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Effect of Dietary Components on the Shear Bond Strength of Orthodontics Brackets after Thermal Aging

Philip Punzalan, Tanya Al Talib, Anthony Fusco, Neamat Hassan Abubakr*

School of Dental Medicine, University of Nevada, Las Vegas, Nevada, USA
Email: *neamat.hassan@unlv.edu

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Abstract

Introduction: The stability of orthodontic brackets throughout orthodontic treatment plays a critical role in the treatment's effectiveness. The present *in vitro* study was designed to assess the impact of various dietary components on the performance of orthodontic brackets. **Methods:** Metal orthodontic brackets were bonded to 66 extracted anterior teeth divided into groups based on the solution type: Milk, Gatorade, Cold Coffee, and a control group using water. Each group consisted of 20 teeth except for the control group, which included six teeth. The bracketed teeth were submerged in their respective solutions for 15 minutes three times daily at different intervals to mimic an *in vivo* environment and were stored in artificial saliva at room temperature (23˚C). The specimens underwent artificial aging through 10,000 cycles of thermocycling (representing one clinical year) between 5˚C and 55˚C. Shade measurements were taken using a VITA Easy Shade device, capturing the classic shade and L^*, a^*, and b^* values. Delta E values were calculated immediately post-bonding and after 7 days, 1 month, 1, and 2 clinical years. The shear bond strength of each bracket was measured using an ultra-tester machine. **Results:** After two clinical years, significant differences in ΔE color values were observed across all groups, with the most substantial change noted in teeth immersed in cold coffee. Brackets submerged in milk demonstrated lower shear bond strength than other solutions, whereas the control group exhibited the highest shear bond strength ($P = 0.01$). **Conclusion:** The study indicates that dietary components significantly influence tooth color stability and the shear bond strength of orthodontic brackets, underscoring the importance of considering these factors in orthodontic treatment planning.

Keywords

Shear Bond, Orthodontic Brackets, Color Stability, Thermal Aging

1. Introduction

There is a discernible increase in the consumption of soft drinks with low pH levels, particularly among adolescents, documented in recent studies [1]. Elevated intake of such dietary components can enhance enamel vulnerability to acids, predominantly from beverages like energy drinks [2]. Furthermore, individual habits significantly impact color stability, leading to tooth and restorative discoloration [3]. The interaction with low-pH dietary components may also compromise the bond integrity at the interfaces between the bonding material and the orthodontic brackets, with failures typically occurring in the defective enamel areas surrounding the brackets due to the acidity of the soft drinks [4]. In orthodontic treatments, aesthetic considerations are as critical as functional requirements [5]. Several factors, including salivary pH, oral microflora and their byproducts, dietary habits, and the surface integrity of materials, crucially influence the material's integrity within the oral cavity [6] [7]. Dietary components affect the sealing quality of orthodontic brackets and negatively impact bracket retention against shearing forces [5]. Numerous studies have evaluated the shear bond strength of orthodontic brackets after exposure to various dietary components, revealing that the bond strength to enamel is indeed compromised. A systematic review of the effects of carbonated soft drinks on orthodontic treatments highlighted that these beverages generally reduce the shear bond strength of orthodontic brackets and alter enamel properties [8]. Specifically, the impact of Coca-Cola on orthodontic materials has been examined, but these studies often suffer from an insufficient number of samples or patients and lack adequate observation periods [4]. Common beverages used in these studies include Sprite, Coca-Cola, orange soda, and orange juice [4] [9] [10]. Assessments of bond strength are generally considered the most accurate *in vivo*, given their comprehensive analysis of all relevant parameters within the oral environment and their effect on the *in vivo* degradation of the bracket bonding system [11]. The present *in-vitro* study aims to evaluate the performance of orthodontic brackets when exposed to various dietary components.

2. Methods

Materials and Survey Data Collection Protocol

This study was undertaken to investigate the effects of dietary components on the stability and coloration of orthodontic brackets. The study was conducted using common beverages identified from a survey of students at the University of Nevada, Las Vegas, School of Dental Medicine (UNLV SDM) regarding their preferred drinks during orthodontic treatment. The dietary solutions selected based on the survey included water, milk, Gatorade, and iced coffee, with water being the most frequently consumed (**Figure 1**).

