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# Strength Evaluation of Different Dental Pulp Capping Materials

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### ABSTRACT

The goal of this research was to examine the compressive strengths of three pulp capping materials (Theracal, visible light-cured calcium hydroxide liner (VLC dycal), and mineral trioxide aggregate (MTA)) during three time periods. **Methods:** Thirty specimens from each of Theracal, VLC Dycal and MTA were fabricate using Teflon molds. The spec-imens removed from the molds and kept in 100% humidity at 37 C° for 24 h, 7 and 28 days. The compressive strength then measured using a Universal Testing Machine for ten specimens of each materials in each testing peri-od (24 h, 7 and 28 days). The maximum load in newton obtained and then the compressive strength value in MPa calculated. The data then analyzed using ANOVA and Tukey's test. **Results:** VLC dycal after 28 days showed the highest compressive strength value while MTA in 24 h measuring peri-od showed the lowers compressive strength value. Two way ANOVA presented that the type of liner affected the compressive strength significantly ( $P < .05$ ). Tukey's HSD test showed the VLC dycal has higher compressive strength ( $P < .05$ ) in all tested periods followed by TheraCal LC while MTA has lowest compressive strength ( $P < .05$ ) in all tested periods. In addition, The Two-way ANOVA presented that the time also affected on compressive strength sig-nificantly ( $P < .05$ ). Tukey's HSD test showed VLC dycal and MTA is signifiglsly higher after 28 days, while TheraCal LC is signifiglsly higher after 24 h. **Conclusions:** The VLC dycal show the highest compressive strength than the other pulp capping liners in the three testing period, while the MTA show the lowers compressive strength. The compressive strength in both VLC dycal and MTA were increase with time while in TheraCal LC the compressive strength is decreasing with time.

## 1. Introduction

Direct and indirect pulp capping with using several materials has used years ago to preserve the vitality and health of the pulp compound and stimulating reparative and tertiary dentin formation. The goal of pulp capping therapy is prevent physical, chemical, thermal, and electrical stimuli harming the pulp, as well as to limit the advancement of any residual caries and to create a biocompatible seal that keeps germs and noxious

agents out of the pulp complex. While indirect pulp capping used in deep prepared teeth with no visible exposure with or without caries remaining (1,2,3).

The materials used for pulp capping must have satisfactory biocompatibility and biointeractivity, which are important for stimulin reparative dentin formation. It should also have high mechanical qualities so that it can tolerate mastication forces (3).

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Calcium hydroxide-based liners, like Dycal, referred to the "Gold Standard" is recommended as the liner of choice for pulp capping for many years due to its excellent antimicrobial property, low toxicity and its ability to release both calcium and hydroxyl ions which stimulating reparative tissue formation. Even with these main properties of preserving the pulp vitality, these liners have poor mechanical characteristics and low compressive strength that necessitating the use of cement over them to give enough compressive strength beneath the restorative materials. (2,3,4) Traditional Calcium hydroxide materials have a high porosity and solubility in tissue fluids, as well as poor adhesion qualities and are less efficient in eliminating some microorganisms (5).

A visible light-cured (VLC) calcium hydroxide liner is a new form of calcium hydroxide liner which is composed of calcium hydroxide and barium sulfate distributed in urethane dimethacrylate resin with visible light-activated initiators and accelerators. (6) The benefits of a visible light-cured (VLC) calcium hydroxide liner over a chemically cured lining is its fast setting time allows for fewer treatment visits and ease of handling and application.

Mineral Trioxide Aggregate (MTA) is a liner based on calcium silicate that replaces calcium-based pulp-capping liners. MTA performed better than calcium hydroxide as a pulp capping liners, but it has several disadvantages, such as a long setting time that needs additional treatment visits, difficult handling, high cost, and no bonding with restoration placed on it (4,7).

TheraCal is a new light cured pulp capping agent it is resin modified calcium silicate based liner that developed to overcome the limitations of conventional MTA, with improving its physical and mechanical characteristics. It can placed on the exposed tissue of the pulp directly. Because of it is fluid consistency before curing, its easy handling with high sealing ability, Then curing the material that prevent its dissolving into the pulp fluids during a pulp capping process, less microleakage, good ability to bond with various adhesives, and also more calcium release comparing with MTA and Dycal. TheraCal LC is a light-cure liner that enables for immediate placement of the final restorative material, unlike conventional calcium silicate cements (4,7).

The majority of oral forces during mastication are of compressive nature. Thus, compressive strength test is commonly use test for assessing the clinical effectiveness of dental materials by simulate the masticatory forces (2).

In this in vitro study, Theracal, VLC Dycal and MTA compressive strength were evaluated and compared at three predetermined time intervals.

## 2. Materials and Methods

This study evaluated the compressive strength of three pulp-capping materials, in each group use one pulp capping material, which are:

*Group I: TheraCal™ LC resin modified calcium silicate pulp capping (BISCO, USA).*

*Group II: visible light-cured (VLC) calcium hydroxide dycal liner Cal CLTM (PREVEST DenPro, India).*

*Group III: Rootdent MTA (TehnoDent, Russia).*

Thirty specimens of each group of pulp capping cement were fabricated using cylinder Teflon molds (4x6) according to ISO 9917-1: 2007 standard (4) the specimens for each cement prepare according to manufacture instruction. The mold fixed on a glass slab then filled with materials and covered with another small glass slab. Thera Cal and VLC dycal applied in small layers each one was about 1 mm thick, then light-cured each layers for the manufacturer stated time utilizing a LED light-curing unit (woodpecker, china). After polymerization of the light cured material remove them from the mold and cured from all other surfaces. While the MTA specimens allowed to set for 12 h at 37 C° before removing from the mold. The specimens then removed and checked for the presence of voids or porosity so discard the defective samples (8).

