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# Evaluation Of Transverse Strength In Provisional Self Cure Material Incorporated With Plant Based Oils – An Invitro Study

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***Abstract:***
***Background:*** *Provisional self-cure polymethyl methacrylate (PMMA) materials are extensively utilized in fabrication of temporary crowns. However, these materials are susceptible to microbial colonization and demonstrate suboptimal mechanical properties. This study aims to evaluate the impact of incorporating lemongrass essential oil (LGEO) and tea tree oil (TTO) into PMMA on enhancing its transverse strength.*
***Materials and Methods****: A total of 100 specimens were prepared, comprising 20 with 2.5% LGEO, 20 with 5% LGEO, 20 with 15% TTO, and 20 with 20% TTO, alongside a control group. The transverse strength was assessed utilizing a three-point bending test conducted with an Instron universal testing machine. Statistical analyses were performed using One-way ANOVA and Tukey HSD tests to facilitate intergroup comparisons.*
***Results:*** *The control group exhibited the highest transverse strength (55.2 MPa). Notably, the incorporation of 5% LGEO resulted in a significant enhancement in strength (58.7 MPa), whereas higher concentrations of TTO (15% and 20%) were associated with marked reductions in strength (21.0 MPa and 27.2 MPa, respectively).*
***Conclusion:*** *The integration of LGEO into PMMA significantly improves its transverse strength, whereas TTO adversely affects the mechanical properties of the material. These findings indicate that LGEO represents a promising additive for augmenting the performance of provisional self-cure acrylic resins in dental applications.*
***Keywords:*** *PMMA, lemongrass essential oil, tea tree oil, transverse strength, provisional self-cure materials, dental applications.*

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## I. Introduction

Provisional PMMA is the most commonly used material for fabricating provisional crowns in routine dentistry due to its advantages, which include ease of fabrication, adequate stability in the oral environment, and cost-effectiveness.[1] However, it also has drawbacks, such as susceptibility to microbial colonization and inferior mechanical and physical properties. The addition of plant-based oils to polymer matrices, such as provisional self-cure materials, has garnered attention for its potential to enhance their physical and mechanical properties.[2,3]

**Lemongrass Essential Oil (LGEO)**

Lemongrass essential oil, derived from the Cymbopogon genus of the Poaceae family, possesses notable antibacterial and antifungal properties. When LGEO is integrated into a PMMA matrix, it can modify the material's mechanical characteristics. The interaction between LGEO and PMMA can lead to changes in flexibility, tensile strength, and overall durability. Studies have shown that the inclusion of LGEO can enhance the material's resistance to stress and improve its performance in denture base applications. [5]

**Tea Tree Oil (TTO)**

Similarly, tea tree oil, known for its antiseptic qualities, can also be blended with PMMA to enhance its functionality. TTO is rich in terpinen-4-ol, which contributes to its antimicrobial properties. When combined

with PMMA, TTO can potentially improve the material's resistance to microbial growth, making it suitable for medical and dental applications where hygiene is critical. Studies have also demonstrated improvements in mechanical properties along with antimicrobial features when used for heat-cured denture base applications. [9]

This study aims to evaluate the transverse strength of provisional self-cure materials when incorporated with lemongrass essential oil and tea tree oil.

## II. Materials & Methods

This invitro short study was carried out in the Department of Prosthodontics, RVSDCH, Coimbatore.

The standardized steel die measuring 65 mm × 10 mm × 3 mm was prepared according to American Dental Association specification no. 12 and was invested using type III gypsum to prepare a mold for fabrication of samples.

To assess the transverse strength of provisional acrylic resin composites, a total of 100 specimens were fabricated. They are divided into 5 groups ( TABLE I ) . Each group consists of 20 samples incorporated with 2.5 %, 5% of lemongrass essential oil (LGEO), 15% &20% of tea tree oil (TTO), and 20 control samples.

