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Evaluation of Shear Bond Strength of Different Concentrations Floriated Phosphoric Acid

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Abstract

Objectives: To evaluate the effect of adding the sodium fluoride to different phosphoric acid concentrations on Shear Bond Strength (SBS) of orthodontics brackets bonded to enamel surface.

Methods: Forty eight freshly extracted human premolar for orthodontic purposes, were collected, and were randomly divided into four Groups. G1 etched by 37% Phosphoric acid for 30 s, G2 etched by 25% Phosphoric acid for 30 s, G 3 etched by 37% fluoridated Phosphoric acid (0.863% F-) for 30 s, G4 etched by fluoridated 25 % Phosphoric acid (0.694% F-) for 30s. Stainless steel metal brackets (Forestadent Company-sprint-Brackets) were bonded to teeth using self curing composite (system–RMO/ mono-lok2 bonding). A Universal Testing Machine (Testometric M350-5KN, UK) was used to measure SBS, 24 hours after bonding, and the force applied to the ligature groove between bracket base and wings. Data were analyzed using One-Way ANOVA with Tukey post-hoc test ($p \leq 0.05$).

Results: The mean SBSs were 14.97 MPa, 15.47MPa, 13.09 MPa and 11.16MPa for Groups 1-4 respectively. Significant differences in shear bond strengths were shown between Groups 2 and 4.

Significance: The results suggested that the using mixed phosphoric acid 37% with NaF gel 1.23% for 30 s (0.863%F-) have no effect on SBS and may have a clinical application in the prevention of demineralization or caries surrounding and under orthodontic brackets bonded to enamel. Nevertheless, mixed phosphoric acid 25% with NaF% gel (0.694% F-) results to reducing SBS it may have a clinical application.

Keywords

Fluoridated phosphoric acid; Shear bond strength; Orthodontic Bonding; Prevention of demineralization

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Introduction

Since the acid-etched technique was introduced by bonding of brackets to enamel has been routinely used in orthodontic procedures in fixed appliance therapy [1-3]. The placement of fixed orthodontic appliances creates a favorable environment for the accumulation of microorganisms, which causes enamel demineralization or exacerbates the effects of any pre-existing caries [4]. Ogaard et al. indicated that the high prevalence of carious lesions may be due to the high cariogenic challenge prevailing in the plaque around orthodontic appliances [5]. Enamel demineralization was a common and major clinical complication of orthodontic treatment with a fixed appliance and it has a recorded prevalence of up to 96% in patients undergoing fixed appliance therapy [6-9]. Different methods to prevent enamel demineralization around orthodontics brackets were studied, such as topical fluoride application and using fluoridated phosphoric acid [10-16]. Incorporation of fluoride agents into bonding adhesives affects their mechanical properties and increases bond failure rate [6,11,16-18]. Two systematic reviews concluded that using fluoride toothpaste and daily rinsing with a 0.05% sodium fluoride mouth rinse appears to reduce the incidence of decalcification in patients undergoing orthodontic treatment with fixed appliances [14,15]. All these methods rely on patient compliance and their cooperation [19,20]. Derks et al. examined different methods used in orthodontic practices to prevent decalcifications during fixed appliance treatment, and they concluded that Orthodontists do not implement the available evidence in order to prevent enamel demineralization during fixed-appliance treatment [7]. Garcia-Godoy et al. after comparing the enamel morphology and shear bond strengths of orthodontic brackets bonded to enamel etched with a fluoridated or a non-fluoridated phosphoric acid gel (even as aggressive as 60% conc. for 60s), concluded the shear bond strengths with fluoridated agent were higher [10]. It has been shown that the use of 37% H_3PO_4 incorporated with 1.23% NaF may have a clinical application in the prevention of demineralization or caries surrounding and under orthodontic brackets bonded to enamel [12]. Previous studies where phosphoric acid was used at different concentrations (5-15-37) % with varying application times (15-30-60s), concluded that the acid concentration can be reduced significantly without a significant increase in the failure of bonding, and clearly explained that enamel decalcification during orthodontic treatment may be reduced by decreasing the phosphoric acid concentration and the duration of etching [21]. Acid etching itself caused some damage to dental enamel and exaggerated its demineralization [22].

Orthodontists have been attempting to reduce demineralization with limited success [5,7,22]. For instance, the beneficial effects of dentifrices and/or home use of fluoride solutions have been confirmed [23]. However, patient adherence to prescribed use of these materials can be problematic. One study observed that 52.5% of the patients did not comply with the home use of fluoride solutions [24].

