

# Comparative Evaluation of Shear Bond Strength of Metal Brackets Etched with Conventional Etchant and Self-Etching Primer on Fluorotic Teeth– an in Vitro Study

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## Abstract

**Background:** Adequate shear bond strength between the brackets and the tooth surface plays a vital role in achieving the desired result in orthodontic treatment. Numerous studies have been done to compare the shear bond strength between brackets and teeth when etched by conventional etchant and self-etch primer, but studies on fluorotic enamel are limited. Thus, this study aimed to do a comparative evaluation of the shear bond strength of metal brackets on fluorotic teeth, which were etched using conventional etchant and self-etching primer. **Material and Methods:** The study was done on 34 extracted premolars with intact surfaces and a TFI score of 3 or 4. The teeth were divided into two groups, namely, the conventional etchant (CE) group and the self-etch primer (SEP) group. Metal brackets were bonded to the teeth in each group following the manufacturer's instructions for each bonding system. The samples in each group underwent a shear bond strength test on a universal testing machine. **Results:** There is no statistically significant difference in the shear bond strength of the CE or SEP groups ( $p$ -value=0.711). The mean Shear bond strength in the CE and SEP groups was 9.8 MPa and 9.41 MPa, respectively. Both are within the clinically acceptable range for shear bond strength. **Conclusion:** The shear bond strength achieved in the conventionally etched group and the self-etching primer group is comparable. A clinical study with a larger sample size needs to be carried out on fluorosed teeth to support the above results.

**Keywords:** Shear bond strength, Conventional etchant, Self-etch primer, Fluorosed teeth.

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## INTRODUCTION

The field of orthodontics has evolved tremendously over the last century. The most common and widely accepted type of orthodontic treatment is a fixed orthodontic appliance, popularly known as dental braces. In a fixed orthodontic appliance, brackets are bonded to the tooth surface and serve as attachments for arch wires, which apply light force on the teeth to bring about their orthodontic movement. The conventional bonding system has three components: an etchant, a primer, and the adhesive. They come in individual bottles and are applied one after the other. Orthophosphoric acid is the most widely accepted agent for conditioning enamel for bonding procedures. Its use is not limited to orthodontics alone; it was first introduced to dentistry in 1955 by Buonocore.<sup>[1]</sup> Initially, it was used at a concentration of 85% but over the years, manufacturers have reduced the concentration to less than half, as studies have proven that a concentration of 30–40% is not only safer but also produces higher bond strengths.<sup>[2,3]</sup> The acid demineralizes enamel at varying rates, creating microporosities and uneven surface topography, allowing for the strong micromechanical adhesion.<sup>[4]</sup> Primers are substances designed to enhance the substrate's readiness to accept a bond. The adhesive is an unfilled and lightly filled resin akin to composites. The newer bonding systems combine the conditioning and priming agents into a single acidic primer solution for simultaneous use on both enamel

and dentin.<sup>[5]</sup> The reduction in the number of steps has proven to be time and cost-effective to the clinician and indirectly to the patient.

The time and cost effectiveness cannot be the only factors determining the use of a particular type of bonding system. Shear bond strength (SBS) plays an important role in the adherence of brackets to the tooth surface. It is defined as the maximum force an adhesive can bear before the bracket debonds from the tooth surface.<sup>[6]</sup> SBS should be high enough to prevent debonding of the brackets during the course of treatment and low enough to cause minimal damage to the enamel surface during bracket removal. An adequate SBS of  $7.1 \pm 4.4$  MPa is recommended.<sup>[7]</sup>

The SBS largely depends on the surface characteristics of enamel, so much so that structural infarctions like fluorosis directly affect the adhesion of brackets. There has been an

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increase in the global prevalence of fluorosis, especially the mild and moderate forms.<sup>[8]</sup> The surface of fluorosed enamel is hypermineralised, but the subsurface below is hypomineralised; this makes it difficult to get a uniformly etched surface. Studies have revealed instances of debonding soon after the bracket is positioned and subjected to stress.<sup>[9]</sup> Frequent debonding in such cases can act as a detriment to the timely completion of treatment.

