DOI: 10.7860/JCDR/2014/7702.4312

Original Article

Dentistry Section

Comparative Evaluation of Shear Bond Strength of Orthodontic Brackets on Pretreatment with CPPACP, Fluor Protector and Phosflur: An In-vitro Study

SUMITA MISHRA

ABSTRACT

Objective: The purpose of this study is to evaluate bond strength, bracket tooth interface of Orthodontic brackets that are bonded for fixed Orthodontic treatment procedure on pretreatment with CPPACP, Fluor Protector and Phosflur. The goal is to assess the adhesive remnants following application of these remineralizing agents using Adhesive Remnant Index.

Materials and Methods: Two hundred freshly extracted premolar teeth each divided into Control, CPP-ACP, Fluor Protector and Phosflur. Teeth were pretreated with these agents prior to bonding procedure. Shear Bond Strength was tested using a Universal Testing Machine. A jig was attached to upper jaw of the machine. The acrylic block containing the embedded teeth was secured in the lower jaw of the machine such that the bracket base of the teeth parallel the direction of the shear force at a crosshead speed of 1 mm/minute until bracket failure. The force required to dislodge the bracket was recorded.

Results: Mean Shear bond strength value is highest for Phosflur (15.3658 ± 2.4546) followed by Fluor Protector , CPP-ACP and lowest for Control (7.0462 ± 0.8838 MPa).

Conclusion: Phosflur, Fluor protector,CPP-ACP have comparable Shear bond strength values in comparison to control.

Keywords: Shear bond strength, Remineralizing agents, CPP-ACP, Fluor Protector, Phosflur, Universal testing machine

INTRODUCTION

Esthetics is a very important reason for which patients seek Orthodontic treatment. The introduction of fixed appliances has several advantages such as shorter treatment times, precise and more controlled tooth movements. However, their advent has brought enamel white spot lesions to the attention of Orthodontists [1]. The banding and bonding of Orthodontic appliances to teeth increases the number of plaque retention sites and as a result maintenance of oral hygiene becomes more difficult. The low pH of plaque adjacent to Orthodontic brackets hinders the remineralization process and decalcification of enamel can occur.

Initial enamel demineralization usually manifests itself clinically as a “white spot lesion” (WSL) [2]. The levels of acidogenic bacteria, such as *Streptococcus mutans*, become significantly elevated in Orthodontic patients.

The characteristic appearance of these lesions is caused by an optical phenomenon owing to subsurface tissue loss and is exaggerated by thorough drying [2]. It lasts approximately two years with smooth surface lesions increasing up to 50% in prevalence during treatment [3].

Many methods like improving oral hygiene, low carbohydrate intake, use of fluoride containing sealants and adhesives can decrease or prevent white spot lesions. Various compliance free methods have been attempted [4]. Newer methods such as the use of Ozone, TiF_4 have also been proposed [5,6]. Following the realization that fluoride was responsible for reduced recurrent decay surrounding silicate restorations, there have been numerous attempts to incorporate Fluorides into dental restorative materials and cements [7].

This study focuses on comparison of three different Fluoride releasing products: MI PASTE PLUS with RECALDENT (Casein phosph-opeptide-amorphous calcium phosphate (GC Corporation, GC Asia Dental Pvt.Ltd, Singapore), FLUOR PROTECTOR (Cervitec, Ivoclar vivadent, United States) and PHOSFLUR (Colgate, New york) in preventing demineralization around brackets without compromising their shear bond strength (SBS) or tensile bond strength.

