Assessment of the Stain Steel Orthodontic Arch Wire's Surface Roughness Following Immersion in Different Media

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Abstract

Orthodontic arch-wires made of stainless steel are frequently employed because of their advantageous properties, particularly in the levelling and alignment stages. The study investigated how three different liquids—date vinegar, apple cider vinegar, and bottled water—affect the surface roughness of orthodontic wires following a predetermined amount of time submerged in each. Depending on the immersion media being utilized, thirty pieces of stainless-steel arch wire were split into three groups of ten. Arch wires made of stainless steel that have been chopped into 4.5 cm pieces. For two weeks, the wires were submerged in three distinct media: date vinegar, apple cider vinegar, and distilled water as a control group. To determine the differences between the groups under study, the LSD (HSD) test and the analysis of variance (ANOVA) test were employed. The results revealed significant differences (P>0.05) among different immersion media for all types of arch-wires. The highest Ra values were recorded after immersion in Date vinegar. The lowest Ra was recorded after immersing in Apple cider vinegar. It was concluded that acidic solutions, including date vinegar and apple vinegar, increase the surface roughness of the stainless-steel wires. suggesting the use of orthodontic arch-wires during orthodontic treatment should be done with caution

Keywords: Stainless steel orthodontic wires; surface roughness; immersion; Date Vinegar, and Apple Cider Vinegar

Introduction

The need for orthodontic equipment to seem more aesthetically pleasing has grown recently. As a result, businesses have released new appliances with preferred therapeutic and cosmetic features [1]. Composite and coated metal arch-wires are two types of aesthetic arch-wires [2]. AISI (American Iron and Steel Institute) type 304 was a stainless-steel alloy used in orthodontic materials [3]. Austenitic 18-8 stainless steel is the most often used kind. Nearly 8% nickel and 18% chromium make up its composition. By creating a passive oxide layer that prevents further oxygen delivery to the inner core, 18-8 stainless steel's unique property is its great corrosion resistance [4]. The quantity of

cold working and annealing that is done throughout the production process may be altered to affect the characteristics of stainless-steel wires. They may be cold worked to harden them and annealed to soften them [5]. Additionally, these wires may be soldered and welded to create other appliances, although solder is required to strengthen the weld connections [6, 7]. Fixed orthodontic treatment typically delays the maintenance of good oral hygiene. Therefore, the insertion of a permanent orthodontic appliance severely compromises oral hygiene, allowing plaque to build up around the appliance, leading to gingivitis and enamel decalcification [8]. Thus, in addition to mechanical plaque reduction methods like brushing and flossing, chemical methods like mouthwashes, toothpaste, and gels are required. Mouthwash usage has increased recently for hygiene reasons, mostly related to orthodontic treatment [9]. Another benefit of mouthwashes is that their antibacterial activity can travel to hard-to-reach places [10]. Mouthwashes are also regarded as an oral hygiene tool that transfers the antimicrobial agent (after brushing) [11].

The relationship between mouthwashes and vinegar lies primarily in their acidity and potential impact on dental and orthodontic materials. Although commercial mouthwashes are formulated for safe intraoral use, some—especially those containing alcohol or chlorhexidine—have been reported to cause mild corrosion or alterations in the surface properties of orthodontic appliances over time. In contrast, vinegar, particularly apple and date vinegar, is significantly more acidic While both substances can interact with orthodontic materials, the corrosive potential of vinegar is notably higher, highlighting the need to caution patients undergoing orthodontic treatment against frequent or prolonged exposure to acidic substances not designed for oral use [11].

In recent years, attention has been drawn to the impact of dietary and natural acidic substances on the integrity of orthodontic appliances. Vinegar, particularly apple cider vinegar and date vinegar, is widely consumed for health-related purposes; however, its acidic nature poses potential risks when it comes into contact with orthodontic materials. Several studies have explored the corrosive and surface-altering effects of acidic solutions on orthodontic arch-wires. For example, Alkurt et al. [12]. examined the influence of apple vinegar on orthodontic arch-wires and found a significant increase in surface roughness and ion release, indicating a strong corrosive potential. Similarly, El-Bialy et al. [13] reported that natural fruit vinegars, including apple vinegar, caused surface degradation in nickel-titanium archwires. This study aims to evaluate and compare surface characteristics stain steel orthodontic arch wire after immersion in distilled water, Date Vingar and Apple cider.

Materials and Methodologies

The materials used in the current study include: the orthodontic arch-wires (True force, Ortho Technology, USA) , Vinegar Date (Al Badawy, Syria), and Apple Cider Vinegar (Zer group, Turkey). Stainless steel Arch-wires were cut into pieces of 4.5cm in length.

Figure 1: Stainless steel arch wires

Preparation of the media used in the study:

1.Preparation of distilled water group

A Hanna pH meter was used to measure the pH, and the distilled water's pH was (7). To be ready for the planned process, equal volumes of 15mm distilled water were added to a covered glass container.

2. Preparation of Date vinegar group.

The Hanna pH meter was used to measure the pH, and the date vinegar's pH was 2.6. To prepare for the planned process, equal parts of date

vinegar (15 mm) were added to a covered glass container.

3. Preparation of Apple cider vinegar

Using a Hanna pH meter, the pH of apple cider vinegar was found to be 2.5. To prepare for the planned process, equal parts of apple cider vinegar (15 mm) were added to a closed glass container.

