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Effects of Modifying Orthodontic Adhesive by Thymus Vulgaris and Lavandula Angustifolia Essential Oils on Compressive Strength

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Abstract

Aims: The aims of the current study were to investigated and compared the effects of different concentrations of Thymus vulgaris and Lavandula angustifolia essential oils incorporated in orthodontic adhesive on compressive strength. **Materials and Methods:** Thirty samples were prepared to be included in the study groups. They were constructed from cylinders of 6 mm in height and 4 mm in diameter for each one. The adhesive samples were modified by incorporating 1%, 3% of Thymus vulgaris and 1%, 3% Lavandula angustifolia essential oils separately. After curing of the modified adhesive, each sample was placed in a universal testing machine between its plate and arm that has a capacity of 1000 kN. The compressive strength was tested by using a crosshead speed of 0.5 mm/min. The force of the machine was delivered perpendicularly to the composite samples by a plate producing a compressive force on the sample. The applied force at fracture time was recorded in Newton, then it was converted into mega Pascal (MP) by dividing the applied force by the surface area of the composite samples. The data were statistically analysed at $p < 0.05$. **Results:** The results revealed that 1% Lavandula angustifolia group showed the highest mean values of compressive strength among the groups except for the control. Whereas, Thymus vulgaris groups showed the lowest mean values of compressive strength. The remaining groups were distributed on statistical levels between the highest and lowest levels of mean value. One way analysis of variance demonstrated a significant difference within and between the mean values. Multiple comparisons showed a significant difference in compressive strength between control and of 3% Thymus vulgaris groups at ($p < 0.05$). **Conclusions:** Compressive strength recorded similar reduction behaviour for the two materials regarding the reduction in its value. However, the incorporation of 3% Thymus vulgaris showed evident decrease.

آثار تعديل لاصـــق تقويم الأســـنان من قبل الغدة الزعترية الشـــائع والزيوت الأســـاســـية لافاندولا أنجستيفوليا على قوة الضغط

الملخص

الأهداف: دراسة ومقارنة تأثيرات التركيزات المختلفة من الزيوت العطرية للزعتر واللافندر على قوة الانضغاط للمادة اللاصقة لتقويم الأسنان. **المواد وطرائق العمل:** تم تحضير ثلاثين عينة لتضمينها في مجموعات الدراسة. تم تصنيعها على شكل اسطوانات بارتفاع 6 ملم وقطر 4 ملم لكل واحدة. تم تعديل عينات لاصق التقويم بدمج 1٪ ، 3٪ من زيت الزعتر و 1٪ ، 3٪ من زيت الافندر بشكل منفصل. بعد تصليب المادة اللاصقة المعدلة ، تم وضع كل عينة في آلة اختبار القص والقطع والكبس بين صفيحتها وذراعها بسعة 1000 كيلو نيوتن. تم اختبار مقاومة الانضغاط باستخدام سرعة تقاطع 0.5 ملم / دقيقة. تم إيصال قوة الآلة بشكل عمودي على العينات بواسطة لوحة تنتج قوة ضغط على العينة. ثم تسجيل القوة المطبقة في وقت الكسر في نيوتن ثم تم تحويلها إلى ميجا باسكال (MP) بقسمة القوة المطبقة على مساحة سطح العينات. تم تحليل البيانات إحصائيا عند p <0.05. **النتائج:** أظهرت النتائج أن 1٪ من مجموعة اللافندر قد أظهرت أعلى متوسط قيم لقوة الانضغاط بين المجموعات باستثناء المجموعة القياسية ، بينما أظهرت مجموعات الزعتر أقل متوسط قيم لمقاومة الانضغاط. تم توزيع المجموعات المتبقية على المستويات الإحصائية بين أعلى وأدنى مستويات متوسط القيمة. أظهر تحليل طريقة واحدة للتباين وجود فرق كبير داخل وبين القيم المتوسطة. حيث أظهرت المقارنات المتعددة فرقاً معنوياً في مقاومة الانضغاط بين المجموعة القياسية ومجموعات الزعتر بنسبة 3٪ عند (p <0.05). **الاستنتاجات:** خلصت هذا الدراسه الى ان دمج 1٪ من اللافندر او الزعتر ذو تأثير محدود على مقاومة الانضغاط للمادة اللاصقة لتقويم الاسنان بينما قللت مجموعة 3٪ من الزعتر مقاومة الانضغاط للمادة اللاصقة لتقويم الاسنان.