MATERIALS AND METHODS

1. MI PASTE PLUS with RECALDENT
2. Fluor Protector varnish
3. Phosflur mouth rinse
4. Therapeutically extracted Premolar teeth
5. Acrylic blocks with teeth embedded
6. Mounting jig made of acrylic for applying force
7. 0.022″ Preadjusted Edgewise MBT prescription stainless steel premolar brackets (GEMINI, 3M UNITEK)
8. Distilled water for cleaning the teeth after extraction
9. Saline to store teeth after cleaning the extracted teeth
10. Bonding accessories
    a. Etchant (Scotch bond 3M ESPE, United States)
    b. Light cure adhesive primer (3M UNITEK, Monrovia, California)
    c. Transbond XT Adhesive (3M UNITEK, Monrovia, California)
    d. Applicator brush
    e. Three way syringe
    f. Bracket holder
    g. Bracket positioning gauge
    h. Mouth mirror
    i. Explorer
    j. Pumice and Polishing Rubber cup
    k. Light Emitting Diode curing unit
11. For evaluation of adhesive remnant
    a. Simple Microscope (10 x)
12. For evaluation of acid etched enamel surfaces [Table/Fig-1]
    a. Scanning Electron Microscope (JSM 6510).

[Table/Fig-1]: Scanning Electron Microscope

METHODOLOGY

Sample for the Study

A total of 200 therapeutically extracted human premolars were obtained from patients reporting to the Department of Orthodontics and Dentofacial Orthopedics for Orthodontic treatment. Teeth were stored in physiologic saline (0.1% NaCl) and study was conducted within a span of 15 days. Acrylic blocks ranging from 3 x 2.5 cm dimensions were prepared and teeth were embedded up to CEJ with their buccal surfaces made perpendicular to the base of the block.

Distribution of the Sample

The experimental and control teeth were randomly divided into 4 groups:

Sample Preparation

1. GROUP I (CONTROL)

BONDING PROCEDURE: The buccal surface of the teeth were washed with distilled water and dried using oil and moisture free air from a three way syringe for 5 seconds. The enamel was then treated with 37% Orthophosphoric acid for 30 seconds, washed away with a spray of water for 10 seconds. The tooth surface was then air dried till a white chalky appearance was seen on the surface. The primer was applied with the help of an applicator brush. The adhesive was then applied to the base of the metal bracket.

The bracket was then positioned on the tooth surface along the long axis of the tooth at a predetermined position from the occlusal surface with the help of a bracket positioning gauge. The adhesive was cured using a LED. The adhesive was cured from the mesial and distal aspects for 10 seconds each.

2. GROUP II (CPP-ACP)

The buccal surface of teeth was applied with a pea sized amount of CPP-ACP paste. It was kept for 30 minutes as per the manufacturer's instructions before the bonding procedure. Bonding procedure is same as that of control group.

3. GROUP III (FLUOR PROTECTOR)

The buccal enamel surface was thoroughly cleaned and dried. A thin layer of Fluor Protector varnish was applied using the viva brush. It was evenly dispersed with an air syringe and after 45 minutes bonding was done.

4. GROUP IV (PHOSFLUR)

The buccal surface of teeth was immersed in 10 ml of Phosflur mouth rinse for one minute and bonding procedure was performed after 30 minutes as per manufacturer's instructions.

Evaluation of Shear Bond Strength

Shear Bond Strength was tested using a Universal Testing Machine (AUCE/TEQIP/MET/E-5). A jig was prepared by attaching a sharp chisel-shaped rod to a block of acrylic of dimensions 7 x 3.5 cm. It was attached to upper jaw of the machine. The acrylic block containing the embedded teeth was secured in the lower jaw of the machine such that the bracket base of the teeth parallel the direction of the shear force at a crosshead speed of 1 mm/minute until bracket failure. The force required to dislodge the bracket was recorded.

Assessment of Adhesive Remnants

After debonding, all samples were examined under 10X magnification to assess adhesive remnants on tooth surface using the ADHESIVE REMNANT INDEX (ARI) system. The scoring criteria for evaluation was:

1 = All the adhesive remained on the tooth.
2 = More than 90% of the adhesive remained on the tooth.
3 = More than 10% but less than 90% of the adhesive remained on the tooth.
4 = Less than 10% of the adhesive remained on the tooth.
5 = No adhesive remained on the tooth.

