.

1.2 Comparison of the shear bond strengths

The first hypothesis of this study was “there is no statistically significant difference in bond strengths among three self etching and one conventional phosphoric acid etching adhesive systems in orthodontic bracket placement”.

From a one way analysis of variance (ANOVA) which is shown in table 4.2, there was a statistically significant difference in shear bond strengths among three self-etching (Xeno® III, ED PRIMER® and AdheSE®) and one conventional phosphoric acid etching adhesive systems ($F=88.848$, $p<0.001$).

Table 4.2 Comparison of mean shear bond strengths among three self-etching (Xeno® III, ED PRIMER® and AdheSE®) and one conventional phosphoric acid etching adhesive systems using one way analysis of variance (ANOVA)

Adhesives	Mean shear bond strengths (MPa)	F	P-value
37% H_3PO_4	9.45	88.848	<0.001
Xeno® III	1.48		
ED PRIMER®	3.98		
AdheSE®	1.74		

A multiple comparisons test (Tukey's test), whose results are shown in table 4.3, indicated that the conventional phosphoric acid etching adhesive system had significantly greater bond strengths than three self-etching adhesive systems ($p<0.001$). The self-etching adhesive system, ED PRIMER®, had significantly greater bond strengths than Xeno® III and AdheSE® ($p<0.001$ and $p=0.001$ respectively). The self-etching adhesive system, AdheSE® had greater bond strengths than Xeno® III. However; the difference was not significant ($p=0.969$).

Table 4.3 Statistical comparison (p-value) of mean shear bond strengths among three self-etching (Xeno® III, ED PRIMER® and AdheSE®) and one conventional phosphoric acid etching adhesive systems using the multiple comparisons test (Tukey's test)

Adhesives	Adhesives	P-value
37% H_3PO_4 (9.45)	Xeno® III (1.48)	<0.001
	ED PRIMER® (3.98)	<0.001
	AdheSE® (1.74)	<0.001
ED PRIMER® (3.98)	Xeno® III (1.48)	<0.001
	AdheSE® (1.74)	0.001
AdheSE® (1.74)	Xeno® III (1.48)	0.969

2. Failure modes

Failure modes of three self-etching (Xeno® III, ED PRIMER® and AdheSE®) and one conventional phosphoric acid etching adhesive systems are presented in two parts as follows:

2.1 Failure sites

Failure sites are described as follows:

2.1.1 Determination of the numbers and percentages of the failure sites

Failure sites were divided into five locations according to Alexander (1993) and Jou, *et al*. (1995) as follows: within enamel, at the adhesive/enamel interface, within the adhesive, at the adhesive/bracket interface and within the bracket. The numbers and percentages (in parenthesis) of failure sites of three self-etching (Xeno® III, ED PRIMER® and AdheSE®) and one conventional phosphoric acid etching adhesive systems are shown in table 4.4:

Table 4.4 The numbers and percentages of failure sites of three self-etching (Xeno® III, ED PRIMER® and AdheSE®) and one conventional phosphoric acid etching adhesive systems

Adhesives	Failure sites				
	within enamel	adhesive/ enamel interface	within adhesive	adhesive/ bracket interface	within bracket
37%H_3PO_4	0 (0%)	17 (53.1%)	9 (28.1%)	6 (18.8%)	0 (0%)
Xeno® III	0 (0%)	30 (93.8%)	0 (0%)	2 (6.2%)	0 (0%)
ED PRIMER®	0 (0%)	18 (56.2%)	11 (34.4%)	3 (9.4%)	0 (0%)
AdheSE®	0 (0%)	25 (78.1%)	6 (18.8%)	1 (3.1%)	0 (0%)

The failure sites of three self-etching (Xeno® III, ED PRIMER® and AdheSE®) and one conventional phosphoric acid etching adhesive systems were mostly found at the adhesive/enamel interface, but were not found within enamel or within the bracket.

The percentages of failure sites at the adhesive/enamel interface of three self-etching (Xeno® III, ED PRIMER® and AdheSE®) and one conventional phosphoric acid etching adhesive systems were 93.8, 56.2, 78.1 and 53.1 respectively.

