Section A-Research paper

Effects of different beverages on Shear Bond Strength and Adhesive Remnant Index of Orthodontic metal brackets

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ABSTRACT

INTRODUCTION: Shear bond strength is the amount of force required to break the connection between a bonded bracket and tooth. Bond failure of the bracket during orthodontic treatment is a common problem which results in treatment interference, increase treatment time and prolonged clinical time for rebonding of failure brackets. Various factors can contribute to bond failure including poor operator technique, saliva contamination and masticatory forces. These days there is increased consumption of all types of beverages among children as well as adults. In previous studies, it has been seen that beverages can also affect the bond strength and adhesion of the brackets. Therefore, this study aims to evaluate the shear bond strength and adhesive remnant index of the bracket-tooth interface during the consumption of different types of beverages.

OBJECTIVES: The purpose of the study was to evaluate the effects of different beverages on the shear bond strength and adhesive remnant index of orthodontic metal brackets.

METHOD: A total of 60 human premolars extracted for orthodontic purposes were used. They were divided into 3 groups with a total of 20 teeth in each group. Group 1 was immersed in Artificial Saliva (AS) and it was changed daily, Group 2 was immersed in Coca-Cola and Group 3 in Tea for a period of 30 days twice a day for 15 minutes and for the rest of the time they were kept immersed in AS till the next cycle; simulating the oral environment. After 30 days all the samples were subjected to shear testing with the help of a universal testing machine to check the shear bond strength (SBS) and a microscopic study was done to check the adhesive remnant index (ARI) of all the 3 groups.

RESULTS: Shear bond strength of the group immersed in Coca-Cola was significantly less as compared to the group immersed in Artificial Saliva. There was no significant difference between groups immersed in Coca-Cola and Tea. There was no significant difference between the Adhesive remnant index of all three groups.

CONCLUSION: The shear bond strength of the group immersed in Coca-Cola was less than that of the control group (AS), which means that phosphoric acid-based drinks should be avoided during fixed orthodontic treatment as it can affect the retention of the stainless-steel brackets. Tea does not seem to have destructive potential on enamel or bond strength of orthodontic brackets. Acid-based drinks also cause enamel erosion as these drinks cause demineralization of the enamel. Therefore, adult patients who seek orthodontic treatment should be informed about such beverages' destructive potential and advised to avoid such drinks during the treatment.

KEYWORDS: Soft drinks; Shear bond strength; Adhesive Remnant Index; Artificial Saliva; Bonding; Orthodontics

INTRODUCTION

Bond failure of brackets during orthodontic treatment is a common problem which results in treatment procedure interference, increased treatment time and prolonged clinical time for re-bonding of failed brackets. The incidence of bracket bond failure varies from 0.5% to 17.6%. Various factors that affect bond failure are poor operator technique, enamel surface texture, salivary contamination of the prepared enamel surface, bracket properties, masticatory forces and patient’s behaviour. Acidic and alcoholic foods and beverages may influence bond failure. There

are also a number of factors affecting bracket retention during orthodontic treatment such as the condition of the enamel surface.[1]

With the introduction of the acid-etch technique for orthodontic bonding a new era in orthodontics has opened. During fixed orthodontic treatment, many factors affect the retention of the brackets. Healthy enamel is also needed for the retention of the brackets to the tooth surface as an altered enamel surface may affect the retention. As the development of adhesives is taking place at a rapid rate, white spot lesions seen clinically as decalcification of enamel around orthodontic brackets have remained a neglected part of orthodontic care.[2]

Decalcification is defined as the loss of calcified tooth substance, and it occurs when the pH of the oral environment favours the diffusion of calcium and phosphate ions out of enamel. Preventing the decalcification that occurs during orthodontic treatment is an important concern because these lesions are unaesthetic, potentially irreversible, and cariogenic.[2]