Sample preparation

The wires were cut and placed in glass containers, each of which held a different liquid. There is distilled water in the first container, date vinegar in the second, and apple cider vinegar in the third. Every day, the wires were immersed in apple cider vinegar and date vinegar for twenty minutes. Then wires were taken out of the containers and paper towels were utilized to clean them. The water should then be replaced with fresh distilled water and maintained in an incubator at 37°C [14].

Grouping of the samples

Thirty samples of arch-wire pieces were divided into three groups:-

A. Samples wires in distilled water

B. Samples wires in Date vinegar

C. Samples wires in Apple cider vinegar

Immersion procedure

A. Using distilled water

The wire segments were fully submerged in 15 milliliters of distilled water, which was maintained in an incubator at 37 degrees Celsius—the temperature of the human body—in a sealed glass container. For two weeks, the bottled water was changed every day.

B. Date vinegar

At 37°C, the wire pieces were fully submerged in 15 milliliters of date vinegar in a sealed glass container. Every day for two weeks, the date vinegar was changed.

C.Apple cider vinegar

The wire pieces were fully submerged in 15 milliliters of apple vinegar in a sealed glass container, which was maintained in an incubator set at 37 degrees Celsius. For two weeks, the apple vinegar was changed every day.

Surface roughness tester:

Surface roughness was measured with the TR220 portable roughness tester (Germany). The average of the three readings was determined.

Figure 2: Surface Roughness Tester TR-200-Bower

Results and Discussion

The Descriptive statistics are shown in Table 1 and Figure 3 for the surface roughness test which included (minimum, maximum value, mean, SD error, and SD) after immersing in Date vinegar and Apple cider vinegar for 20min every day for two week , The results revealed that the highest mean value of the roughness test was (2.34193) after immersing in Date vinegar while the lowest mean value of the hardness test was(2.12930) after immersing in Apple cider vinegar. One-way ANOVA test was performed in order to see if there was a significant difference among groups. The results of this test revealed that significant difference among groups value ($P<0.05$) were found as shown in Table 1.

Table 1: Descriptive Statistics of the surface roughness

Groups	Mean	Std. Deviation	ANOVA
Water(control)	2.26104	.117435	.008
Date vinegar	2.34193	.176793	
Apple cider vinegar	2.12930	.088119	
Total	2.24409	.155640	

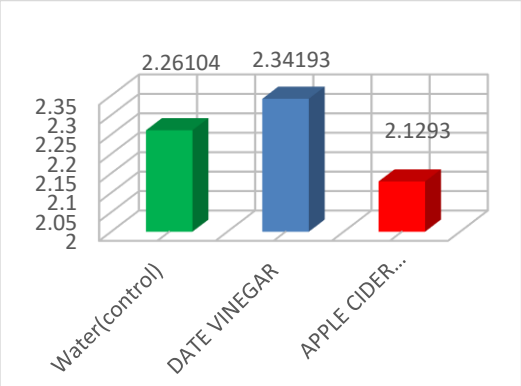

Figure 3: Mean distribution of surface roughness test

Table 2: Multiple comparisons between groups

		Mean Difference (I-J)	P-value	Sig.
Distilled water	Date vinegar	-.080889	.208	NS
	Apple cider vinegar	.131741	.046	NS
Date vinegar	Apple cider vinegar	.212630	.002	HS

Multiple comparisons revealed no significant differences (P>0.05) between the control and Date vinegar groups, and the control and Apple cider vinegar groups. On the other hand significant differences (P<0.05) were found between Date vinegar and Apple cider vinegar groups(Table 2).

Maintaining a good oral hygiene is very necessary during orthodontic treatment as orthodontic patients are more susceptible to have plaque accumulation, dental caries study as immersion media for the studied wires. The water has a pH of (7) and was used 27 wires choose 3 pieces of each wire type. The data obtained from the current study showed that the Ra values of stainless-steel orthodontic arch-wires were affected by the type of media. For all tested arch-wires, the highest Ra values were found after immersion in date vinegar, followed by bottled water, while the lowest Ra values were found in apple cider vinegar because of the effect of pH, as there was a significant increase in roughness in the acidic medium of date vinegar. Consequently, Ra values increased as pH decreased. This result is consistent with the findings of (Brar et al., [15]. ; Hameed, [16]; Rincic et al. [17]. .The H^+ ion is the key component of acids and is responsible for the pH level in solutions .The higher the H^+ concentration, the stronger the acidity and the lower the PH. In addition, these results were similar to results obtained by Nema [18]. who found that the surface roughness of nickel titanium arch-wires which immersed in different media (silica, Listerine cool mint and Listerine Total care zero) was higher than that of the control. This was perhaps to the impact of the media ph as there was an increase in the surface roughness in acidic media compared to the control. The surface roughness values increased with ph decreased [15-17]. The differences between the control and other media were no significant, this could be due to distilled water ph (7) which was not acidic [19,20].

Conclusion

The present study concluded that date vinegar exhibited a more pronounced impact on the surface roughness of orthodontic arch-wires compared to apple vinegar, indicating a stronger corrosive potential. Notably, despite its lower pH, date vinegar resulted in a significantly greater increase in surface roughness. These findings suggest that exposure to acidic solutions, such as date and apple vinegar, can adversely affect the surface integrity of orthodontic arch-wires. Therefore, caution should be exercised when consuming such acidic substances during orthodontic treatment to minimize potential damage to orthodontic appliances. The pH is not the only factor influencing surface roughness, as other chemical properties in the vinegar may contribute to the corrosion effect. It is recommended to brush the teeth regularly and reduce the consumption of foods containing apple vinegar and date vinegar to protect the orthodontic arch-wires from excessive surface roughness.

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