Effects of Modifying Orthodontic Adhesive by Thymus Vulgaris Essential Oil on Shear Bond Strength of the Brackets

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Abstract

Background: Early enamel changes and white spot lesions could happen in patients undergoing fixed orthodontic therapy who do not receive strict caries prophylactic care. As some types of natural products may have antimicrobial properties, incorporating them into orthodontic adhesive systems may help to reduce the incidence of dental caries around brackets.

Objectives: The aims of the current study were to investigate and compare the effects of incorporating Thymus vulgaris essential oil on shear bond strengths of adhesive used to attach orthodontic brackets.

Material and methods: The sample consisted of 30 freshly human upper first premolars of normal shape and size which were newly extracted for orthodontic treatment purposes. The teeth were cleaned, polished, rinse with water, air dried, then, phosphoric acid gel (37%) was used for etching of the buccal surface. The brackets used were 0.022 × 0.028-inch stainless steel standard edge wise brackets. Brackets were bonded with (3M Unitek,TransbondTM XT, U.S.A) orthodontic composites in three groups: The control group bonded without any modification in adhesive, experimental or modified groups that used Thymus vulgaris essential oil to be incorporated in the adhesive in concentrations of 1%, 3% wt/wt respectively. Then, shear bond strength test was estimated using universal testing machine with crosshead speed of 0.5 mm/min.

Results: The results revealed that Thymus vulgaris essential oil with 1% concentration had the highest shear bond strength mean value after the control group. Whereas, Thymus vulgaris with 3% concentration showed the lowest mean values of shear bond strength. One way analysis of variance demonstrated a significant difference within and between the mean values ($p < 0.05$). Multiple comparisons showed significant difference in shear strength between control and Thymus vulgaris groups in one hand and between 1% and 3% Thymus vulgaris groups on the other hand ($p < 0.05$).

Conclusion: This study concluded that the incorporation of Thymus vulgaris reduced shear strength of the orthodontic adhesive in evident manner particularly 3% concentration. Further studies are indicated to assess various concentrations of this product on physical properties of the orthodontic adhesive.

Keywords: *Essential oil, Orthodontic adhesive, Thymus vulgaris, White spot lesion.*

INTRODUCTION

During fixed orthodontic treatment, demineralization may occurs adjacent to brackets due to the presence and reaction of different types of bacteria. Main oral pathogens, S.mutants and L.acidophilus are crucial in caries development. S. mutants plays main role in early demineralization of dental hard tissues, while L. acidophilus is pivotal in caries development. Without special prevention concepts, early enamel changes may progress, and white spot lesions occur. Because, it is well accepted that caries progression is initiated by an imbalance of the remineralization–demineralization equilibrium with favoring of demineralization [1].

Orthodontic Patients are usually subject to strict caries preventive care, including application of remineralization agents containing fluoride [2]. The application of fluoride is one of the important aids for caries prevention [3]. It was reported in a recent study [4] that active patient reminders and surface sealants or fluoride varnish around orthodontic brackets might be associated with reduced white-spot-lesion [1]. However, the fluoride release is short-lived, and some studies suggest that the fluoride is only beneficial for three months after that no fluoride is released [5].

The addition of antimicrobial to orthodontic adhesive agents [6, 7] might prevent plaque accumulation and bacterial adhesion. Natural products defined as compounds derived from natural sources that possess biological activities [8], have historically been known to include active components of many traditional medicines and have continuously received attention for their extensive pharmacological and/or biological activities, that can be of great therapeutic value and market potential [9].

Essential oils, known as volatile oils, are complex mixtures of volatile constituent biosynthesized by plants, which mainly include two biosynthetically related groups. They have been incorporated in several products that used to resist dental caries [10]. These products are known to penetrate through the microbial membrane (formatting pores) leading to the leakage of ions and cytoplasmatic content and finally to cellular breakdown [11],

Incorporating essential oils into adhesive systems may contribute to the decrease in occurrence of secondary caries due to its antimicrobial activity reported in an in vitro dental biofilm model [12]. Moreover, incorporation of essential oil into dental composite structure do not significantly compromise the mechanical properties [13, 14], while it could improve its antibacterial activity and thus reduce the risk of secondary caries.

One of these essential oils is Thymus vulgaris. This product exhibited significantly high antimicrobial activity against C.albicans and S.mutans ,whereas the antibacterial activity against L.acidophilus was significantly higher than other Essential oils [15].