The control group was prepared using provisional self cure acrylic resin (DPI) following the manufacturer's guidelines. The experimental groups consisted of 80 specimens prepared from the same provisional self-cure acrylic resin, incorporating 100% organic pure lemongrass essential oil at concentrations of 2.5% and 5% and pure organic tea tree oil (TTO) was included at concentrations of 15% and 20% by volume of monomer.

To incorporate the oil into the acrylic resin, the required oil volume was deducted from the monomer using a micropipette, and the remaining monomer was combined with the oil in a clean glass beaker. This mixture was blended with a mini electric hand mixer for about twenty seconds to ensure thorough integration. The resulting mixture was then combined with the acrylic powder and placed into the mold for setting.

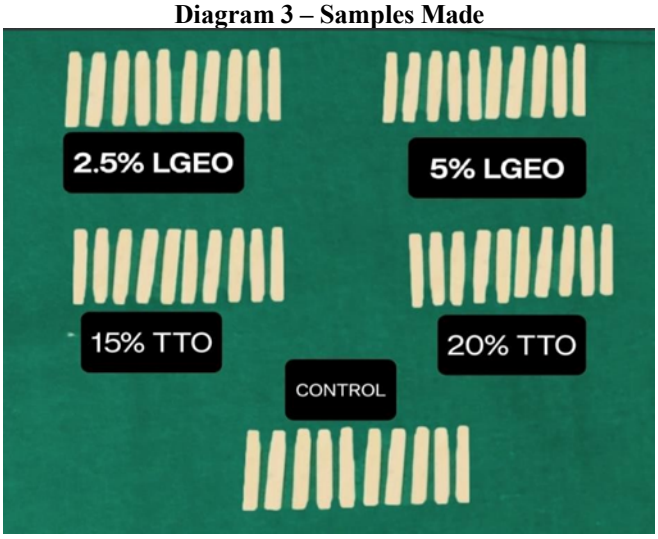
**Table – I – Groups**

| | |
|---|---|
| Group 1 | Control Group (n = 20) |
| Group 2 | 2.5% LGEO (n = 20) |
| Group 3 | 5% LGEO (n = 20) |
| Group 4 | 15% TTO (n = 20) |
| Group 5 | 20 % TTO (n = 20) |

**Diagram – 1 – Plant Based Oils ( Lemon Grass Oil & Tea Tree Oil)**


**Diagram – 2 – Incorporation Of Oil To Monomer**

**Diagram 3 – Samples Made**




**Transverse Strength Test:**

The transverse strength of the specimens was assessed using a three-point bending test. Each specimen was positioned on two supports, with a span of 50 mm between them. An Instron universal testing machine (Deepak Poly Plast, Gujarat, 30 kN) was utilized to apply a load at the center of the specimen from the upper side. The testing was conducted at room temperature with a crosshead speed set to 5 mm/min, continuing until the specimen fractured. The flexural strength was calculated using the formula:

Transverse strength = 3PL/2bd2

P: is the peak load L: is the span length (50mm) b: is the sample width d: is the sample thickness.

**Diagram 4 – Universal Tensile Tester**

**Statistical Analysis**

All data were evaluated using the Statistical Package for Jamovi version 16.0 (SPSS Inc., Chicago, IL, USA) with a 5% significance level. Shapiro wilk tests were first used to check for normal distribution, and all data were normally distributed.A One-way-ANOVA test and post-hoc Tukey HSD tests were used for multiple comparison

## III. Results

The mean, SD of the specimens tested for transverse strength are explained in TABLE II

**Table – II – Mean & Sd**

| | GROUPS | MEAN(SD) |
|---|---|---|
| 1. | CONTROL | 55.2 (10.61) |
| 2. | 2.5% LGEO | 56.4 ( 24.7) |
| 3. | 5% LGEO | 58.7 (35.2) |
| 4. | 15% TTO | 21.0 (14.0) |
| 5. | 20%TTO | 27.2 (12.2) |