The bracket retention mechanism also plays an important role in retention. The retention mechanism of mesh pads in the bracket base with a mechanical undercut provides a place for the orthodontic adhesive to extend before polymerization. A fine‐brazed mesh in metal brackets provides retention to most of the metal brackets. Studies have stipulated that bond failure in enamel‐bonded metal brackets with a mechanical interlock with 15 seconds of acid‐etching time occurs at the resin–bracket base interface, between the resin and enamel or within the resin itself.[3]

The term ‘soft’ drinks refer to all drinks except alcohol, mineral water, fruit juice, tea, coffee or milk-based drinks which may or may not be carbonated. Recently, the consumption of soft drinks has increased. They are damaging not only because of the high levels of sugar they contain but also because most have pH levels below the critical limit for enamel demineralization (pH <5.5; Frequently consumed soft drinks have been shown to cause extreme dental erosion.[4]

The appearance of white spot lesions is caused by the demineralization of tooth enamel occurring around and beneath the brackets due to a decrease in pH. Studies that use SEM to evaluate the effect of soft drinks on enamel sealed with orthodontic adhesives have observed areas of enamel

showing adhesive loss after exposure to soft drinks. This suggests that soft drink consumption increase in microleakage beneath brackets and also compromise bond strength.

Nowadays, soft drinks as well as herbal teas have become popular worldwide because of their beneficial effect on both physical and mental health. Some researchers have found enamel loss caused by herbal teas. As many orthodontic patients, especially adults, routinely drink herbal tea, there could be a possible relationship between the teas' initial pH and the brackets' bond failure.[4]

Hence, this study was undertaken to evaluate the effects of two drinks (Coca-Cola and tea) on SBS and ARI of orthodontic metal brackets.

METHODOLOGY

This study was conducted for a period of 30 days to evaluate the effects of different beverages on SBS and ARI of orthodontic metal brackets.

60 extracted human premolars of patients who require orthodontic treatment were collected with inclusion and exclusion criteria as follows:

Inclusion criteria- Premolars extracted for orthodontic purpose with healthy enamel on the buccal surface of teeth, intact crown with roots, and teeth with good morphology.

Exclusion criteria- No attrition, fracture or restorations, no hypoplastic lesion, premolars without congenital anomalies and structural defects and no chemical substance application on the tooth such as hydrogen peroxide.

A total sample size of 60 extracted human premolars was divided into 3 groups with 1 control group and 2 experimental groups i.e., 20 extracted premolars in each group: (Fig. 1)

Group I- Artificial saliva (Red)

Group II- Coca-Cola (Blue)

Group III- Tea (Green)

Figure- 1 extracted premolars after bonding

Bonding procedure: Sixty extracted non-carious human premolars of orthodontic patients were used in the study. They were stored in distilled water before the study was conducted. All teeth were mounted with roots of teeth completely embedded vertically in plaster slab/blocks so that the load could be applied to the bracket-tooth interface parallel to the buccal tooth surface. The buccal surface of the teeth was cleaned with fluoride-free pumice and was etched with 37% phosphoric acid for 30 seconds, rinsed with water for 15 seconds and air dried with oil-free compressed air. A layer of primer was applied to each tooth and then light cured for 10 seconds. The orthodontic adhesive was applied to the base of the metal bracket. The brackets were centered on the crown of the tooth mesiodistally with a height of each bracket at 4mm, along the long axis of the tooth and then pressed firmly on the tooth surface. The excess adhesive was removed with a scaler and the adhesive was light cured from four sides of the bracket edge, each for 10 seconds. All samples were kept in artificial saliva at room temperature for 24 hours. (Fig.2)

