European Journal of Orthodontics 31 (2009) 385–389
doi:10.1093/ejo/cjn129
Advance Access publication 31 March 2009

The effect of herbal teas on the shear bond strength of orthodontic brackets

Çağrı Ulusoy*, Arzu Müjdeci** and Osman Gökay**
*Department of Orthodontics, Gazi University and **Department of Operative Dentistry, Ankara University, Turkey

SUMMARY The present study was conducted to evaluate the effects of some types of herbal tea on the shear bond strength (SBS) of orthodontic brackets to enamel surfaces.

The brackets were bonded with Transbond XT to 90 extracted human premolar teeth and divided equally into six groups, that is, black, mint–mate herbal, mint–lemon herbal, and rosehip fruit tea and two control groups, Coca-Cola and distilled water. All groups were conditioned for three 5-minute sessions with equal intervening intervals for 90 days. The initial pH, SBS, and adhesive remnant index (ARI) of the groups were evaluated and the data were analysed statistically by Kruskal–Wallis and Mann–Whitney *U*-tests, one-way analysis of variance, and Duncan and *Z*-tests, respectively.

Rosehip fruit tea (2.4±0.07) and Coca-Cola (2.5±0.05) had the lowest pH values. Coca-Cola (6.04±1.11 MPa) and rosehip fruit tea (7.26±1.11 MPa) significantly reduced the SBS to enamel ($P<0.001$). The SBS results for the other groups were similar ($P>0.05$). Except for the Coca-Cola group (ARI score=0), fracture sites for all other groups were similar with the majority of bond failures at the enamel–adhesive interface (ARI score=1).

Although this experiment could not completely replicate the complex oral environment, it seems to confirm that Coca-Cola and rosehip fruit tea may be a causative factor in bracket–enamel bonding failure.

Introduction

Bond failure of brackets during orthodontic treatment is a commonly encountered problem. The frequency of this has been found to vary between 0.5 and 17.6 per cent (Zachrisson, 1977; Sunna and Rock, 1998; Reis *et al.*, 2008). Various factors can contribute to bond failure, including poor operator technique, variation in the enamel surface, saliva contamination, bracket properties, masticatory forces, and patient behaviour (Bishara *et al.*, 2002; Cozza *et al.*, 2006; Soderquist *et al.*, 2006; Northrup *et al.*, 2007). Acidic and alcoholic foods and drinks in the diet of the patient can also be a causative factor for bond failure. (Hobson *et al.*, 2000; Dinçer *et al.*, 2002; Oncag *et al.*, 2005; Akova *et al.*, 2007).

The consumption of soft drinks is popular with adolescents and the habit is carried over into adulthood. However, their popularity has raised concern about their detrimental potential on adhesion of brackets. It has been reported that acidic and alcoholic soft drink consumption during orthodontic treatment decreases the retention of brackets by enamel softening around the brackets (Dinçer *et al.*, 2002; Oncag *et al.*, 2005) or adhesive resin/composite resin degradation or softening (Hobson *et al.*, 2000; Akova *et al.*, 2007). Therefore, patients with fixed orthodontic appliances are advised not to consume acidic soft drinks during treatment (Oncag *et al.*, 2005).