**Table – III - Within And Between Group Comparisons Of Flexural Strength: (One Way Anova – Group Descriptives)**

| Variable | Group | N | Mean | SD | 95% CI for mean | | F | P value |
|---|---|---|---|---|---|---|---|---|
| | | | | | Lower bound | Upper bound | | |
| FLEXURAL STRENGTH | 1(Control) | 20 | 55.2 | 10.61 | 33.9 | 77.9 | 40.3 | < 0.001 |
| | 2 (2.5% LG) | 20 | 56.4 | 18.33 | 24.7 | 81.2 | | |
| | 3 (5% LG) | 20 | 58.7 | 11.38 | 35.2 | 75.5 | | |
| | 4 (15% TTO) | 20 | 21.0 | 4.21 | 14.0 | 28.5 | | |
| | 5 (20% TTO) | 20 | 27.2 | 8.21 | 12.2 | 40.2 | | |

The ANOVA test of transverse strength in table III shows significance difference between control and experimental groups(P<0.001).

**Table – IV - Tukey Post Hoc Test – Flexural Strength**

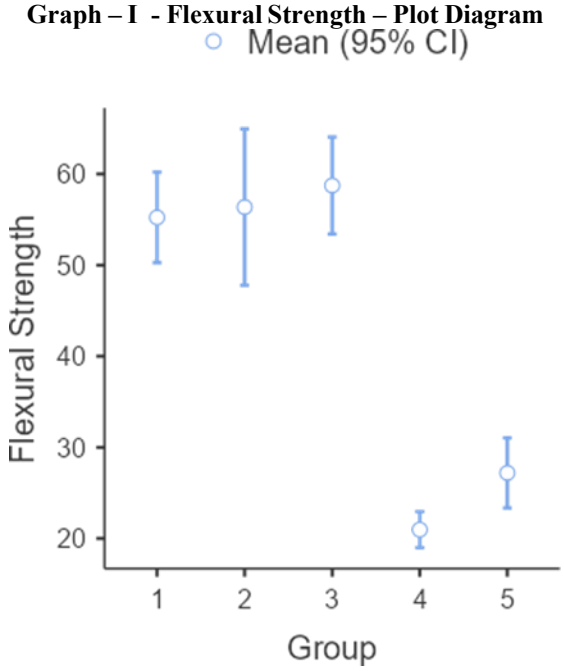
| | | Control | 2.5% LG | 5% LG | 15% TTO | 20% TTO |
|---|---|---|---|---|---|---|
| Control | Mean | - | -1.13 | -3.50 | 34.3*** | 28.04*** |
| | Difference | | | | | |
| | t value | - | -0.311 | -0.962 | 9.41 | 7.70 |
| | df | - | 95.0 | 95.0 | 95.0 | 95.0 |
| | P value | - | 0.998 | 0.871 | <.001 | <.001 |
| 2.5% LG | Mean | | - | -2.37 | 35.4*** | 29.17*** |
| | Difference | | | | | |
| | t value | | - | -0.651 | 9.72 | 8.01 |
| | df | | - | 95.0 | 95.0 | 95.0 |
| | P value | | - | 0.966 | <.001 | <.001 |
| 5% LG | Mean | | | - | 37.8*** | 31.54*** |
| | Difference | | | | | |
| | t value | | | - | 10.37 | 8.66 |
| | df | | | - | 95.0 | 95.0 |
| | P value | | | - | <.001 | <.001 |
| 15% TTO | Mean | | | | - | -6.23 |
| | Difference | | | | | |
| | t value | | | | - | -1.71 |
| | df | | | | - | 95.0 |
| | P value | | | | - | 0.433 |
| 20% TTO | Mean | | | | | - |
| | Difference | | | | | |
| | t value | | | | | - |
| | df | | | | | - |
| | P value | | | | | - |