Evaluation of Depth of Etching

SEM observations were carried out to observe the acid etched enamel surfaces pretreated with or without the agents using a Scanning Electron Microscope (JSM 6510). The results obtained were subjected to statistical evaluation.

RESULTS

As per [Table/Fig-2,3] it can be seen that, the mean strength value is highest for PHOSFLUR followed by FLUORPROTECTOR , CPPACP and lowest for CONTROL.

Group	n	Means	SD.
Group I	50	7.0462	0.8838
Group II	50	10.5368	1.1307
Group III	50	13.4854	1.8243
Group IV	50	15.3658	2.4546

[Table/Fig-2]: Mean, SD of shear bond strength (in MPA) for all the four groups (Control, Cppacp, Fluorprotector, Phosplur)

From the [Table/Fig-4], it can be seen that, there is a significant difference in strength values between the four groups at 5% level of significance and Group IV samples have significantly higher strength (MPa) other groups.

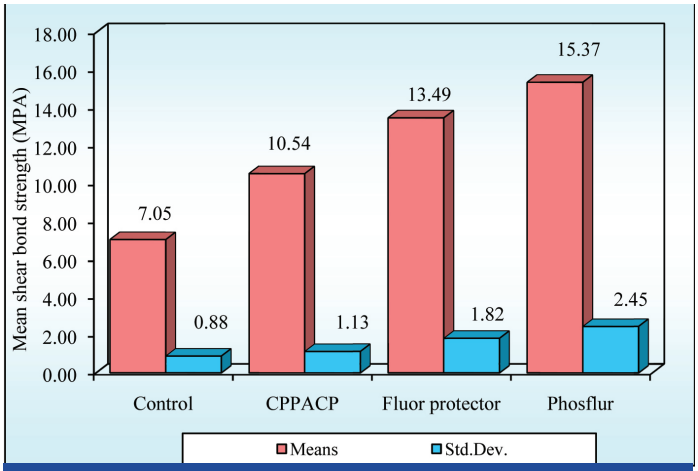
From this it can be seen that, significant difference in strength was observed between Group I and Group IV, Group I and Group III, Group I and Group IV ($p<0.05$) at 5% level of significance and group IV has higher mean strength value (MPa) when compared to Group I, Group II and Group III.

According to the Mean and SD of ARI scores as represented in [Table/Fig-5-7], the mean ARI score is highest for Fluorprotector (2.82 ± 0.80) followed by CPPACP (2.78 ± 1.04), PHOSFLUR (353.49±23.47) and lowest for Control (2.02 ± 1.08).

As per [Table/Fig-8], all the groups showed a higher percentage of ARI scores of one.

From the [Table/Fig-9], it can be seen that, there is a significant difference in ARI score values between the four groups and the group III samples have significantly higher ARI score value than those of the other groups.

From the [Table/Fig-10], it can be seen that significant difference in ARI scores was observed between the groups and Group III has higher mean ARI scores when compared to Group I, Group II and Group IV.



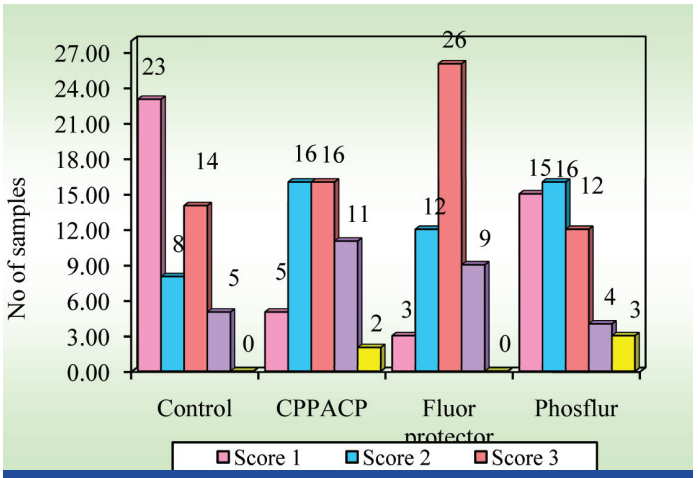
[Table/Fig-3]: Comparison of four groups (Control, CPPACP, Fluorprotector, Phosflur) with respect to shear bond strength (MPa) values