Nowadays, as well as soft drinks, herbal teas have become popular worldwide and especially in Turkey (Başgel and Erdemoğlu, 2006) because of their beneficial effect on both physical and mental health (Aoshima *et al.*, 2007). The average consumption of tea is reported to be higher than that of soft drinks with an average of 3 units of tea being consumed per day compared with 1.6 units of soft drinks (The Tea Council Ltd, 2000). Herbal flavoured tea was introduced as a low-caffeine alternative to conventional black tea (Brunton and Hussain, 2001). In a short period of time, herbal flavoured tea has increased in popularity in the United Kingdom and currently represents 3–4 per cent of all tea consumed (The Tea Council Ltd, 2000). Phelan and Rees (2003) reported that the consumption of herbal teas is similar to that of traditional teas. Herbal teas contain various fragrances which have a tranquillizing effect on the mind (Aoshima *et al.*, 2007). In addition, they are low in calories (Brunton and Hussain, 2001). They are based on dried fruit products and often contain a mixture of dried berries and fruit leaves together with other fillers and flavourings (Phelan and Rees, 2003). Although herbal teas are known to be 'safe', it has been reported that many of these have a high erosive potential because of their fruit products containing hydroxyl organic acids, such as citric, malic, and oxalic (Hughes *et al.*, 2000). Some researchers (Brunton and Hussain, 2001; Phelan and Rees, 2003) have found enamel loss caused by herbal teas. To date, no study has been performed to evaluate the effect of black or herbal teas on the enamel bond strength of orthodontic brackets. As many orthodontic patients, especially adults, routinely drink herbal tea and there could be a possible relationship between the initial pH of the teas and the bond failure of brackets, the present *in vitro* study was carried out to provide information on the resistance of a metallic bracket to shearing forces after tea exposure and to evaluate the mode of failure.

Materials and methods

Ninety non-carious human premolar teeth from 12- to 16-year-old orthodontic patients, that had been extracted not more than 2 weeks previously, were handled and prepared solely by the same operator (ÇU). The teeth were cleaned and polished with fluoride-free pumice slurry and examined under a stereo microscope (Discovery V8 Stereo, Carl Zeiss MicroImaging GmbH, Göttingen, Germany) to ensure the absence of caries and cracks on the labial surface. The roots of the teeth were embedded in standardized 16 × 20 mm acrylic blocks. The buccal enamel was etched with 37 per cent orthophosphoric acid (3M Espe, St Paul, Minnesota, USA) for 30 seconds, rinsed with water for 15 seconds, and air dried with oil-free compressed air shrinkage for 20 seconds. Bracket bonding to the enamel was performed using a highly filled orthodontic adhesive, Transbond XT (3M/Unitek Corporation, Monrovia, California, USA), and Transbond XT Light Cure Adhesive Primer according to the manufacturer's recommendation. Transbond XT primer was applied to the etched surface in a thin film and light cured for 10 seconds with a halogen-curing unit (Hilux Ultra Plus, Benlioğlu Dental, Ankara, Turkey). Before each testing procedure, the light intensity of the unit was checked with a curing radiometer (Demetron Kerr, Danburry, Connecticut, USA) and confirmed at 700 mW/cm^2. Transbond XT adhesive paste was then applied to each bracket base, and a metal premolar bracket (Victory Series, 3M Unitek GmbH, Seefeld, Germany) with a 0.018 inch slot was placed on each tooth. The bracket was centred on the crown of the tooth mesiodistally along the long axis of the tooth, and pressed firmly with a Hollenback carver to expel the excess adhesive. The excess resin was removed using a sharp scaler. After light irradiation from two sides of the bracket edges for 10 seconds, the specimens were kept in distilled water at 37°C for 24 hours to allow polymerization of the resin.

The 90 specimens were randomly divided into six equal groups:

Group 1: Black tea
Group 2: Mint–mate herbal tea
Group 3: Mint–lemon herbal tea
Group 4: Rosehip fruit tea
Group 5: Coca-Cola (positive control group)
Group 6: Distilled water (negative control group).

The contents of the drink are listed in Table 1. All the groups were conditioned with each solution for three sessions of 5 minutes with equal intervening intervals during the day. After each session, the solutions used were replenished. For the remainder of the time, they were kept in distilled water.

Table 1 Drink contents according to the manufacturers' information.