NOTE: *p<.05, **p<.01, ***p<.001

Table IV - Tukey HSD of multiple comparisons between studied groups was done. There was no significanct difference between 2.5% LGEO ,15% and 20 % concentrations of tea tree oil and the mean of these concentrations was lower than control group, while the transverse strength at 5% of addition of LGEO increased

strength significantly as compared with other groups and control

**Graph – I - Flexural Strength – Plot Diagram**




## IV. Discussion:

Provisional self-cure materials present several benefits in dental practice, primarily due to their ease of use, facilitating rapid application in provisonalization. They provide immediate functionality and aesthetics, serving as effective temporary solutions during the fabrication of permanent restorations. Furthermore, these materials typically demonstrate good adhesion to dental structures and can be designed with antimicrobial properties, which help mitigate the risk of infection. However, there are drawbacks to consider; provisional self-cure materials generally exhibit lower mechanical strength and wear resistance compared to permanent options, rendering them more prone to fractures and wear over time. They may also suffer from discoloration or degradation due to moisture and oral conditions, potentially affecting their aesthetic quality. Additionally, their limited lifespan necessitates timely replacements, which could increase chair time and costs.

Recent studies have shown that adding plant-based oils to provisional self-cure materials enhances strength by acting as natural fillers, improving flexibility, and promoting better chemical bonding within the polymer matrix. These oils help distribute stress more efficiently, increasing load-bearing capacity, while also providing antimicrobial properties that contribute to material longevity. Additionally, some oils may enhance thermal stability, allowing the material to maintain its strength under varying conditions.

Hence, lemongrass oil and tea tree oil were studied for enhancing the transverse strength of provisional self-cure materials due to their unique properties. In literature, lemongrass oil improves the flexibility and toughness of the polymer matrix, facilitating better stress distribution and reducing fracture risk, while also providing antimicrobial benefits that help maintain material integrity. Tea tree oil was also recognized for its strong antimicrobial effects, resistance to microbial degradation and improvement of overall mechanical properties, including tensile and flexural strength. This study was done to compare lemongrass oil with tea tree oil and on their effects in affecting the transverse strength of provisional self cure acrylic resins.

Flexural (transverse) strength is a combination of compressive, tensile, and shear strengths, and it represents the stiffness and resistance of a material to fracture

Results of the present study showed that the control group exhibited highest transverse strength among all the groups with a significant increase of strength only in 5% concentration of LGEO. (Group 3)

This study is in accordance with the Al- Nema et al study[10] where addition of plant fixed oil extracts decreased the strength of heat cure denture based materials. This is also in accordance with the study done by Al-Shanmari where 5 % of LGEO significantly increased the strength .However this contradicts the study done by Ban Nahal [9] where addition of TTO in 15 % was less than control but 20 % increased the strength of denture base material. In this study addition of TTO drastically reduced the mean transverse strength of self cure provisional material. The key difference could be the use of self cure provisional resin material in place of heat cure denture base material .

However adding oil to cold-cure resin systems can reduce transverse strength due to several factors. Some possible reasons are discussed. Oils often act as plasticizers[6], increasing flexibility but weakening the material by disrupting the polymer's tight network. They can also cause phase separation, leading to weak spots

that lower the material's mechanical integrity.[4] Oils may interfere with the resin's cross- linking process, reducing the density of the polymer network and weakening the overall structure. Additionally, oils can affect the viscosity and curing process, potentially causing incomplete curing and further reducing strength[7,8] . Experimental studies, especially in areas like dental resins, confirm that oil additives often lead to decreased mechanical properties, including transverse strength.

## V. Conclusion

The addition of 5 vol. % LGEO has the best effect on the acrylic's improved mechanical properties. The addition of tea tree oil to provisional self cure material significantly reduced the transverse strength These findings highlight the importance of carefully selecting additives in the formulation of provisional self-cure materials, as the choice of essential oils can markedly influence their mechanical behavior and overall effectiveness in clinical applications. Further research is warranted to explore the mechanisms behind these effects and to optimize formulations for improved performance in dental practices.

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