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F-value	P-value
Between groups	3	1980.16	660.05	231.3362	0.0000*
Within groups	196	559.23	2.85		
Total	199	2539.39			

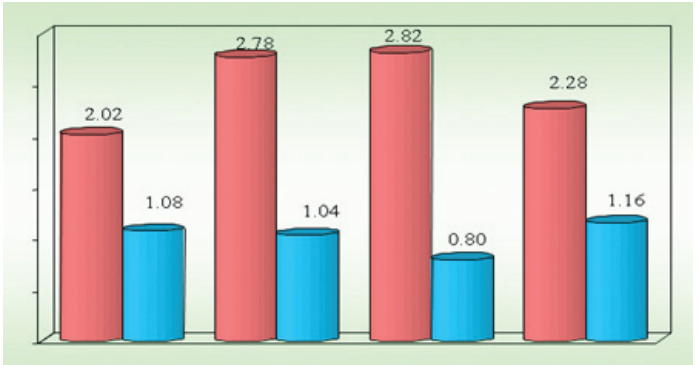
[Table/Fig-4]: Comparison of four groups (Control, CPPACP, Fluorprotector, Phosplur) with respect to Shear bond strength (MPa) values by one way ANOVA *p<0.01

Group	N	Means	Std.Dev.
Control	50	2.02	1.08
CPPACP	50	2.78	1.04
Fluor protector	50	2.82	0.80
Phosflur	50	2.28	1.16

[Table/Fig-5]: Mean, SD of ARI scores according to four groups



[Table/Fig-6]: Comparison of four groups (Control, CPPACP, Fluorprotector, Phosplur) with respect to ARI score values



[Table/Fig-7]: Comparison of four groups (Control, CPPACP, Fluorprotector, Phosplur) with respect to ARI score values

Representative SEM images of the etched enamel specimens pretreated with and without CPPACP, FLUOR PROTECTOR, PHOSFLUR are shown in [Table/Fig-11-14].

DISCUSSION

The technique of bonding Orthodontic brackets to enamel with acrylic resin dates back to 1965 [8]. The procedure included acid-etch technique to better adhere the brackets to enamel [9].

Orthodontic appliances as such are not a cause of demineralization or caries, but creation of new retentive sites could result in oral hygiene problems when Orthodontic appliances are worn [10].

In a previous study, it was reported that 49.6% of Orthodontic patients experienced some degree of white spot lesion formation which is a result of demineralization of enamel in and around the bracket area [11]. Caries and enamel decalcification can be greatly reduced by maintaining good oral hygiene, applying topical Fluorides, and/or using a Fluoride-containing dentifrice during Orthodontic treatment [12]. In other studies, however, the topical application of Fluoride to enamel surface before etching with phosphoric acid did not negatively affect the bond strength [13]. Topical Fluoride application works primarily through (1) a reduction in the rate of dissolution in the demineralization phase in acidic conditions, (2) the enhancement of remineralization at the crystal surface, and (3) the inhibition of bacterial enzymes [14].

In an earlier study conducted by Dunn it was suggested that Orthodontic brackets bonded to teeth with an ACP containing composite material failed at significantly lower forces than brackets bonded to teeth with conventional resin-based composite Orthodontic cements. So the question that arises is whether the disadvantage of low bond strength due to the effect of the material outweighs its advantage as a protector against demineralization.

Recent studies however show that CPP-ACP application can cause increased shear bond strength of brackets when light-cured adhesive is used. In this in vitro study the effects of pretreatment of CPP-ACP on Shear bond strength (SBS) of Orthodontic brackets was examined.