Drinks and manufacturers	Contents
Black tea—Lipton, Unilever, Istanbul, Turkey	Black tea leaves
Mint–lemon herbal tea—Dogadan, Dogadan Inc., Ankara, Turkey	Curled mint (37%), lemon grass, lemon verbena, lemon peel, natural lemon flavour, chicory root
Mint–mate herbal tea—Doga, Doga Inc., Istanbul, Turkey	Mate, peppermint (10%), spearmint (10%), lemon grass, natural lemon flavour, chicory root
Rosehip fruit tea—Dogadan	Rosehip, hibiscus
Coca-Cola—Coca-Cola Company, Istanbul, Turkey	Carbonated water, sugar, phosphoric acid, fructose, corn syrup, caramel, colour, natural flavours, caffeine

The process was carried out for 90 days. All the tea bags were brewed according to the manufacturers' instructions using a standardized method. One tea bag was added to 250 ml of boiling tap water and stirred at 0, 2, 4, and 5 minutes and the bag was then removed. The volume of 250 ml was chosen as this represented the average volume of a typical tea mug. The solution was allowed to cool until it reached 37°C before testing (Phelan and Rees, 2003). Only Coca-Cola was used cold, directly from the refrigerator, at each session.

The initial pH of each liquid was tested using an electronic pH metre (Thermo Orion, Model 720, Witchford, Cambridgeshire, UK). The pH metre was calibrated using test solutions with a known pH value (Fisher Scientific International, Hampton, New Hampshire, USA) prior to testing. Each liquid was tested using five different samples (Phelan and Rees, 2003).

After 3 months, each bonded bracket was positioned in a universal testing machine (Instron Corp., Canton, Massachusetts, USA) parallel to the direction of load application. Shear load was directly applied to the bracket–tooth interface at a crosshead speed of 1 mm per minute until debonding occurred. The load at bracket failure was recorded using a personal computer connected to the testing machine. The load at failure was recorded in Newtons (N), and the stress was calculated in megapascals (1 MPa = 1 N/mm^2) by dividing the force in N by the area of the bracket base. The area of the bracket base, determined by measuring five brackets with digital callipers (Masel Orthodontics, Bristol, Pennsylvania, USA) accurate to 0.01 mm, was found to be 10.53 mm^2.

After debonding, each tooth was examined under ×40 magnification with a stereo microscope (Discovery V8 Stereo, Carl Zeiss MicroImaging GmbH) and the residual adhesive remaining on the teeth was scored using the adhesive remnant index (ARI), as described by Årtun and Bergland (1984). The possible values for the ARI are 0, no adhesive left on the tooth; 1, less than half of the adhesive left on the tooth; 2, more than half of the adhesive left on the tooth; and 3, all the adhesive left on the tooth with an impression of the bracket mesh. Data of initial pH, SBS, and ARI scores were analysed statistically by Kruskal–Wallis and Mann–Whitney *U*-tests, one-way analysis of variance (ANOVA), and Duncan and *Z*-tests, respectively.

Results

The initial pH and mean SBS of the groups tested are presented in Table 2. The pH of the different types of herbal tea tested ranged from 2.4±0.07 to 7.1±0.05 compared with values of 2.5 (0.05) for Coca-Cola and 6.7±0.00 for distilled water. The pH of the rosehip fruit tea was significantly less than all the other teas ($P<0.05$).

One-way ANOVA and Duncan test were used to analyse the differences in SBS among the groups. Duncan test showed that Coca-Cola and rosehip fruit tea had a significantly lower bond strength than all the other tea groups and the negative control group ($P<0.001$). There were no significant differences between the other tea groups (black, mint–mate herbal, and mint–lemon herbal) and the negative control group ($P>0.001$). The negative and positive control groups were significantly different from each other ($P<0.001$).

The location of the fracture for each group was evaluated with the ARI (Table 3). Except for the positive control group, all other test groups showed similar bracket failure modes. The enamel–adhesive interface was the most common site of failure among the groups. There was no evidence of enamel fracture in any of the groups. The results of the *Z*-test showed that, except for the positive control group ($P<0.05$), the distribution of ARI scores was similar for the other groups ($P>0.05$).

Table 2 Initial pH value and mean shear bond strength (SBS) values in megapascals (standard deviations in parenthesis).