Thus, this study was conducted to evaluate the difference in the shear bond strength of metal brackets and fluorotic teeth when etched by a conventional etchant or a self-etching primer.

## MATERIALS AND METHODS

This study was conducted to compare the Shear Bond Strength between metal brackets and fluorotic teeth etched by conventional etchant and self-etch primer.

**Study setting:** The study was conducted in the Department of Oral Surgery, Department of Orthodontics at a tertiary dental healthcare centre and the Bio-Medical Technology Wing of a central research institute in India.

**Study design:** The study conducted was an in vitro experimental study.

The ethical clearance was obtained, and the approval number was DCT/IEC/SS/24/58 dated 02/05/2024.

**Sample Size Calculation:** The minimum sample size for each group was calculated by using the formula

$$n = \frac{2 \left( Z_{1-\alpha/2} + Z_{1-\beta} \right)^2 \sigma^2}{d^2}$$

The average standard deviation for the groups is expected to be 2.72, and the expected difference between the means is set at 2.71; therefore

$$n = \frac{2(1.96 + 0.842)^2 2.72^2}{2.71^2}$$

n = 17

Therefore, the number of samples in each group = 17

The study population consisted of 34 freshly extracted fluorotic teeth with intact enamel. The fluorotic teeth were selected according to the Thylstrup-Fejerskov Index (TFI), which is based on clinical changes in the fluorotic teeth. Teeth with a TFI score of three and above were selected. Teeth with a history of endodontic, prosthodontic, or orthodontic treatment, those with cracks on the enamel surface developed during extraction and teeth with structural and developmental anomalies were excluded.

Teeth were collected over a period of 2 months and stored in distilled water. This was done to avoid the influence of storage media on the bond strength, as reported by a few studies. For preparation for bonding, teeth were cleaned of all soft tissue remnants and polished with pumice paste applied by a rubber cup on a slow-speed handpiece (NSK Contra Angle Handpiece, 3000-6000 rpm) for ten seconds. After polishing, they were rinsed with water and then dried with a moisture and oil-free air stream.

The sample was divided into two groups of 17 teeth each. One group was named Conventional Etchant (CE) group,

and the other was named Self-etching Primer (SEP) group. All the teeth were embedded in acrylic blocks measuring 4mmx3mm. This was done to ensure stability of the samples. The teeth were positioned in such a way that the buccal surfaces were parallel to the force modeling direction of the universal testing machine.

In the CE group, 17 teeth were etched with 37% phosphoric acid (3M Scotchbond Multi-Purpose Etchant Gel) for 30 seconds, rinsed and air-dried. A thin layer of Transbond XT primer (3M Unitek) was applied to the enamel surface and light-cured for 10s. Identical MBT prescription 0.022 slot metal brackets were bonded onto the buccal surface of teeth with Transbond XT (3M Unitek), a light-cured composite adhesive. Before curing, the excess resin material was removed with a sharp probe without disturbing the bracket position. The adhesive will be light-cured for a total of 40 seconds. In the SEP group, 17 teeth were etched and primed using self-etching primer, Transbond Plus SEP (3M Unitek), which contains both the acid and the primer. It is applied on the enamel surface of the teeth and gently evaporated with air. Identical MBT prescription 0.022 slot metal brackets were bonded using Transbond XT adhesive (3M Unitek) and light-cured for 40s, in the same manner as in the conventional group. All samples were kept immersed in an isotonic solution for one hour till the resin was completely polymerised. [Table 1, Figure 1]

The samples were subjected to Shear Bond Strength test on Instron Universal Testing Machine (model 3345). The standard U-shaped loops were bent from 0.36 mm diameter orthodontic archwire (3M Unitek Permachrome Resilient .014inches archwire) and adjusted to the machine. These loops were fixed to the brackets with ligatures. The bond strength was determined in the shear mode at a cross-head speed of 1 mm/min until fracture occurred. The value of failure loads (N) was recorded and converted into stress in mega pascals (MPa) by dividing the failure load (N) by the surface area of the bracket base (9.63 mm<sup>2</sup>).