Sixty-six anterior teeth were collected from UNLV SDM clinics and bonded with stainless steel orthodontic brackets (American Orthodontics Metal Twin

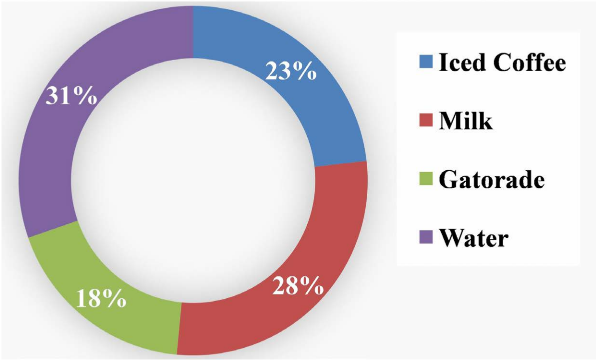

Figure 1. Most preferred drinks among young adults.

Brackets). These were then randomly divided into three test groups (milk, Gatorade, and iced coffee) and one control group (water) (**Figure 2(a)** & **Figure 2(b)**). To simulate in vivo conditions, the bonded teeth were submerged in their respective solutions for 15 minutes, three times daily, and stored in artificial saliva (Pickering Laboratories, Mountain View, CA, USA) at room temperature (23˚C) (**Figure 2(c)**).

The specimens underwent artificial aging through thermocycling for 10,000 cycles (representing one clinical year) between 5˚C and 55˚C. Shade measurements were taken using a VITA Easy Shade device, with readings of the classic shade and the CIE L^*, a^*, and b^* color values recorded. Delta E values were calculated immediately post-bonding, after 7 days, 1 month, 1 year, and 2 years. Post-aging, the roots were severed, and the coronal portions containing the brackets were embedded in acrylic resin, exposing the buccal side (**Figure 3(a)**, **Figure 3(b)**). Shear bond strength for each bracket was measured using an UltraTester™ Bond Strength Testing Machine. [UltraTester™ Bond Strength Testing Machine] (**Figure 3(c)**).

The color parameters were recorded immediately after bonding of the brackets, then after 7 days, 1 month, 1 clinical year, and 2 clinical years using VITA easy shade. The CIE system: L^* (luminescence), a^* (red/green), and b^* (blue/yellow) as the baseline parameters to determine the delta $E\,(\Delta E)$. Delta $E\,(\Delta E)$ is a variable that is commonly used to measure the difference in color. To calculate color differences the following equation was used:

$$\Delta E^* = \left[\left(\Delta L^*\right)^2 + \left(\Delta A^*\right)^2 + \left(\Delta b^*\right)^2\right]^{1/2}$$

The statistical analysis included two-way ANOVA and post-hoc Tukey tests to evaluate the shear bond strength data.

3. Results

Across all test groups, significant differences in ΔE color values were observed after two years of artificial aging. Specifically, teeth submerged in iced coffee exhibited the highest mean ΔE after the first clinical year. Interestingly, while the ΔE values for teeth exposed to milk initially decreased after one year, they increased

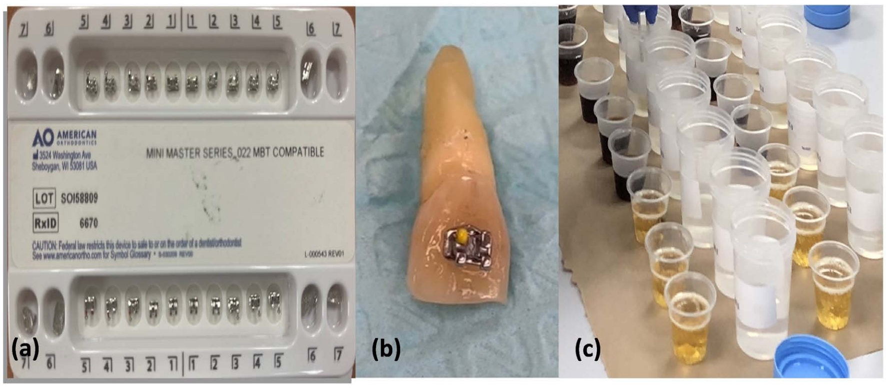

Figure 2. (a) American Orthodontics Metal Twin Brackets. (b) Brackets placed on each individual anterior tooth. (c) Dietary solutions on which teeth with bonded brackets were immersed.

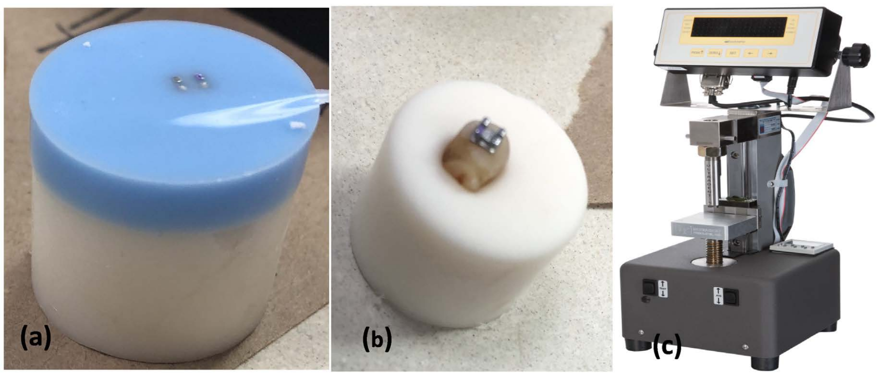

Figure 3. (a) Samples mounted in acrylic resin with the buccal side c (b) Exposed bonded brackets ready to be tested by shear bond strength. (c) Ultra Tester™ Bond Strength Testing Machine.