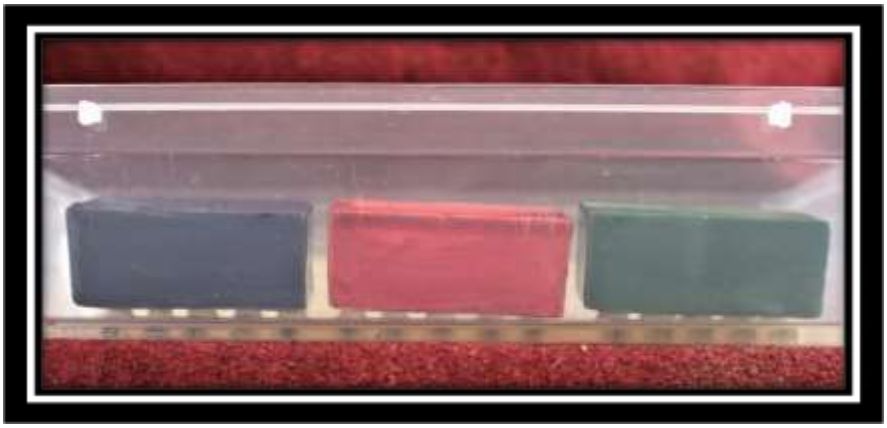


Figure 2- samples immersed in artificial saliva

Storage of specimens (Fig. 3)

Group I- Artificial saliva (Control Group)

- 20 teeth were kept in artificial saliva during the 30 days
- Artificial saliva was refreshed daily

Group II- Coca-Cola

- 20 extracted teeth were submerged in Coca-Cola for 15 minutes twice a day.
- In the first immersion cycle 20 teeth were submerged in Coca-Cola for 15 minutes.
- After 15 minutes they were kept in artificial saliva before the second immersion cycle is conducted.
- In the second immersion cycle, again the teeth were transferred to Coca-Cola directly from artificial saliva and were submerged for 15 minutes.
- After 15 minutes they were kept in artificial saliva till the next immersion cycle was initiated the next day.
- 2 cycles were completed every day in a similar manner
- Coca-Cola was used cold, directly from the refrigerator at each session
- Procedure was repeated over a period of 30 days
- After each session the solution (Coca-Cola) was replenished
- In each interval, after thorough irrigation with distilled water the specimens were stored in artificial saliva.
- Artificial saliva was changed at weekly interval

Group III- Tea

- 20 extracted teeth were submerged in tea for 15 minutes twice a day.
- Tea used in the study was brewed according to the manufacturer's instructions before the teeth were submerged in tea.
- In the first immersion cycle 20 teeth were submerged in tea for 15 minutes.
- After 15 minutes they were kept in artificial saliva before the second immersion cycle is conducted.
- In the second immersion cycle, again the teeth were transferred to tea directly from artificial saliva and were submerged for 15 minutes.

- After 15 minutes they were kept in artificial saliva till the next immersion cycle was initiated the next day.
- 2 cycles were completed every day in a similar manner
- Procedure was repeated over a period of 30 days
- After each cycle the solution (Tea) was replenished
- In each interval, after thorough irrigation with distilled water the specimens were stored in artificial saliva.
- Artificial saliva was changed at weekly intervals

Figure 3- storage of specimens in their respective storage medium

After each immersion cycle, all specimens were kept in artificial saliva at room temperature. After 30 days, they were tested for shear bond strength and adhesive remnant index.

The shear bond strength was measured with a universal testing machine with a shear load applied to the bracket at a crosshead speed of 1mm/min. An occluso-gingival load was applied till the bracket was debonded from the tooth surface.

The load at which the bracket was deboned was recorded in Newtons and subsequently calculated in Mega Pascals using the formula:

$$\text{Shear bond strength (MPa)} = \frac{\text{F (debonding force in Newtons)}}{\text{D x Lmm}^2 \text{ (bracket base area)}}$$

Where:

D= width of the bracket base

L= height of the bracket base.

After debonding, each tooth was examined under a stereomicroscope at 12x magnification and the fraction of the remained adhesive on the tooth surface was scored using Adhesive Remnant Index (ARI). The possible values of the Adhesive Remnant Index (ARI) as described by Artun and Bergland (1948) are as follows[2]-

- 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
- 3- All the adhesive left on the tooth

RESULTS

The study was performed with a total sample size of 60 extracted human premolars. These were further divided into 3 groups with 20 teeth in each group. The buccal surfaces of each tooth were bonded with premolar metal brackets.