The percentages of failure sites within the adhesive of three self-etching (Xeno® III, ED PRIMER® and AdheSE®) and one conventional phosphoric acid etching adhesive systems were 0, 34.4, 18.8 and 28.1 respectively.

The percentages of failure sites at the adhesive/bracket interface of three self-etching (Xeno® III, ED PRIMER® and AdheSE®) and one conventional phosphoric acid etching adhesive systems were 6.2, 9.4, 3.1 and 18.8 respectively.

2.1.2 Comparison of the percentages of the failure sites

The second hypothesis of this study was “there is no statistically significant difference in the failure modes (failure sites) among three self etching and one conventional phosphoric acid etching adhesive systems in orthodontic bracket placement”.

From the Pearson Chi-square test, whose results are shown in table 4.5, there was a statistically significant difference in the percentages of failure sites at the adhesive/enamel interface among three self-etching (Xeno® III, ED PRIMER® and AdheSE®) and one conventional phosphoric acid etching adhesive systems ($p<0.001$).

Table 4.5 Comparison of the percentages of failure sites at the adhesive/enamel interface among three self-etching (Xeno® III, ED PRIMER® and AdheSE®) and one conventional phosphoric acid etching adhesive systems using the Pearson Chi-square test

Adhesives	percentages of failure sites at adhesive/enamel interface (%)	Chi-square	df	p-value
37%H_3PO_4	53.1	16.94	3	<0.001
Xeno® III	93.8			
ED PRIMER ®	56.2			
AdheSE®	78.1			

The Z-test whose results are shown in table 4.6, indicated that Xeno® III had significantly greater percentages than the conventional phosphoric acid adhesive system and ED PRIMER® at $p<0.001$ and $p=0.001$ respectively. Xeno® III had greater percentages than AdheSE®. However; the difference was not significant ($p=0.148$). In addition, there were no significant differences in percentages of failure sites at the adhesive/enamel interface among two self-etching (ED PRIMER®, AdheSE®) and the conventional phosphoric acid adhesive systems.

Table 4.6 Statistical comparison (p-value) of the percentages of failure sites at the adhesive/enamel interface among three self-etching (Xeno® III, Ed PRIMER® and AdheSE®) and one conventional phosphoric acid etching adhesive systems using the Z-test

Adhesives	Adhesives	P-value
37%H_3PO_4 (53.1)	Xeno® III (93.8)	<0.001
	ED PRIMER® (56.2)	0.995
	AdheSE® (78.1)	0.065
Xeno® III (93.8)	ED PRIMER® (56.2)	0.001
	AdheSE® (78.1)	0.148
ED Primer® (56.3)	AdheSE® (78.1)	0.111

From the Pearson Chi-square test whose results are shown in table 4.7, there was a significant difference in percentages of failure sites within the adhesive among three self-etching (Xeno® III, ED PRIMER® and AdheSE®) and one conventional phosphoric acid etching adhesive systems (p= 0.003).

Table 4.7 Comparison of the percentages of failure sites within the adhesive among three self-etching (Xeno® III, ED PRIMER® and AdheSE®) and one conventional phosphoric acid etching adhesive systems using the Pearson Chi-square test

Adhesives	percentages of failure sites within adhesive (%)	Chi-square	df	P-value
37%H_3PO_4	28.1	13.32	3	0.003
Xeno® III	0			
ED PRIMER®	34.4			
AdheSE®	18.8			

The Z-test whose results are shown in table 4.8, indicated that the conventional phosphoric acid adhesive system, ED PRIMER® and AdheSE® had significantly

greater percentages of failure sites within the adhesive than Xeno® III at p=0.004, p<0.001 and p=0.032 respectively. In addition, there were no significant differences in percentages of failure sites within the adhesive among two self-etching (ED PRIMER®, AdheSE®) and the conventional phosphoric acid adhesive systems.