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INTRODUCTION

Patients with fixed orthodontic treatment are usually subjected to strict caries preventive care by using different approaches such as application of different remineralization agents containing fluoride [1 & 2]. It was reported in a recent study (that active patient reminders and surface sealants or fluoride varnish around orthodontic brackets associated with reduced white-spot-lesion [3 & 4].

The addition of antimicrobials into orthodontic adhesive agents [5 & 6] and resin-modified glass ionomers cements might prevent plaque accumulation and bacterial adhesion [7-9]. Non-fluoride releasing resin composites are significantly prone to higher white spot lesion and demineralization, the fluoride release is short-lived, and various studies suggest that the fluoride is only beneficial for three months after that no fluoride is released [10].

Essential oils, or volatile oils, are complex mixtures of volatile constituents biosynthesized by plants, which mainly include two biosynthetically related groups. These main groups include terpenes and terpenoids and aromatic and aliphatic constituents, all characterized by low molecular weight [11]. Most of the antimicrobial activity in essential oil is found in the oxygenated terpenoids (e.g., alcohols and phenolic terpenes), while some hydrocarbons also exhibit antimicrobial effects. Interactions between these components may lead to antagonistic, additive or synergistic effects [12]. Studies have demonstrated that essential oils have higher antibacterial activity than the mixtures of their major components, suggesting that the minor components are critical to the synergistic activity, though antagonistic and additive effects have also been observed [11].

One of these essential oils are Lavandula angustifolia and Thymus vulgaris. Antimicrobial activity of this essential oil extracted from Lavandula stoechas L. exhibit good antimicrobial activities against most of the bacteria, filamentous fungi, and yeasts [13]. Thymus vulgaris Essential oil exhibited the significant highest antimicrobial activity against *C.albicans* and *S.mutans* ,whereas the antibacterial activity against *L.acidophilus* was significantly higher than of other Essential oils [14].

Accordingly, incorporating essential oils into dental materials composition seem like a promising alternative that would allow for enhancement of antimicrobial activity of dental restorative materials. In terms of potential anticariogenic effects. According to the best knowledge of the researcher, limited informations are available regarding the effects of natural products on shear bond strength of orthodontic brackets [15]. As well as no study was conducted to assess the effects of essential oils incorporation on the physical and chemical properties of orthodontic adhesive particularly Lavandula angustifolia and Thymus vulgaris essential oils.

Thus, the objectives of this study were to investigate and compare the effects of different concentrations of Thymus vulgaris and Lavandula angustifolia essential oils incorporated in orthodontic adhesive on compressive strength. The study hypothesis is that there is a statistically significant difference in compressive strength after incorporation of Thymus vulgaris and Lavandula angustifolia essential oils in orthodontic adhesive.

MATERIALS AND METHODS

Ethical concern

The ethical approval was released by the Research and Ethical Committee of the College of Dentistry, University of Mosul (Ref. no. UoM. Dent/ H.DM/.52/22 Date:2022/06/14).

Study sample

In an in vitro research, 30 samples were prepared using 3M composite (3M Unitek, Transbond^{TM} XT, U.S.A) using a plastic cylinder (China) of 6 mm in height and 4mm in diameter [16].

Modified resin in a concentration of 1%, 3% mixed wt /vol for both Thymus vulgaris and Lavandula angustifolia essential oils by using analytical balance. Six equal groups; each group consisted of 5 samples of orthodontic composite. These groups were given as follows:

Control group: Five samples of orthodontic adhesive were included without incorporation of any products. This group was subjected to a compressive test.

Group one: Five samples of orthodontic adhesive were included with incorporation of 1%Thymus vulgaris essential oil into orthodontic adhesive. Then, subjected to a compressive test.