Groups	Initial pH ($n=5$)	Mean SBS ($n=15$)
Black tea	5.6 (0.02) d	12.34 (1.36) b
Mint–lemon herbal tea	4.3 (0.06) c	12.79 (2.30) b
Mint–mate herbal tea	7.1 (0.05) e	12.17 (2.27) b
Rosehip fruit tea	2.4 (0.07) a	7.26 (1.11) a
Coca-cola (positive control)	2.5 (0.05) a	6.04 (1.11) a
Distilled water (negative control)	6.7 (0.00) e	13.09 (1.90) b

The same letters in the pH column indicate no significant difference ($P>0.05$). The same letters in the SBS column indicate no significant difference ($P>0.001$).

Table 3 Adhesive Remnant Index (ARI) scores by group.

Groups	n	ARI scores			
		0	1	2	3
Black tea	15	3	10	2	0
Mint–lemon herbal tea	15	2	13	0	0
Mint–mate herbal tea	15	3	12	0	0
Rosehip fruit tea	15	2	11	2	0
Coca-cola (positive control)*	15	15	0	0	0
Distilled water (negative control)	15	3	10	2	0

*There was a significant difference ($P<0.05$) among the groups.

Discussion

Herbal tea products are widely and habitually consumed worldwide. Four types of tea, one black and three herbal, were tested in the present study.

The investigation was designed assuming that a young or adult patient receiving orthodontic treatment might consume tea three times a day and that the consumption period would be 5 minutes. Distilled water was chosen as the negative control to simulate wet oral conditions provided by saliva, as in other bracket bonding studies (Larmour *et al.*, 1998; Hobson *et al.*, 2000; Murray and Hobson, 2003; Akova *et al.*, 2007). As Coca-Cola is known to have a deleterious effect on enamel–bracket retention (Oncag *et al.*, 2005), it was selected as the positive control.

Brunton and Hussain (2001) measured the pH of a traditional tea and recorded a value of 4.8, which is slightly more acidic than the black tea tested in the present study (5.6±0.02). Mint–mate herbal tea and distilled water were well above these values at 7.1±0.05 and 6.7±0.00, respectively. The pH of all the other teas tested had values from 2.4±0.07 to 4.3±0.06 and were significantly different from the mint–mate herbal tea, black tea, and distilled water ($P<0.05$). The pH range of rosehip fruit tea and Coca-Cola (2.4±0.07 to 2.5±0.05) was similar to carbonated cola drinks having a pH of 2.44 (Oncag *et al.*, 2005).

The results of this study showed a direct relationship between the initial pH of the drinks and the SBS of the orthodontic brackets tested; the lower the initial pH the lower the SBS. The *in vitro* effect of tea on bracket–enamel bonding was pH dependent. All the teas used provided clinically acceptable bond force levels (6–8 MPa) as suggested by Reynolds and von Fraunhofer (1976). Rosehip fruit tea significantly decreased the SBS of brackets, whereas all the other teas did not affect bracket bonding. The bond strength value in the rosehip fruit tea group (7.26±1.11 MPa) was similar to the positive control group (6.04±1.11 MPa). Rosehip fruit tea, that had the lowest pH (pH=2.4±0.07) among the tested teas, contains hibiscus and rosehip and the rosehip plant is rich in vitamin C (ascorbic acid; Phelan and Rees, 2003). It has been reported that acidic drinks have a negative effect on bracket–enamel bonding by causing enamel demineralization around the brackets (Oncag *et al.*, 2005) and this might be a possible explanation for the decrease in bond strength after exposure to rosehip fruit tea. Adhesive/composite resin softening or degradation impairs the interlock between the bracket–adhesive resin–enamel and may also cause bond failure. It has been reported that acids and acidic drink absorption may degrade the structure of bisphenol A glycidyl methacrylate-based composite resins (McKinney and Wu, 1985; Hobson *et al.*, 2000); the resin matrix can be softened and fillers can leach out, decreasing the bracket bond (Hobson *et al.*, 2000). Although the effect of herbal teas on adhesive resin is not known, softening of the adhesive resin by rosehip fruit tea may be a possibility and can be considered as a causative factor on SBS reduction. However, it is not known which factor is really dominant in bracket retention. As there are no previously conducted studies about the effect of herbal teas on the SBS of orthodontic brackets, comparisons with previous studies with respect to teas are not possible. As for the positive control group (Coca-Cola), bond strength reduction in the present study is in accordance with the results of Oncag *et al.* (2005), reporting that acidic soft drinks, for example Coca-Cola, have a deleterious effect on bracket retention against shearing force.