To evaluate bond strength, a variety of test methods and conditions have been employed. Parameters like cross-head speed, storage time of specimens after bonding time, teeth types and force location have been typically varied [25-27]. Cross-head speed variation between 0.1 and 5 mm/min does not seem to influence debonding force measurements or failure mode of brackets bonded to enamel with a composite adhesive [25,28]. The highest bond strengths were after storage specimens in water for 24 hours [26].

The purpose of this study was to evaluate the effect of adding sodium fluoride to different phosphoric acid concentrations on shear bond strength of orthodontics brackets bonded to enamel surface. The null hypothesis was that adding sodium fluoride to Phosphoric acid would have no effect on the shear bond strength of orthodontics brackets bonded to enamel surface.

Materials and Methods

Forty eight freshly extracted human premolar for orthodontic purposes were collected and stored initially in a 10% formaldehyde solution, and then in distilled water. The criteria for tooth selection included intact buccal enamel, not subjected to any pre-treatment to chemical agents such as phosphoric acid, hydrogen peroxide, no cracks due to the presence of the extraction forceps, and no caries. Every tooth was cleaned and polished with pumice for 10 s.

The teeth were embedded in acrylic which was placed into phenolic rings diameter 1.5 cm and 4 cm height. A custom made jig was used to align the facial surface of the tooth in order to be as possible perpendicular with the bottom of the mould. The specimens were randomly divided into four groups in Table 1 and Figure 1:

1. **Group 1:** (12 bicuspid) were etched by 37% Phosphoric acid for 30 s,

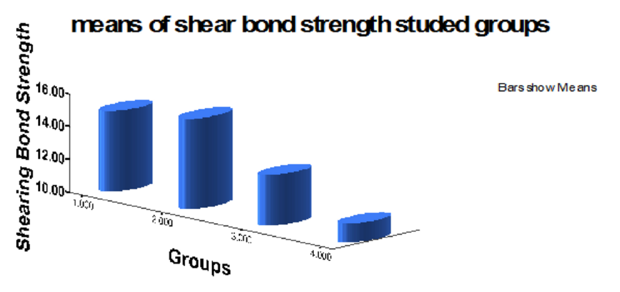

Figure 1: 1=**G1** 37% phosphoric acid, 2= **G2** 25% Phosphoric acid, 3= **G3** Flourited phosphoric acid 37%, 4=**G4** Flourited phosphoric acid 25%

2. **Group 2:** (12 bicuspid) were etched by 25% Phosphoric acid for 30 s,
3. **Group 3:** (12 bicuspid) were etched by fluoridated 37% Phosphoric acid for 30 s,
4. **Group 4:** (12 bicuspid) were etched by fluoridated 25% Phosphoric acid for 30 s.

Bonding procedure

Stainless steel metal brackets (Forestadent Company-sprint-Brackets) were used. And the brackets were bonded to teeth according to the protocol above and using self curing composite (system–RMO/mono-lok2 bonding) for adhesion to the brackets. The main area of the bracket base surface was 12.4 mm2 as given by the manufacturer.

Debonding strength testing

A Universal Testing Machine (Testometric M350-5KN, UK) was used to test shear bond strength, 24 hours after bonding [26]. The specimens mounted in its acrylic block were secured to the lower grip of the machine (fixed head). To maintain a consistent debonding force, a custom-made blade was fixed in the upper grip (movable head) connected to the load cell. The blade was positioned in such a way that it touched the bracket and the force applied to the ligature groove between bracket base and wings [28]. Each tooth was oriented with the testing device as a guide so that its labial surface was parallel to the force during the shear strength test. A cross-head speed of 2 mm/min was used. The debonding forces of the brackets were recorded the in N, and then calculated in MPa.

Fluoridated phosphoric acid 37% was prepared by mixing 10.88 ml 85% phosphoric acid (Merec) and 14.22 sodium fluoride gel 1.23%. Fluoridated phosphoric acid 25% was prepared by mixing 7.35 ml 85% phosphoric acid (Merec) and 17.85 sodium fluoride gel 1.23%. The concentration of phosphoric acid was confirmed by chemical titration.