Group Two: Five samples were included with incorporation of 3% Thymus vulgaris essential oil in orthodontic adhesive. Then, subjected to a compressive test.

Group three: Five samples were included with incorporation of 1% Lavandula angustifolia essential oil into orthodontic adhesive. Then, subjected to a compressive test.

Group four: Five samples were included with incorporation of 3% Lavandula angustifolia essential oil in orthodontic adhesive. Then, subjected to a compressive test.

Group five: Five samples were included with incorporation of 1% of Lavandula angustifolia and 1%Thymus vulgaris essential oils into orthodontic adhesive. Then, subjected to a compressive test.

The required concentrations of Thymus vulgaris and Lavandula angustifolia essential oils modified resin were mixed at the time of compressive testing.

Natural Product Concentration Adjustment:

The required concentrations of essential oil were obtained using micropipette. For 1%

and 3% Thymus vulgaris and Lavandula angustifolia essential oils we withdrew 10µl, and 30µl of each oil respectively. The preparation was done by manually with a plastic spatula. To obtain a uniform mixture, the mixing procedures continued for 30s on a sterilized glass slab. The mixture was placed in dark container to avoid unwanted effect of light.

The adhesive samples were cured from each side using LED light curing device (Coxo Medical, China) for (20s) and then plastic rings removed and then placed in the universal testing machine (GESTER, China) between its plate and arm having a capacity of 1000 kN. The compressive strength was tested by using a crosshead speed of 0.5 mm/min [17]. The force of the machine was delivered perpendicularly to the composite samples by rode, producing a compressive force on the sample (Fig. 1). Electronic recording of the results of each test was done [18 & 19].The applied force at fracture time was recorded in Newton, then it was converted into mega Pascal (MP) by dividing the applied force by the surface area of the composite samples.

The statistical analysis included mean and standard deviation and one-way analysis of variance at significant level of $p<0.05$.

Figure (1): Compressive strength measurement

RESULTS

Concerning parametric distribution of compressive strength, the results in Table (1) showed that all the data were normally distributed.

Table (1): Tests of normality of compressive strength for the study groups.

Group	Statistic	p- value
Control	0.82	0.12
Lavandula angustifolia 1%	0.88	0.32
Thymus vulgaris 1%	0.96	0.81
Lavandula angustifolia 3%	0.93	0.61
Thymus vulgaris 3%	0.93	0.62
Mixed 1%	0.99	0.98

The descriptive data for the compressive strength of control, Lavandula angustifolia and Thymus vulgaris with different concentrations were demonstrated in Table (2). These data include the mean, standard deviation, minimum and maximum values of the compressive strength. The analysis revealed that control had the highest value with declination in the rest. 1% Lavandula angustifolia group showed the highest mean values among the rest of groups, whereas 3% Thymus vulgaris group showed the lowest mean values of compressive strength. The remaining groups were distributed on statistical levels between the highest and lowest levels of mean value.

Table (2): Descriptive statistics for the compressive strength of the study groups

Group	Mean	SD	Minimum	Maximum
Control	173.48	13.97	160.67	191.13
Lavandula angustifolia 1%	146.78	20.53	129.34	179.29
Thymus vulgaris 1%	140.62	16.84	121.71	164.24
Lavandula angustifolia 3%	136.28	29.18	101.52	169.57
Thymus vulgaris 3%	119.58	20.01	40.80	145.19
Mixed 1%	135.15	28.06	94.77	169.66

The Comparison between the six groups by use the one-way ANOVA groups obtained by one-way (ANOVA) statistical test, which was demonstrated in Table (3) and showing a significant difference at ($P \leq 0.05$) compressive strength.

Table (3): One way analysis of variance for the mean values of compressive strength among the study groups.

	Sum of Squares	df	Mean Square	F	p- value
Between Groups	13751.31	5	2750.26	3.26	0.022*
Within Groups	17898.84	24	745.78		
Total	31650.15	29			

* Significant at $P \leq 0.05$.