The sites of failure can occur within the bracket, between the bracket and the adhesive, within the adhesive, and between the tooth surface and the adhesive (Littlewood *et al.*, 2000). ARI scores were used to identify the amount of adhesive remaining on the teeth. The results of this study showed that the Coca-Cola produced the most consistent separation at the enamel–adhesive interface, leaving the enamel surface intact (ARI score 0). For all other groups, the majority of bond failures were ARI 1, that is, at the enamel–adhesive interface. ARI score 1 means that more adhesive has adhered to the bracket base and less adhesive remains on the tooth structure. This reduces clean-up time and is less troublesome for the patients. Thus, it is not harmful to the structural integrity of the enamel. For the tea groups, no correlation was found between a particular site of bond failure or a high or low bond strength. No enamel damage was evident in any of the groups. ARI scores in the rosehip fruit tea group were similar to the other teas. It is surprising that despite similar effects on SBS, the mode of failure in ARI scores between the Coca-Cola and rosehip fruit tea groups was different. This may be due to differences in the product contents or the actual failure mechanism of Coca-Cola could be different from that of rosehip fruit tea. It may be that the carbonated water and phosphoric acid in Coca-Cola are responsible for softening the resin matrix resulting in the leaching out of fillers and the decrease in bond strength.

The destructive potential of drinks on enamel and resins can be influenced by several parameters, including frequency and timing of intake, the period in the mouth, temperature, sugar content of the drinks, and type of resin. In the present study, the teeth were exposed intermittently to tea at 37°C and sugar was not added. Of course, not everyone drinks tea at this temperature. Some people sip tea at higher temperatures approaching 60°C. This may in turn have a varying effect on the destructive potential of teas on the bond strength of orthodontic brackets. As Coca-Cola is marketed as a drink that can be served chilled, in the present study it was applied cold, directly from the refrigerator. In addition, the salivary protective effect can play a major role in the mouth, in moderating the negative effect of acidic drinks on enamel–bracket retention. Further tests on different herbal teas and different resins on enamel–bracket bonding may be needed.

Although this study could not completely replicate the complex oral environment, it seems to confirm that Coca-Cola and rosehip fruit tea have a negative effect on bracket–enamel bonding. Assuming that an orthodontic treatment lasts an average of 1 year or more, the possibility of greater damage should be considered.

Conclusions

1. The results of this study revealed that there was a direct relationship between the initial pH of the tested drinks and the SBS of the orthodontic brackets after exposure to the drinks; the lower the initial pH the lower the SBS.
2. Rosehip fruit tea had an acidic pH and caused a reduction in the bond between the enamel–bracket, which was also seen in the Coca-Cola group.
3. Black, mint–mate herbal, and mint–lemon herbal tea do not seem to have a destructive potential on enamel or on the bond strength of orthodontic brackets.
4. There was no significant correlation between the SBS and ARI scores of the tea groups.
5. Adult patients who are receiving fixed orthodontic treatments should be informed about the destructive potential of Coca-Cola and rosehip fruit tea or any other soft drink with a low pH.