significantly by the end of the second year, surpassing all other solutions in ΔE values. Regarding mechanical properties, brackets submerged in milk's shear bond strength was lower than those in other solutions. In contrast, brackets in the control group (water) demonstrated the highest shear bond strength (P = 0.01).

Figure 4 illustrates the shear bond strength of all samples after two clinical years of thermal aging. The data indicate that the control group (water) exhibited the highest shear bond strength. Subsequent to water, the shear bond strength of brackets was least compromised by immersion in Gatorade and iced coffee. Conversely, brackets immersed in milk demonstrated the lowest shear bond strength among all groups tested (P = 0.01) (Figure 4).

4. Discussion

The stability of orthodontic bracket bond strength and aesthetics are critical concerns for patients and practitioners. The performance of orthodontic brackets can influence the orthodontic treatment efficiency. The current study illustrates significant alterations in the performance of orthodontic brackets when

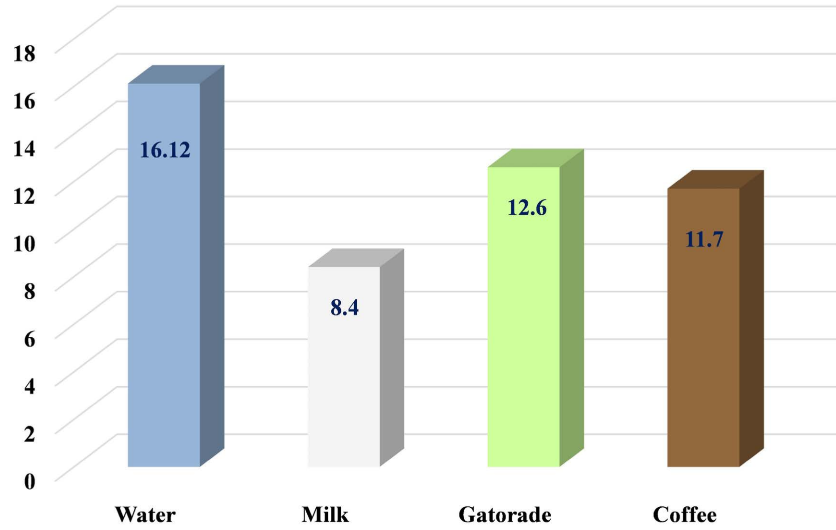

Figure 4. Shear Bond strength of all samples after thermal aging for 2 clinical years.

exposed to various dietary components. Specifically, the color stability of teeth and the shear bond strength of orthodontic brackets which manifest as clinical challenges in the oral environment during orthodontic treatment.

The primary objective of this study was to evaluate the effects of common beverages consumed by orthodontic patients, focusing on the impact of thermal aging over time. The investigation assessed the influence of milk, iced coffee, and Gatorade on the shear bond strength of orthodontic brackets and the color stability of bonded teeth. The findings indicate a detrimental effect over time on bond strength and color stability, aligning with similar recent studies that highlight dietary liquids' significant and sustained impacts on these parameters [12] [13]. These results corroborate other recent experimental data that examine the effects of various beverages on orthodontic bonded tooth color stability and bracket shear bond strength [12] [14] [15] [16]. The reduced shear bond strength of brackets may be attributed to the degradation of composite bonding the bracket to the tooth [17] as well as the microleakage sound the bracket [18]. Notably, the teeth immersed in milk exhibited the lowest shear bond strength among all samples, a surprising result potentially attributable to the lactic acid content in milk. The present findings comes into agreement with previous research that indicated that milk contribute in lowering the shear bond strength [16]. Future research in this area could benefit from more detailed investigations into milk's effects and the potential correlations between the acidity of dietary liquids, tooth shade, and bond strength.

5. Conclusion

The selected dietary components significantly influenced the color stability and mechanical integrity of the orthodontic brackets. The findings suggest that both aesthetic and structural considerations are crucial for orthodontic treatment planning, particularly regarding dietary habits during treatment.

Author Contributions

TA and NHA were responsible for the overall project design. PP and AF were responsible for data generation. TA and NHA were responsible for analysis and worked alongside PP for the writing of this manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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