Table 4.8 Statistical comparison (p-value) of percentages of failure sites within the adhesive among three self-etching (Xeno® III, ED PRIMER® and AdheSE®) and one conventional phosphoric acid etching adhesive systems using the Z-test

Adhesives	Adhesives	P-value
37%H_3PO_4 (28.1)	Xeno® III (0)	0.004
	ED PRIMER® (34.4)	0.784
	AdheSE® (18.8)	0.560
Xeno® III (0)	ED PRIMER® (34.4)	<0.001
	AdheSE® (18.8)	0.032
ED PRIMER® (34.4)	AdheSE® (18.8)	0.259

2.2 Amount of residual adhesives on the debonded enamel surface

Amount of residual adhesives on the debonded enamel surface are described as follows:

2.2.1 Determination of the amount of residual adhesives on the debonded enamel surface

The amount of residual adhesives on the debonded enamel surface resulting from three self-etching (Xeno® III, ED PRIMER® and AdheSE®) and one conventional phosphoric acid adhesive systems were described by mean ranks which are shown in table 4.9.

Table 4.9 Mean Ranks of the amount of residual adhesives on the debonded enamel surfaces resulting from three self-etching (Xeno® III, ED PRIMER® and AdheSE®) and one conventional phosphoric acid adhesive systems

Adhesives	Number	Mean Ranks
37%H_3PO_4	32	84.89
Xeno® III	32	41.33
ED PRIMER®	32	78.09
AdheSE®	32	53.69

The mean ranks of residual adhesives on the debonded enamel surface resulting from three self-etching (Xeno® III, ED PRIMER® and AdheSE®) and one conventional phosphoric acid etching adhesive systems were 41.33, 78.09, 53.69 and 84.89 respectively.

2.2.2 Comparison of the amount of residual adhesives on the debonded enamel surface

The second hypothesis of this study was “there is no statistically significant difference in the failure modes (amount of residual adhesives on the debonded enamel surface) among three self etching and one conventional phosphoric acid etching adhesive systems in orthodontic bracket placement”.

From the Kruskal-Wallis test whose results are shown in table 4.10, there was a statistically significant difference in the amount of residual adhesives on debonded enamel surfaces among three self-etching (Xeno® III, ED PRIMER® and AdheSE®) and one conventional phosphoric acid etching adhesive systems ($p< 0.001$).

Table 4.10 Comparison of mean ranks of the amounts of residual adhesives on the de-bonded enamel surfaces among three self-etching (Xeno® III, ED PRIMER® and AdheSE®) and one conventional phosphoric acid etching adhesive systems using the Kruskal-Wallis test

Adhesives	Mean Ranks	Chi-Square	df	P-value
37%H_3PO_4	84.89	29.175	3	<0.001
Xeno® III	41.33			
ED PRIMER ®	78.09			
AdheSE®	53.69			

The Mann-Whitney Test whose results are shown in table 4.11, indicated that the conventional phosphoric acid adhesive system had significantly greater amounts of residual adhesives on deboned enamel surfaces than Xeno® III and AdheSE® at p<0.001 and p=0.001 respectively. The conventional phosphoric acid adhesive system had greater amounts of residual adhesives on debonded enamel surfaces than ED PRIMER®. However; the difference was not significant (p=0.372). The self-etching adhesive system, ED PRIMER ®, had significantly greater amounts of residual adhesives on debonded enamel surfaces than Xeno® III and AdheSE® at p<0.001 and p=0.008 respectively. The self-etching adhesive system, AdheSE® had greater amounts of residual adhesives on debonded enamel surface than Xeno® III. However; the difference was not significant (p=0.159).

Table 4.11 Statistical comparison (p-value) of the mean ranks of the amounts of residual adhesives on the debonded enamel surfaces among three self-etching (Xeno® III, ED PRIMER® and AdheSE®) and one conventional phosphoric acid etching adhesive systems using the Mann-Whitney Test

Adhesives	Adhesives	P-value
Phosphoric acid (84.89)	Xeno® III (41.33)	<0.001
	ED PRIMER® (78.09)	0.372
	AdheSE® (53.69)	0.001
Xeno® III (41.33)	ED PRIMER® (78.09)	<0.001
	AdheSE® (53.69)	0.159
ED PRIMER® (78.09)	AdheSE® (53.69)	0.008