CPP-ACP was found to have higher bond strength compared to the bond strength recommended by Reynolds and Whitlock et al. as adequate for Orthodontic purposes. SBS was favorably affected when the enamel was pretreated with CPP-ACP.

Fluor protector varnish strengthens enamel by protecting it against demineralization and promotion of remineralization by forming Calcium Fluoride layer (CaF2). Several investigators have shown that the etching effect of phosphoric acid on enamel surfaces pretreated with topical Fluoride agents was impeded, causing reduced bond strengths of dental resins. In our study, Shear bond strength (SBS) was favorably affected when the enamel was pretreated with Fluor Protector.

Phosflur mouth rinse has APF formulation that promotes remineralization and strengthens teeth. In our study, Shear bond strength (SBS) was favorably affected when the enamel was pretreated with Phosflur.

This in-vitro study clearly indicates that significant differences in Shear bond strength (SBS) existed between Group I (Control) and Group II (CPP-ACP), Group III (Fluor Protector) and Group IV (Phosflur). Group IV (Phosflur) having APF formulation showed the maximum Shear bond strength in comparison to control and the other groups.

Assessment of residual debris following bond failure was evaluated with the Adhesive Remnant Index (ARI) index. It has been stated that the most common failure site when stainless steel brackets are used is the adhesive/bracket base interface and consequently the bond strength at the etched enamel and adhesive interface is greater than that at the bracket base/adhesive interface. Failure at the base

Groups	Score 1	%	Score 2	%	Score 3	%	Score 4	%	Score 5	%	Total
Control	23	46.00	8	16.00	14	28.00	5	10.00	0	0.00	50
CPPACP	5	10.00	16	32.00	16	32.00	11	22.00	2	4.00	50
Fluor protector	3	6.00	12	24.00	26	52.00	9	18.00	0	0.00	50
Phosflur	15	30.00	16	32.00	12	24.00	4	8.00	3	6.00	50
Total	46	23.00	52	26.00	68	34.00	29	14.50	5	2.50	200

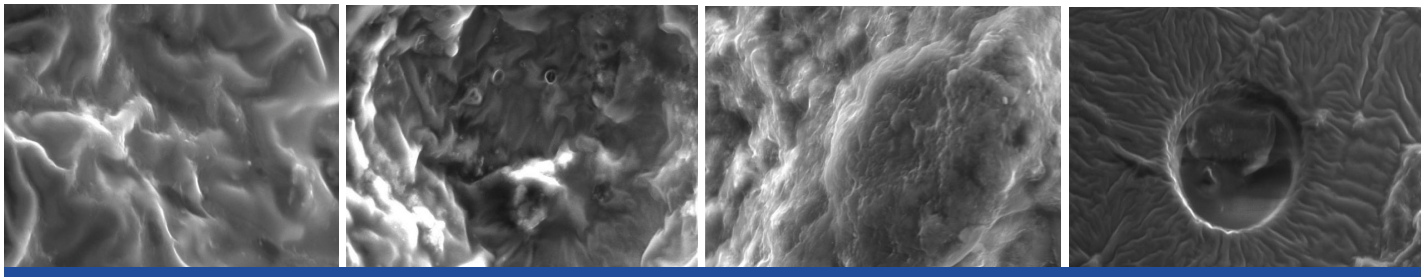
[Table/Fig-8]: Comparison of four groups with respect to ARI scores by Chi square test
Chi-square = 42.6471 df = 12 p = 0.00003*
*p<0.01

Groups	Means	Std.Dev.	Median	Sum of ranks	h-value	p-value
Group I	2.02	1.08	2.00	3880.50	20.7897	0.0001*
Group II	2.78	1.04	3.00	5784.50		
Group III	2.82	0.80	3.00	6014.50		
Group IV	2.28	1.16	2.00	4420.50		

[Table/Fig-9]: Comparison of four groups with respect to ARI scores by Kruskal Wallis ANOVA test
*p<0.01