Accordingly, incorporating essential oils into dental materials composition seems like a promising alternative that would allow for enhancement of antimicrobial activity of dental materials. However, limited studies are available regarding the effects of natural products on physical and chemical properties of orthodontic brackets [16]. According to our best knowledge, no study was conducted to assess the effects of Thymus vulgaris essential oil incorporation on shear bond strength of orthodontic adhesive.

Thus, the aims of this study were to investigate and compare the effects of incorporating different concentrations of Thymus vulgaris essential oils on shear strengths of brackets bounded into tooth surface.

The study hypothesis was that there were significant increase in shear bond strength of the adhesive after incorporation of Thymus vulgaris essential oils.

Materials and Methods

The ethical approval was released by the Research and Ethical Committee of the College of Dentistry, University of Mosul

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The study samples consisted of 30 freshly human upper first premolars of normal shape and size which were newly extracted for orthodontic treatment purposes. The teeth were collected from Special Dental Health Centers and from the private orthodontist's clinics in Mosul city.

The teeth were free from caries, cracks, restorations, and not subjected to any kind of orthodontic or endodontic treatment, no history of any pretreatment with chemical agents such as alcohol, formalin or H2O2. Labial surfaces of teeth were evaluated by magnifier (×5) to confirm that the selected teeth were free from any cracks. The samples were stored in distilled water immediately after extraction and at room temperature for a maximum period of one month [17]. The water was changed regularly for the rest of the experiment to avoid bacterial growth [17].

Acrylic bases were made inside the plastic rings (20 mm in diameter and 30mm in height) and the teeth that used in the study were fixed inside the plastic rings using wax then cold cure acrylic powder (VERACRIL®, Colombia) with resin monomer purred inside the plastic ring to the level of cemento-enamel junction of the teeth. To ensure parallelism of teeth we used dental surveyor to adjust the long axis of each tooth within the plastic ring, as shown in figure (1).

Figure (1): Paralleling of tooth

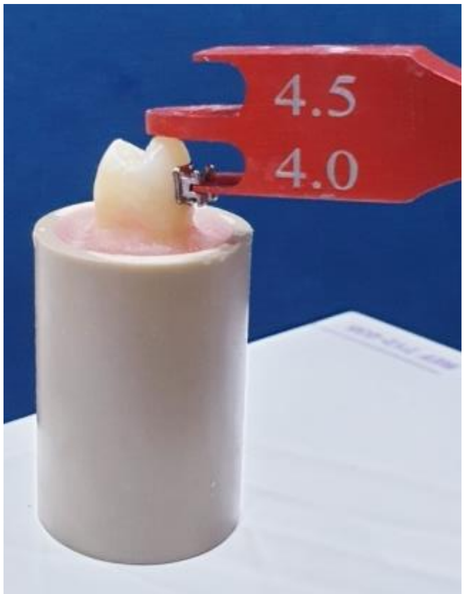
Before initial bonding procedures, the buccal surface of each tooth was cleaned and polished by pumice and rubber prophylactic cups for 10s [18], rinse with water to ensure all pumice washed. Phosphoric acid gel (37%) (blue gel, condac 37 FGM, Joinville,SC, Brazil) was used for etching of the buccal surface of the premolar for 30 s according to manufacturer instructions, washed for 20 s, then air dried [18]. The brackets used in the current study were 0.022 × 0.028-inch stainless steel standard edgewise (standard edgewise type, slot size 0.022 inch, Dentaurum, Germany) with an average surface area of the bracket 9mm2 [19].

Brackets were bonded with (3M Unitek,TransbondTM XT, U.S.A) orthodontic composites without any modification at bonding. Whereas, the modified adhesive was mixed with 1%, 3% wt/wt for Thymus vulgaris essential oil (Sigma–Aldrich, St.Louis,USA).

The required concentrations of Thymus vulgaris essential oil modified resin was mixed at the time of bonding. Light cure for 20 s from the mesial side and 20s from the distal side of each bracket according to manufacture instruction, after bonding, the sample was kept in distilled water at room temperature.

The required concentrations of essential oil were detected using micropipette (for 1% Thymus vulgaris essential oil we withdrew 10µl of oil, and for 3% Thymus vulgaris essential oil we withdrew 30µl) and the preparation was done by manual mixing using plastic spatula in area with minimal light for (30s), to obtain uniform mixture on sterilized glass slab and during procedure the rest of mixture was placed in dark container to avoid unwanted effect of light on mixture.

Figure (2): Bracket positioning on experimental tooth surface



The teeth were randomly divided into three equal groups; each group consisted of 10 teeth. These groups were given below:

Control group: Ten teeth were included; the brackets were bonded into tooth surface directly without incorporation of any products. This group was subjected to shear test.