Address for correspondence

Dr Çağrı Ulusoy
Gazi Universitesi Diş Hekimliği Fakültesi
Ortodonti Anabilim Dalı
1. sokak
Emek
Ankara 06510
Turkey
E-mail: culusoy77@yahoo.com

References

Akova T, Ozkomur A, Aytutuldu N, Toroglu M S 2007 The effect of food simulants on porcelain-composite bonding. Dental Materials 86: 163–168

Aoshima H, Hirata S, Ayabe S 2007 Antioxidative and anti-hydrogen peroxide activities of various herbal teas. Food Chemistry 103: 617–622

Årtun J, Bergland S 1984 Clinical trials with crystal growth conditioning as an alternative to acid-etch enamel pretreatment. American Journal of Orthodontics 85: 333–340

Başgel S, Erdemoğlu S B 2006 Determination of mineral and trace elements in some medicinal herbs and their infusions consumed in Turkey. The Science of the Total Environment 359: 82–89

Bishara S E, Oonsombat C, Ajlouni R, Denehy G 2002 The effect of saliva contamination on the shear bond strength of orthodontic brackets when using a self-etching primer. Angle Orthodontist 72: 554–557

Brunton P A, Hussain A 2001 The erosive effect of herbal tea on dental enamel. Journal of Dentistry 29: 517–520

Cozza P, Martucci L, Toffol L D, Penco S I 2006 Shear bond strength of metal brackets on enamel. Angle Orthodontist 76: 851–856

Dinçer B, Hazar S, Sen B H 2002 Scanning electron microscopic study of the effects of soft drinks on etched and sealed enamel. American Journal of Orthodontics and Dentofacial Orthopedics 122: 135–141

Hobson R S, McCabe J F, Hogg S D 2000 The effect of food simulants on enamel–composite bond strength. Journal of Orthodontics 27: 55–59

Hughes J A, West N X, Parker D M, van den Braak M H, Addy M 2000 Effects of pH and concentration of citric, malic and lactic acids on enamel, *in vitro*. Journal of Dentistry 28: 147–152

Larmour C J, McCabe J F, Gordon P H 1998 An *ex vivo* investigation into the effects of chemical solvents on the bond behaviour of ceramic orthodontic bracket. British Journal of Orthodontics 25: 35–39

Littlewood S J, Mitchell L, Greenwood D C, Bubb N L, Wood D J 2000 Investigation of a hydrophilic primer for orthodontic bonding: an *in vitro* study. Journal of Orthodontics 27: 181–186

McKinney J E, Wu W 1985 Chemical softening and wear of dental composites. Journal of Dental Research 64: 1326–1331

Murray S D, Hobson R S 2003 Comparison of *in vivo* and *in vitro* shear bond strength. American Journal of Orthodontics and Dentofacial Orthopedics 123: 2–9

Northrup R G, Berzins D W, Bradley T G, Schuckit W 2007 Shear bond strength comparison between two orthodontic adhesives and self-ligating and conventional brackets. Angle Orthodontist 77: 701–706

Oncag G, Tuncer A V, Tosun Y S 2005 Acidic soft drinks effects on the shear bond strength of orthodontic brackets and a scanning electron microscopy evaluation of the enamel. Angle Orthodontist 75: 243–249

Phelan J, Rees J 2003 The erosive potential of some herbal teas. Journal of Dentistry 31: 241–246

Reis A, dos Santos J E, Loguercio A D, de Oliveira Bauer J R 2008 Eighteen-month bracket survival rate: conventional versus self-etch adhesive. European Journal of Orthodontics 30: 94–99

Reynolds I R, von Fraunhofer J A 1976 Direct bonding of orthodontic attachments to teeth: the relation of adhesive bond strength to gauge mesh size. British Journal of Orthodontics 3: 91–95

Soderquist S A, Drummond J L, Evans C A 2006 Bond strength evaluation of ceramic and stainless steel bracket bases subjected to cyclic tensile loading. American Journal of Orthodontics and Dentofacial Orthopedics 129: 175.e7–e12

Sunna S, Rock W P 1998 Clinical performance of orthodontic brackets and adhesive systems: a randomized clinical trial. British Journal of Orthodontics 25: 283–287

The Tea Council Ltd 2000 The facts about tea. Tea Council, London

Zachrisson B U 1977 A post treatment evaluation of direct bonding in orthodontics. American Journal of Orthodontics 71: 1173–1189