For further assessment, Post Hoc Test were conducted (Tab.4) these comparisons shown that there was a significant difference in compressive strength between the samples of the control group and group of 3% Thymus vulgaris.

Table (4): Post Hoc Test for groups of compressive strength.

Group		Mean Difference	Std. Error	P-value
Control	**Lavandula angustifolia 1%**	26.69	17.27	0.789
	Thymus vulgaris 1%	32.85	17.27	0.612
	Lavandula angustifolia 3%	37.20	17.27	0.480
	Thymus vulgaris 3%	72.90	17.27	0.015*
	Mixed 1%	38.32	17.27	0.447
Lavandula angustifolia 1%	**Thymus vulgaris 1%**	6.156	17.27	1.000
	Lavandula angustifolia 3%	10.50	17.27	0.996
	Thymus vulgaris 2%	46.20	17.27	0.249
	Mixed 1%	11.63	17.27	0.993
Thymus vulgaris 1%	**Lavandula angustifolia 3%**	4.34	17.27	1.000
	Thymus vulgaris 3%	40.04	17.27	0.399
	Mixed 1%	5.47	17.27	1.000
Lavandula angustifolia 3%	**Thymus vulgaris 3%**	35.70	17.27	0.525
	Mixed 1%	1.12	17.27	1.000
Thymus vulgaris 3%	**Mixed 1%**	34.57	17.27	0.560

* Significant at $P \leq 0.05$.

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. 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 [20].

Essential oils exhibit different biological and pharmacological activities, such as antibacterial, antifungal, and antiviral [21]. Incorporating essential oils into adhesive systems may contribute to the decrease in occurrence of secondary caries due to its antimicrobial activity [22]. However, should be conducted with caution so as not to effect on the properties of orthodontic composites.

The agents that used in the current study were Thymus vulgaris and Lavandula angustifolia essential oils. The essential oils and dimethacrylate resins possess hydrophobic features [23]. Hence, they can be easily mixed to obtain homogeneous material. The concentrations that used in this study were 1% ,3% as these concentrations provide good antibacterial activity [23]. However, the previously mentioned study used Thymus vulgaris and Lavandula angustifolia essential oils that were mixed with flowable bulk-fill composite resin material mechanically rather than orthodontic adhesive.

Compressive strength is particularly important because of chewing forces. It is one of the measures of strength of material in different force conditions, increased value represents increased strength of the material [24].

The current study revealed that 1% Lavandula angustifolia group showed the highest mean values of compressive strength among the groups except the control one, while 3% Thymus vulgaris group showed the lowest mean values of compressive strength. The remaining groups were distributed between the highest and lowest levels of mean value.

Due to the limited information regarding essential oils incorporation with orthodontic or dental composite, general comparisons were conducted with studies utilized other products. For example, the current study is in agreement with the result discussed by Ruddell *et al.,* [25]. Although they used Nanoparticles in their study, but they stated that pre polymerized Nanoparticles have the potential to improve wear properties; however, there was reduction in compression properties as compared with conventional composites.

The current study is generally going with result discussed by Ozturk *et al.,* who they revealed that flowable composites have lower compressive strength when the specimens were subjected to water sorption. Mostly, mechanical strength tends to increase with an increase in filler content. Because most composites contain a small amount of filler, decreased mechanical strength is not surprising, also showed the lowest sorption recorded for group XT composite because it contains bisphenol-A glycidyl methacrylate and bisphenol-A benzyl methacrylate which are less hydrophilic there for less effect on compressive strength of group XT composite was observed [26].

Even with extensive planning, this study had certain limitations. Firstly, this study, like other *in vitro* studies, cannot imitate fully the clinical setting.

Second, there was difficulty in obtaining the materials because they were locally not available. Third, the work required a special atmosphere which should be fully sterile with minimal light exposure and special equipment.

CONCLUSIONS

This study concluded the followings: The incorporation of 1% and 3% of Lavandula angustifolia showed limited reduction in compressive strength. Thymus vulgaris with the utilized concentrations caused evident reduction in compressive strength, particularly at 3% concentration and when mixed with Lavandula angustifolia.

Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication and/or funding of this manuscript.

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