Statistical analysis

To calculate shear bond strength, the debonding forces were converted into stress values (MPa) by taking into account the surface area of the bracket base. Means and standard deviations of the shear bond strength were calculated for the experimental groups. Shear bond strengths of the different groups were compared by one-way analysis of variance and post-hoc Tukey test at ($p \leq 0.05$) (Table 2).

Results

The means shear bond values (MPa) for Groups 1-4 were 14.97, 15.47, 13.09, and 11.16 respectively. Group 2 had the highest mean value and Group 4 the lowest. In both cases the use of fluoridated H_3PO_4 resulted in a reduction in shear bond. Group 4 was significantly different from Group 2 only.

Discussion

The fluoride role in preventing enamel decalcification has been confirmed and three main mechanisms have been identified to account for the observed protective effects of F– on the reduction of enamel decay [29]. These are reduction in solubility of calcium hydroxyapatite balance of rates of demineralization and remineralisation and antimicrobial effects of F– in terms of affecting metabolism and as a killing agent [30-32]. Regardless of the mode of action of F–, it is becoming generally accepted that topical application rather than systemic delivery is most effective in reducing caries and the effect of fluoride is not systemic but mainly local [33,34]. In order to prevent enamel demineralization NaF 1.23% was added to phosphoric acid. In this study the shear bond strengths off all groups were higher than 6 MPa which is regarded as the minimum acceptable value for clinical use [34-38]. Mixing

Groups	Mean SBS (MPa)	Maximum	Minimum
(G1) 37% H_3PO_4 30 s	14.97 (3.5)	12.70	17.19
(G2) 25% H_3PO_4 30 s	15.47 (4.5)	12.61	18.32
(G3) Fluoridated 37% H_3PO_4 30 s	13.09 (3.8)	10.67	15.52
(G4) Fluoridated 25% H_3PO_4 30 s	11.16 (3.9)	8.62	13.69

Table 1: Mean shear bond strength (SBS) values (MPa) including standard deviation (SD) in parenthesis and the Maximum and Minimum measurements for all four Groups (N=12).

Groups		Mean Difference	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
G1	G2	-0.58	1.61	0.98	-4.87	3.71
G1	G3	1.79	1.61	0.68	-2.5	6.09
G1	G4	3.72	1.61	0.11	-0.57	8.01
G2	G3	2.37	1.61	0.46	-1.91	6.67
G2	G4	4.31	1.61	0.05	-0.01	8.60
G3	G4	1.93	1.61	0.63	-2.36	6.23

Table 2: Comparing shear bonds strength measurement between groups by one-way analysis of variance (ANOVA, $p \leq 0.05$), and Multiple comparison (Tukey test)

fluoride gel with phosphoric acid did not significantly affect the shear bond strengths of 37% concentration but significantly decreased bonding forces after adding NaF to 25% Phosphoric acid, from 15.47 MPa to 11.16 MPa. A reduced phosphoric acid concentration is very important, as it is associated with minimal enamel loss [39]. A 37%, H_3PO_4 concentration can cause damage to the enamel prisms, thus deviating from ideal condition for bonding the bracket [40]. The optimum application time of 37% phosphoric acid is 30 s [21, 41,42]. The application of phosphoric acid concentration greater than 27% H_3PO_4 to enamel have been resulted in the formation of monocalcium phosphate monohydrate, whereas with weaker H_3PO_4 solutions the main reaction products dicalcium phosphate dihydrate. The monocalcium phosphate monohydrate is more soluble than dicalcium phosphate dehydrate [43]. The choice of 30 s etching time was based on previous findings as well as the reduced Phosphoric acid concentration from 37% to 25% [21,41-43]. The results showed that adding NaF to phosphoric acid 37% did not affect the shear bond strength and is in agreement with previous findings but were used 60% fluoridated phosphoric acid concentration duration for 60 sec it may be caused maximum enamel losing and in they study used 37% phosphoric acid incorporated NaF. 1.23% for 15 s only and did not determined percent each of the phosphoric acid and the fluoride in used agent, whereas adding NaF gel to the acid caused increasing fluoride concentration and its preventive influence [12,34,44].

Conclusion

The using mixed phosphoric acid 37% with NaF gel 1.23% for 30 s (0.863%F-) may have a clinical application in the prevention of demineralization or caries surrounding and under orthodontic brackets bonded to enamel. Nevertheless that mixed phosphoric acid 25% with NaF% gel (0.694% F-) results to reducing shear bond strength it may have a better clinical application in the preventive of demineralization by minimizing enamel loss and fluoride effect.

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