**Statistical Analysis:** Data obtained was entered in Microsoft Excel and analyzed using SPSS version 20.0 (IBM SPSS Statistics 20). Categorical and quantitative variables will be expressed as frequency (percentage) and mean  $\pm$  SD, respectively. The difference between the two groups on shear bonding strength was assessed via independent sample t-test. A significance value of 5% (0.005) was considered statistically significant.

## RESULTS

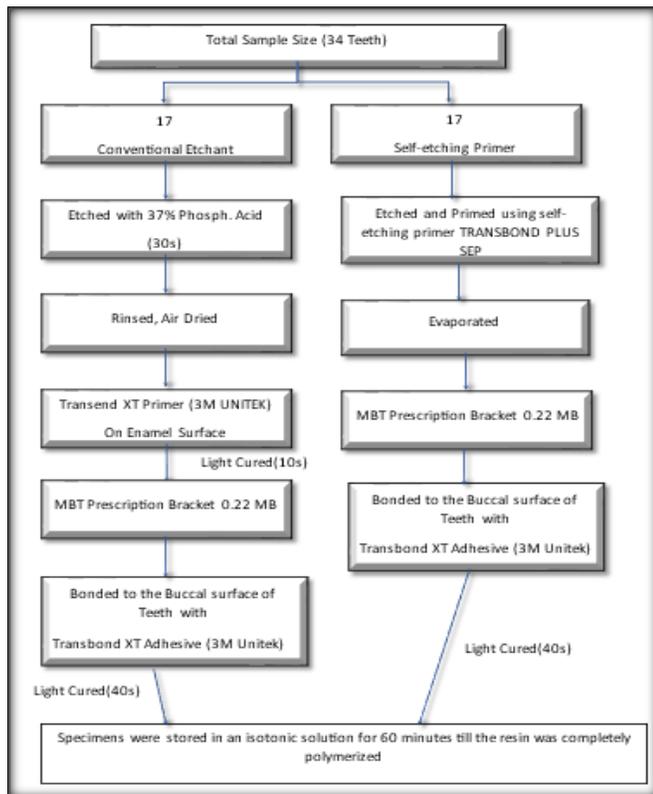
The summarized result is described in Table II. The mean shear bond strength in both groups is well above the acceptable range (7.1 $\pm$ 4.4MPa) [Figure 2]. The P-value is the key indicator of statistical significance. A value greater than 0.05 (common threshold) means the difference between groups is likely due to random chance. All three P-values (0.711, 0.711, and 0.521) are above 0.05. There is no evidence of a statistically significant difference in performance between group CE and group SEP for any of the strength metrics tested.

**Table 1: Components used in the two groups.**

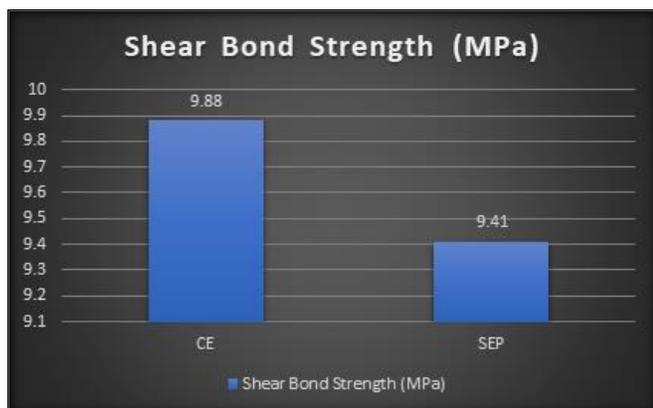
|          | Conventional Etchant(CE) group           | Self-etching Primer (SEP) Group          |
|----------|--|--|
| ETCHANT  | Phosphoric acid(37%)                     | Transbond Plus SEP                       |
| PRIMER   | Transbond XT Primer                      |  |
| ADHESIVE | Transbond XT                             | Transbond XT                             |
| BRACKETS | MBT prescription 0.22 slot metal bracket | MBT prescription 0.22 slot metal bracket |