Group one: Ten teeth were included; the brackets were bonded into tooth surface directly with incorporation of 1%Thymus vulgaris essential oil into orthodontic composite. Then, subjected to shear test.

Group Two: Ten teeth were included; the brackets were bonded into tooth surface directly with incorporation of 3% Thymus vulgaris essential oil in orthodontic composite. Then, subjected to shear test.

Bond (3M Unitek,TransbondTM XT, U.S.A) was applied on the buccal surface of each tooth and cured for 20s according to manufacturer instructions then orthodontic composite was applied on the inner surface of each bracket then place it on the buccal surface of the tooth in the center using bracket positioner (Fig. 2).

The brackets were seated with firm pressure [20]. Each bracket was subjected to a 300 g force for 10 seconds, according to the report of Bishara, Ajlouni [21] and excess bonding resin (3M Unitek,TransbondTM XT, U.S.A) was removed this process ensures a constant thickness of composite resin layer. Then, curing done using LED light curing device (Coxo Medical, China) with wavelength 900-925 mw/cm2 applied for 20s for the mesial side and 20s for the distal side [22]

After bonding, the sample was kept in distilled water at room temperature for 24 h before shear bond testing [17, 23]. All the samples were attached to the lower part of the universal testing machine (GESTER, China) having a capacity of 1000 kN. The shear stress was tested by using a crosshead speed of 0.5 mm/min [24].

The force of the machine was delivered perpendicularly to the bracket base by knife-edge rode producing a shear force at the bracket – tooth interface as shown in figure Fig. (3). Electronic recording of the results of each test was done [17, 23].The applied force at fracture time was recorded in Newton then it was converted into mega pascals (MPa) by dividing the debonding force by the surface area of the bracket [25, 26].

Figure (3): Shear bond test strength test

After deboning, all the samples for shear bond strength test were examined under stereomicroscope at 10x magnification power ,to assess the amount of the adhesive material left on the tooth ,this was done by using the adhesive remnant index scores (ARI) [27] these scores are as follows :

-score 0 = No adhesive left on the tooth surface.

-score1= Less than half of the adhesive left on the tooth surface.

-score 2= More than half of the adhesive left on the tooth surface.

-score 3=All of the adhesive left on the tooth.

The data of shear bond strength for all groups were analyzed using SPSS 26 software (IBM-SPSS Inc., Chicago, IL, USA). First, descriptive statistics such as minimum, maximum, mean and standard deviation were assessed. The data were then evaluated using a oneway analysis of variance (ANOVA) to see whether there were any significant differences between and within the different concentrations For further assessment, Schaffe's test was conducted to assess the difference within the study groups. The p value was set to be at <0.05.

Results

In this study, the measurements of shear bond strength for samples in groups of different concentrations were normally distributed. The descriptive data for shear bond strength of the control group and Thymus vulgaris with different concentrations are demonstrated in table (1). These data include the mean of the samples in each group, standard deviation, minimum and maximum values of the shear bond strength. The descriptive analysis revealed that control group had the highest value, followed by Thymus vulgaris with 1% concentration that had the highest shear bond strength mean value, while Thymus vulgaris with 3% concentration showed the lowest mean values of shear bond strength.

Table (1): Descriptive statistics for the shear bond strength

Group	Mean	SD±	Minimum	Maximum
Control	28.74	13.02	7.55	50.56
Thymus vulgaris 1%	15.29	9.43	4.22	29.34
Thymus vulgaris 3%	7.83	2.12	3.92	10.03

The difference between and within study groups obtained by one way (ANOVA) statistical test. The results have showed a significant difference at ($p < 0.05$) among the mean values of the shear bond strength for the different groups.

For further assessment of the difference within the groups, Scheffe's test was conducted. The results of the multiple comparisons in table (2) showed that there was significant difference ($p< 0.05$) in shear bond strength between the control and 1%, 3% Thymus vulgaris group. However, no significant difference was recorded between group of 1% with 3% Thymus vulgaris.