Groups	Mean	SD	Median	Sum of ranks	u-value	z-value	p-value
Group I	2.02	1.08	2.00	2055.00			
Group II	2.78	1.04	3.00	2995.00	780.000	-3.2401	0.0012*
Group I	2.02	1.08	2.00	2001.00			
Group III	2.82	0.80	3.00	3049.00	726.000	-3.6124	0.0003*
Group I	2.02	1.08	2.00	2374.50			
Group IV	2.28	1.16	2.00	2675.50	1099.500	-1.0375	0.2995
Group II	2.78	1.04	3.00	2475.00			
Group III	2.82	0.80	3.00	2575.00	1200.000	-0.3447	0.7303
Group II	2.78	1.04	3.00	2864.50			
Group IV	2.28	1.16	2.00	2185.50	910.500	-2.3405	0.0193**
Group III	2.82	0.80	3.00	2940.50			
Group IV	2.28	1.16	2.00	2109.50	834.500	-2.8644	0.0042*

[Table/Fig-10]: Pair wise comparison of four groups with respect to ARI scores by Mann-Whitney U-test
*p<0.01, **p<0.05.



[Table/Fig-11]: SEM observation of acid-etched enamel surface
[Table/Fig-12]: SEM observation of acid-etched enamel surface after pretreatment with CPP-ACP
[Table/Fig-13]: SEM observation of acid-etched enamel surface after pretreatment with FLUOR PROTECTOR
[Table/Fig-14]: SEM observation of acid-etched enamel surface after pretreatment with PHOSFLUR

and adhesive interface results in adhesive remnants being firmly attached to the enamel. In our study too, the most common failure site was the adhesive/bracket interface for all the four groups.

In context to the shear bond strength values, Group I (Control) having the least bond strength and Group IV (Phosflur) having highest bond strength, showed similar residual debris at the debonding surfaces. When comparing Group IV (Phosflur) with Group II (CPP-ACP) and Group III (Fluor Protector) it was found that the amount of residual debris at the debonding surfaces was proportional to the increase in shear bond strength values. However, with the work by Maijer and Smith, it is confirmed that debonding of Orthodontic adhesives was easy after crystal growth conditioning. It is supported by the fact that Fluoride is known to enhance crystal growth.

Thus, it can be explained that it is not a case of differing bond strengths at the separate interfaces that governs failure site; it is probably caused by stress concentration and consequent crack formation that progresses to bond failure.

When the adhesive material is used in very thin sections, as in the bonding system, the site of failure becomes influenced by the design of the bracket base and by the type of adhesive material used.

Scanning Electron Microscope (SEM) observations were carried out on the enamel surfaces pretreated with CPP-ACP, Fluorprotector, Phosflur. Images as in [Table-Fig- 5-8] revealed relatively rougher etched enamel surfaces than Control. A rougher enamel surface results in a greater adhesive area and more resin tags available for bonding.

In our study, Group I (Control) and Group IV (Phosflur) showed a Type 1 etching pattern, Group II (CPP-ACP) showed a Type 2 etching pattern and Group III (Fluor Protector) showed Type 3 etching pattern.

From the observations of this study, we can presume that CPP-ACP, Fluor Protector and Phosflur favourably affect the Shear bond strength of Orthodontic brackets.

CONCLUSION

Based on findings and within the limitations of the present in-vitro study, the following conclusions can be drawn:

1. SBS values of CPPACP, Fluor Protector, and Phosflur are higher than Control.
2. ARI scores indicate the role of Fluoride in enhancing crystal growth.
3. There is increase in surface area of etching after pretreatment with the fluoride rich materials.

REFERENCES

[1] Robert N. Staley. Effect of Fluoride Varnish on Demineralization around Orthodontic Brackets. *Semin Orthod*.2008;14:194-9.