**Table 2: Summarised table showing findings in the study.**

| Measurement               | Group | Number of Samples (N) | Average (Mean) | Standard Deviation (SD) | P-Value |
|---------------------------|-------|-----------------------|----------------|-------------------------|---------|
| Maximum Load (N)          | CE    | 17                    | 120.97 N       | 31.04                   | 0.711   |
|                           | SEP   | 17                    | 115.29 N       | 55.19                   |         |
| Shear Bond Strength (MPa) | CE    | 17                    | 9.88 MPa       | 2.53                    | 0.711   |
|                           | SEP   | 17                    | 9.41 MPa       | 4.51                    |         |
| Load at Break (N)         | CE    | 17                    | 114.79 N       | 33.29                   | 0.521   |
|                           | SEP   | 17                    | 104.40         | 57.96                   |         |



**Figure 1: Steps followed in the bonding process of the two groups.**



**Figure 2: Bar graph showing mean shear bond strength in both groups.**

## DISCUSSION

Numerous in vitro studies have been done to determine the most effective method for bonding brackets to the enamel surface. There are multiple steps involved in orthodontic bonding. In the present study, the pre-bonding steps followed are universally accepted and have proven to produce a clinically acceptable bond strength.

The present study revealed no statistically significant difference in the shear bond strength of metal brackets bonded to fluorotic teeth etched by a conventional etchant or by a self-etch primer. The literature review shows that studies have shown ambiguous results. According to the findings of a study by Fritz et al, there was a significant difference in the SBS of conventionally etched enamel and that etched by a self-etching primer.<sup>[10]</sup> In their study, the SEP group had the least bond strength. Bishara et al in their study reported similar findings; the bond strength of the SEP group was lower than the CE group, but it was within the clinically acceptable range.<sup>[11]</sup> In contrast to the studies mentioned above, a study done by Holzmier et al showed no significant differences between the SBSs of various bonding systems.<sup>[12]</sup> A.R. Yazici and J.C Dormanay also established that the bond strength of ground and unground enamel was similar with one-step self-etch adhesives and their predecessors.<sup>[13,14]</sup>

An in vivo, randomized, cross-mouth clinical trial by A.J Ireland and his colleagues suggests that enamel pretreatment with the Transbond Plus Self-Etching Primer system before orthodontic bonding is likely to result in a higher bond failure rate than conventional enamel acid etching and priming.<sup>[15]</sup> According to a long-term clinical trial by Phil Banks, there was no difference in the failure rates of brackets bonded with either Transbond Plus SEP or conventional AE using Transbond XT paste; the only advantage was that bonding with SEP was significantly faster than conventional AE.<sup>[16]</sup>

The sample in our study was composed exclusively of fluorosed teeth. Ng'ang'a et al have reported that there were no differences between SBS of brackets to fluorosed or non-fluorosed enamel.<sup>[17]</sup> On the other hand, Adanir et al found that the severity of fluorosis affected the SBS of an etch and rinse bonding system to fluorosed enamel.<sup>[18]</sup> Teeth with TFI score of 4 and higher need longer etching time due to the presence of a hypermineralised surface.<sup>[19]</sup> Our findings were in contrast to the findings of A.Y. Gungor et al, who concluded that when the standard etching protocol was used, enamel fluorosis significantly decreased the bond strength of orthodontic

brackets. Satisfactory bond strengths were obtained when SEP was used for bonding brackets to the fluorosed teeth.<sup>[20]</sup> After careful perusal of the available literature, the discrepancy in the findings of the present study can be attributed to the sample composed exclusively of fluorosed teeth. The sample size is too small to satisfactorily evaluate the efficiency of the two bonding systems. Moreover, it is difficult to simulate the oral environment in an in vitro study. Hence, clinical studies with a larger sample size should be conducted in patients with dental fluorosis to substantiate the results of this study correctly.

## CONCLUSION

To conclude this study reiterates that there is no statistically significant difference in the shear bond strength of metal brackets when pre-bonding was done using either conventional etchant or self-etch primer system. The shear bond strength achieved in both groups was above the acceptable range, despite the bonding being done on fluorosed enamel. A clinical trial incorporating a larger sample needs to be done to support these findings.

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## Conflicts of interest

There are no conflicts of interest.

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