The specimens then stored in 100% humidity at 37 C° for three testing period 24 h, 7 and 28 days (9).

Ten specimens of each of the teasing materials specimens was use in every testing period (24 h, 7 and 28 days). They were remove from the containers and dry with an absorbing paper. Then measuring the compressive strength at crosshead speed of 1 mm/min using a Universal Testing Machine (GESTER, total testing solution, China)

according to the ISO 9917-1 recommendation. The greatest force required to fracture every samples obtained in newton and the compressive strength in MPa was calculate using the next formula:

where (P) is the maximum load in Newtons (N) that requiring for each sample fracturing, (D) is the sample diameter in millimeter (mm), and (Cs) is the maximum load in (MPa) (4).

**3. Results**

the amount of compressive strength mean and standard deviation of the three groups are showed at three time periods. As shown, VLC dycal after 28 days showed the highest compressive strength value while MTA after 24 h showed the lowers compressive strength value.

According to Two-way ANOVA the type of liner affected the compressive strength significantly (P < .05). In another word, the compressive strength of the three materials was significantly different. Tukey’s HSD test carried out to pairwise comparisons between the three liners and it showed the VLC dycal has higher compressive strength (P < .05) in all tested periods followed by TheraCal LC while MTA has lowest compressive strength (P < .05) in all tested periods.

In addition, The Two-way ANOVA showed that the compressive strength also affected by the time significantly (P < .05). In other words, the compressive strength was significantly differ at three time intervals. Tukey’s HSD test carried out to pairwise comparisons the three time intervals. The result showed VLC dycal and MTA is significantly higher after 28 days, while TheraCal LC is significantly higher after 24 h.

**4. Discussion**

This study was carry out to assess the compressive strength of three different pulp-capping materials in three different measuring periods. The compressive strength test is use in dentistry for simulated the stress that may result from forces applied clinically to a restorative, base-liner or core build material, as most mastication forces are compressive in nature. Thus, it is essential to study whether compressive force plays a role in fracture failure during mastication (10).

Previous research has shown that a variety of factors influence compressive strength measurement, including sample size and shape, time for hydration, technique of mixing, preparation method, powder/liquid ratio, pressure used when compacting the samples in the mold, and the temperature (8).

Table 1 Compressive strength (MPa) mean ±standard deviation results of the tested materials during different testing period.

The test materials	24 hrs	7 days	28 days	P value
VLC dycal	86.5000Ab ± 3.02765	89.5000Ab ± 3.02765	93.5000Aa ± 3.02765	0.000*
TheraCal LC	80.5000Ba ± 3.02765	75.5000Bb ± 3.02765	69.5000Bc ± 3.02765	0.000*
MTA	29.5000Cc ± 3.02765	38.5000Cb ± 3.02765	45.5000Ca ± 3.02755	0.000*
P value	0.000*	0.000*	0.000*	

Different capital letters in same column represent a significant difference between the three tested liners (P ≤ .05), Different small letters in the same row represent a significant difference between the three-time periods (P ≤ .05). \*: significant (P ≤ .05).

Compressive strength measured after 24 hours, 7 days, and 28 days in the present study. The first period was select to measure the compressive strength after initial setting. The 7 days period was chose to ensure materials complete setting

and to stimulate the primary strength of the cement. While the 28 days period was chose to measure materials long-term stability as it is important the pulp capping material to sustain its strength in order to survive within the oral

environment. (8)

According to this study the MTA has the lowest compressive strength, but the compressive strength increases with time and this was agreed with Aziz 2019, Al-Sherbiny et al. 2021, Gasperi 2020, Negm 2016, and Tanomaru-Filho et al. 2012. (4,8,9,11,12). This may be due to the continuous setting of MTA material and ending of the hydration phase that leads to increasing in its strength and stability with time. (12)

The visible light-cured (VLC) calcium hydroxide liner has the highest compressive strength and the compressive strength was also increasing with time, this was disagreed with Omrani 2021 finding, and this because the calcium hydroxide use in our study was light cure and the high compressive strength due to the incorporation of light-cured UDMA resins in the VLC dycal. (2)

The TheraCal LC has initial high compressive strength that give it high fracture resistance during a pulp capping procedure after placing the final restorative material, and this may be due to its resinous nature with an organic matrix of monomers which is mostly Bis-GMA and inorganic fillers elements of barium, zirconium, silicon, strontium, aluminum and calcium. The compressive strength depends on the composition, size, and content of the inorganic filler particles. (4) But the compressive strength of the TheraCal LC was decreased with time and this agreed with what found by Aziz 2019. (8)

The effective compressive strength of TheraCal LC, as seen in this study, might support its application as a viable pulp capping liner. It can be clinically valuable for patient and dentists if the final restoration can be placed over the pulp capping liner in one appointment, saving time and money.

## 5. Conclusion

The VLC dycal shows the highest compressive strength than the other pulp capping liners in the three testing periods, while the MTA shows the lowest compressive strength. The compressive strength in both VLC dycal and MTA increases with time while in TheraCal LC the compressive strength is decreasing with time.

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