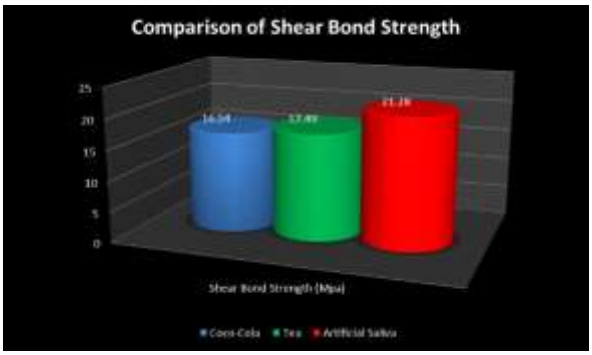
The bonded metal brackets were subjected to shear bond testing with the universal testing machine and adhesive remnant index with a stereomicroscope.

Shear Bond Strength

Maximum mean shear bond strength was observed with artificial saliva (21.28±4.54 MPa) followed by tea (17.49±5.87 MPa) and least with coca-cola (16.54±4.42 MPa) Statistical analysis showed that there was a statistically significant difference in bond strength among the study groups (P=0.010).

Multiple comparisons were carried out which showed that there was a statistically significant difference in shear bond strength between coca-cola and artificial saliva (P=0.011). The shear bond strength with artificial saliva was significantly higher than that with coca-cola. (Graph 1)

There was no statistically significant difference in shear bond strength between coca-cola and tea (P=0.820) and between tea and artificial saliva (P=0.050).

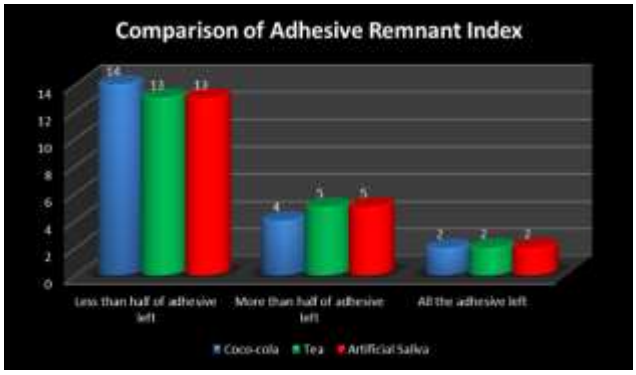


Graph 1- Comparison of SBS

Adhesive Remnant Index

According to Artun and Bergland's classification, 14 (70%) samples in the coca-cola group had a score of 1 i.e., less than half of the adhesive left on the tooth. In both tea and artificial saliva groups, there were 13 (65%) samples each with a score of 1. In the coca-cola group, 4 (20%) samples had a score of 2 i.e., more than half of the adhesive left on the tooth. In both tea and artificial saliva groups, there were 5 (25%) samples each with a score of 2. There were 2 (10%) samples in all three study groups with a score of 3 i.e., all the adhesive left on the tooth. Statistical analysis showed that there was no statistically significant association between study groups and their ARI scores (P=0.996).

The comparison of ARI was carried out using the chi-square test. These three groups showed no statistically significant association between three study groups with a 'P' value < 0.05 (P= 0.996) (Graph 2)



Graph 2- Comparison of ARI

DISCUSSION

Bond strength determines the amount of force delivered and also affects the treatment duration. Shear bond strength depends on several factors which include the adhesive properties of the bonding materials, the attachment at the different interphases such as the tooth to composite interphase and the composite-to-bracket interphase as well as the polymerization of the composite bonding material. The bonding procedure involves etching, primer solution and adhesive application followed by composite application.[13]

Other factors affecting the bond strength of orthodontic metal brackets are the size and design of the bracket base. The bracket base attachment must withstand masticatory loads, be able to deliver orthodontic forces, be esthetic, and be easy to remove at the end of treatment. Efforts have been made to improve mechanical retention because bracket bases do not bond chemically to enamel or resin. The increasing demand for a more esthetic metal‑bonded appliance has led to other things, a reduction in the size of the brackets and their bases. However, bond strength is influenced by the smaller retentive area of the bracket base.[3]