Table (2): Multiple comparison set for groups of shear bond strength

Group		Mean Difference	p- value
Control	Thymus vulgaris 1%	13.44	0.13*
	Thymus vulgaris 3%	20.90	0.01*
Thymus vulgaris 1%	Thymus vulgaris 3%	7.46	0.74

* Significant at $p<0.05$

In regards to adhesive remnant index, In control group 63.64% of the sample no adhesive remained on enamel surface however 36.36% of sample in control group have less than 50%adhesive remained on enamel. For 1% Thymus vulgaris group there was 33.33% of samples with no adhesive remain on enamel, 58.33% of samples with less than 50% adhesive remain on enamel, 8.33% of samples with more than 50% adhesive remain on enamel. Scores for 3% Thymus vulgaris group there was 8.33% of samples with no adhesive remain on enamel ,16.67% of samples with less than 50% adhesive remain on enamel, 41.67% of samples with more than 50% adhesive remain on enamel, 33.33% of samples with all adhesive remain on enamel.

Discussion

The success of fixed appliance orthodontic therapy depends on the positioning of the brackets and tubes as well as their capacity to deliver the best orthodontic force in the desired direction and magnitude. Additionally, Throughout the active treatment stages, these attachments must be able to withstand the applied masticatory loads and orthodontic force with a low bond failure rate and must be easily removed at the end of the treatment. [28].

Demineralization is an inevitable side-effect associated with fixed orthodontic therapy, especially when associated with poor oral hygiene [29]. The acidic byproducts of the bacteria in plaque are responsible for the subsequent enamel demineralization and formation of white spot lesions. These can cause caries thereby leading to poor esthetics, patient dissatisfaction and legal complications [30]. A specialty whose objective is to enhance esthetics in the dentofacial area is discouraged by the development of WSL after orthodontic treatment is finished.

Essential oils exhibit different biological and pharmacological activities, such as antibacterial, antifungal and antiviral [31]. Incorporating essential oils into adhesive systems may contribute to the decrease in occurrence of secondary caries due to its antimicrobial activity [12], but incorporation of essential oils should be conducted with caution so as not to effect on the properties of orthodontic composites.

The antibacterial activities of Thymus vulgaris essential oil are associated with the content of thymol (2-isopropyl-5-

methylphenol) and its conformational isomer, carvacrol (5-isopropyl-2-methylphenol), which are less poisonous and have more potent antibacterial and antifungal properties than phenol [32]. Thymol, an essential component of toothpaste and a phenolic antioxidant derived from plants, has shown to have antimicrobial and antifungal properties., while carvacrol has been investigated for its antibacterial activity [33].

The bonding power must be strong enough to withstand the forces of orthodontic biomechanics and oral functions, such as mastication. The materials and bonding techniques should keep the brackets attached for the duration of treatment and prevent damage to the surface of the crown during debonding. [34].

In current study the result of shear bond strength test revealed the control had the highest values followed Thymus vulgaris with 1% concentration which had the highest shear bond strength mean value, while Thymus vulgaris with 3% concentration showed the lowest mean values of shear bond strength. Although, the three was significant reduction in shear bond strength, authors still think that the recorded values at 1% Thymus vulgaris is within the acceptable limits of shear strength.

It is important to mention that this could be the first study that try to assess the effect of incorporation of Thymus vulgaris essential oil on shear strength of orthodontic adhesive. For that reason, comparisons are conducted in caution with the available studies due to the difference in methodological aspects and materials used.

The current study is in partial agreement with Yaseen, Taqa [16] how used Cinnamon Nano particles except for the 3% concentration of Thymus vulgaris essential oil which had negative effect on shear strength. However, the author disagree with Akhavan, Sodagar [35] who added silver nanoparticles to Transbond™ XT primer; the results of their study showed that incorporation of silver/HA nanoparticles containing 1% silver significantly increase the orthodontic shear bond strength of orthodontic adhesive. However, they used higher concentrations (5% and 10%) of silver Nano particles and added 5% hydroxyapatite to the mixtures and recorded that increasing the amount of silver to 5% and 10% reduces the bond strength. This could be go with the results that mention that the 3% concentration of Thymus vulgaris essential oil which had negative effect on shear strength although it provides good antibacterial effect.

Moreover, results of the current study disagree with studies that found that no significant effect for the incorporation of products such as benzalkonium chloride or monomer 2-methacryloxylethyl hexadecyl methyl ammonium bromide on shear bond strength of orthodontic brackets [18, 36] in which benzalkonium chloride (0.25% and 5%) added to the Superbond C&B resin.

Like any an in-vitro research, even with extensive planning, authors cannot imitate fully the clinical setting and they think that further studies may be suggested with different concentrations to assess the shear bond strength and other physical properties.

Conclusions

This study concluded that Thymus vulgaris with the utilized concentrations caused evident reduction in shear bond strength particularly at 3% concentration than may make it not suitable to mix with orthodontic adhesive in that concentration.

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