[2] Samir E. Bishara and Adam W. Ostby. White Spot Lesions: Formation, Prevention, and Treatment. *Semin Orthod*.2008;14:174-82.

[3] Jasmine Gorton, John D.B.Featherstone. In vivo inhibition of demineralization around orthodontic brackets. *Am J Orthod Dentofacial Orthop*.2003;123:10-4.

[4] Nasrin Farhadian, Amirfarhang Miresmaeili, and Sara Mehrabi. Effect of fluoride varnish on enamel demineralization around brackets: An in-vivo study. *Am J Orthod Dentofacial Orthop*.2008;133:S95-8.

[5] Tamer Büyükyilmaz, Vivat Tangugsorn, Bjørn Øgaard, Joop Arends, Jan Ruben, and Gunnar Rølla. The effect of titanium tetrafluoride (TiF4) application around orthodontic brackets *Am J Orthod Dentofacial Orthop*.1994;105:293-6.

[6] Otmar Kronenberg, Adrian Lussi, Sabine Ruf. Preventive Effect of Ozone on the Development of White Spot Lesions during Multibracket Appliance Therapy. *Angle Orthod*.2009; 79:64–9.

[7] Underwood, Rawls, and Zimmerman. Evaluation of fluoride-releasing orthodontic adhesive. *Am J Orthod Dentofacial Orthop*.1989; 96:93 – 9.

[8] Newman GV.Epoxy adhesives for orthodontic attachments:progress report.*Am J Orthod Dentofacial Orthop*.1965; 51: 901–12.

[9] S Bryant, BS, DH Retief, EL Bradley, Jr, FR Denys. The effect of topical fluoride treatment on enamel fluoride uptake and the tensile bond strength of an orthodontic bonding resin *Am J Orthod Dentofacial Orthop*. 1985; 85(4).

[10] Y Lijima, F Cai, P Shen, G Walker, et al. Acid resistance of enamel subsurface lesions remineralized by a sugar-free chewing gum containing Casein-Phosphopeptide-Amorphous Calcium Phosphate. *Caries Res*.2004; 38:551-6.

[11] Theresia Rini Sudjalim, Michael Geoffrey Woods, David John Manton, Eric C. Reynolds. Prevention of demineralization around orthodontic brackets in vitro. *Am J Orthod Dentofacial Orthop*.2007; 131:705,e1-705.e9.

[12] Defne Kecika, Sevi Burcak Cehreli, Cagla Sar, Bahtiyar Unver. Effect of Acidulated Phosphate Fluoride and Casein Phosphopeptide-Amorphous Calcium Phosphate Application on Shear Bond Strength of Orthodontic Brackets. *Angle Orthod.* 2008; 78:129–33.

[13] Arnold M Geiger, Leonard Gorelick, A John Gwinnett, Barbara J. Benson. Reducing white spot lesions in orthodontic populations with fluoride rinsing. *Am J Orthod Dentofac Orthop.* 1992; 101:403-7.

[14] Mark A Todd, Robert N Staley, Michael J Kanellis, Kevin J Donly, James S Wefel. Effect of a fluoride varnish on demineralization adjacent to orthodontic brackets. *Am J Orthod Dentofacial Orthop.* 1999; 116: 159-67.

PARTICULARS OF CONTRIBUTORS:

1. Senior Lecturer, Department of Orthodontics, Institute of Dental Sciences, Sector-8, Kalinganagar, Ghatikia, Bhubaneswar-751030, Odisha, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Sumita Mishra,
Senior Lecturer, Department of Orthodontics, Institute of Dental Sciences,
Sector-8, Kalinganagar, Ghatikia, Bhubaneswar-751030, Odisha, India.
E-mail: sumita.mitali@gmail.com

FINANCIAL OR OTHER COMPETING INTERESTS: None.

Date of Submission: **Sep 20, 2013**
Date of Peer Review: **Jan 27, 2014**
Date of Acceptance: **Jan 24, 2014**
Date of Publishing: **May 15, 2014**