A fixed orthodontic appliance is a powerful tool, but bracket failure during orthodontic treatment is the key factor that can extend the duration of treatment. Orthodontic bracket bond failure is a common problem during orthodontic treatment with a reported incidence of 17.6%. This might be due to the adhesives used, an improper bonding process as well as inadequate materials and curing lights. Furthermore, some diets may also result in bracket failure. The bond strength also gets affected by the food or drinks that decreases the intraoral pH value below the critical value of 5.5 which creates enamel decalcification or erosion. Examples of low-pH food or drink are acidic fruits like lime, lemon, and orange or soft drinks like Coca-Cola, Sprite, etc. The effects of acidic foods, acidic and alcoholic beverages, herbal teas and different chemical solvents on the bond strength of orthodontic brackets have been investigated by researchers.

'Erosion' is defined as the loss of the tooth surface by non-bacterial acids and has a multifactorial etiology which includes acids from dietary, environmental and gastric sources. Over the last few years, the prevalence of dental erosion seems to have increased possibly as a result of the increasing consumption of soft drinks and commercial fruit juices. Frequent contact of the dentition with acidic food or beverages that generate exogenous acids might result in dental

erosion**.** Evidence shows that erosion is strongly correlated with the frequency and amount of soft drink intake.

During orthodontic treatment with fixed appliances, frequent intake of soft drinks increases the risk of erosion, which can decrease the retention of the brackets.

This in-vitro study was conducted with a sample of 60 teeth which were divided into 3 groups with 20 teeth in each group. Group 1 was Artificial Saliva which was the control group with a colour coding of red, group 2 was Coca-Cola with a colour coding of blue and group 3 was Tea with a colour coding of green were used. Maxillary and mandibular first and second premolars were used and orthodontic metal brackets were bonded following the careful inclusion and exclusion criteria. They were bonded on the buccal surface of each tooth following the same bonding procedure and the bracket was centered on the crown of the tooth mesiodistally and along the long axis of the tooth**.**

All the study groups were immersed in all three beverages for 15 minutes twice a day using the fresh solution every time and leaving them immersed in artificial saliva for the rest of the time. However, the control group was different as the teeth were kept submerged in AS for a day and the solution was replenished the next day. The teeth were kept in artificial saliva between the immersion cycles in the drinks in order to reproduce normal oral environmental conditions and also to allow the possible remineralizing effects of saliva on enamel to take place.

This in-vitro study was conducted assuming that a young or adult patient receiving orthodontic treatment might consume coca-cola & tea twice a day and that the consumption period would be 15 minutes. Artificial saliva was chosen as the control to simulate wet oral conditions.

The shear test was performed with a universal testing machine (UTM) with a crosshead speed of 1mm/minute at the bracket tooth interface which showed SBS of coca-cola was 16.54±4.42 MPa and AS was 21.28±4.54 MPa whereas the SBS of tea was 17.49±5.87 MPa. In our in-vitro study results of shear testing showed that artificial saliva had the maximum shear bond strength followed by tea with moderate and least with the coca-cola. Statistical analysis showed that there was a statistically significant difference in the bond strength among the study group with a ‘P’ value of 0.010.

In a comparison of coca-cola, tea and artificial saliva, the shear bond strength was found to be lowered with the coca-cola as compared to the control group. The difference in the shear bond strength of these groups was statistically significant with a 'P' value of <0.05. Multiple comparisons were carried out which showed no statistically significant difference in shear bond strength between coca-cola and tea with a 'P' value of 0.820 and comparison in our study between tea and artificial saliva with a 'P' value of 0.050 also showed no statistically significant difference in shear bond strength. As coke-based drinks have phosphoric acid, these results can be explained by the studies showing that drinks with a phosphoric acid base have greater erosive potential.

An in-vivo study[4] was conducted by to evaluate the effects of acidic drinks on metal brackets with and without resin infiltration treatment. The author explained that they choose coca-cola because of its high levels of consumption and their pH levels were below the critical limit for demineralization of tooth enamel (pH, 5.5). Coca-Cola contains phosphoric acid and Sprite contains citric acid, both of which were used in acid etching for the placement of orthodontic brackets. The results of the study showed that coca-cola had lower SBS than sprite. This supports the results of our study as our study also showed the statistically significant result in coca-cola and AS.

According to a study, the erosive effects of phosphoric acid are more as compared to citric acid. Due to erosion, the retention of the brackets gets affected. The in-vitro study conducted by the author to evaluate the effects of Coca-cola and Mirinda with artificial saliva as control group, it was found that maximum SBS was seen with the control group followed by coca-cola.[3]

According to some studies, the values of SBS can also vary because of the blade design used for testing the shear strength. Most studies used a shearing blade for debonding the brackets, whereas some studies used wire loops. Debonding brackets with a wire loop is not a true form of shear bond strength testing, since it also incorporates a component of tensile stress.[5]

The ARI was done on all 60 samples. Any adhesive that remained after the bracket removal was assessed under a stereomicroscope of 12 x magnification and scored according to the ARI proposed by Artun and Bergland. In this study, after evaluating the ARI score, a higher mean score was recorded in group 2 (coca-cola) with 70% of samples with an ARI score of 1 (less than

half of the adhesive left on the tooth) followed by tea and artificial saliva with same scoring of samples with ARI 1 (65%). Statistical analysis showed that there was no statistically significant association between study groups and their ARI with a 'P' value of 0.99. The results were similar[1] another study which also showed statistically insignificant results of ARI with a 'P' value of 0.79.

It has been reported[11] that the absorption of acids and acidic drinks may degrade the structure of Bisphenol A Glycidyl Methacrylate or bis-GMA – based composite resins the resin matrix is softened and fillers leach out, decreasing the bracket bond strength. This supports the decrease of SBS in our study**.**

The literature is contradictory regarding the erosive potential of beverages containing citric acid or phosphoric acid. One study showed that beverages containing phosphoric acid are more erosive than those containing citric acid while others showed the opposite.[6]

A scanning electron microscopic (SEM) study was conducted to evaluate the effects of soft drinks on etched enamel. It was conducted by simulating the oral environment on 60 human-extracted premolars for orthodontic purposes including the drinks that might be consumed at intervals of 2 or 3 times a day similar to our study. According to the researchers, acidic soft drinks might not harm the enamel if they are removed from the enamel by saliva as saliva is considered a key defence mechanism against demineralization but the more contact that occurs, the greater the enamel loss.[7]

One of the limitations of our study was the determination of pH values which was not taken into consideration. According to previous studies, the pH values of beverages and saliva play a role in the bond strength of orthodontic brackets as the bicarbonate levels in saliva are positively correlated to the salivary flow rate, which means that higher salivary flow leads to a higher pH and higher buffering capacity. Despite this increase, it takes about 25‑30 minutes for the pH to return to intraoral physiological values. The greater the ability to titrate the beverage, the greater the time necessary for the saliva to neutralize the acid.[8]

A study showed that carbonated soft drinks can affect shear bond strength either by deteriorating the structure of the adhesive materials or by causing erosive lesions on the enamel surface

around the brackets with the main effect of the beverage compositions and total acid content, rather than pH of the beverage.[6]

In this in-vitro study, the teeth were intermittently exposed to different beverages over a period of 30 days. Although it is not possible to replicate the complex oral environment such as dental anatomy, the composition of dental hard tissues, salivary conditions and real buffer capacity, frequency and duration of consumption of drinks and other dietary habits, this in-vitro study reveals the decrease in SBS with coca-cola as well as tea. As the consumption of different beverages like coke and tea are common nowadays, especially among adolescents, the possibility of greater damage to tooth structure should be considered by the clinician. During the fixed orthodontic treatment, the patients are not able to maintain good oral hygiene and along with the consumption of acidic beverages, the strength of the brackets decreases with the erosion of dental tissue as per our study and previous literature available. Therefore, the patients are advised to maintain good oral hygiene and to reduce the consumption of acidic or soft drinks.

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