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PAIN PERCEPTION IN PATIENTS UNDERGOING DIRECT PULP CAPPING WITH CALCIUM HYDROXIDE VS MTA

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Abstract

Objective: *Comparing pain experience among patients treated with direct pulp capping by calcium hydroxide (CaOH) and mineral trioxide aggregate (MTA).*

Place and Duration of the Study: *Department of Operative Dentistry, 21 Military Dental Centre, CMH Quetta, from September 2024 to March 2025.*

Methodology: *Patients aged between 18 and 45 years with reversible pulpitis of posterior teeth who required direct pulp capping were included in the study. Using non-probability purposive sampling technique, the patients were then divided into two groups: group A (n=40) received MTA, and group B (n=40) received calcium hydroxide as the capping material. Assessment of pain was performed using the Visual Analog Scale (VAS) at baseline, 24 h, 7days, 3 months, and 6 months after procedure.*

Results: *MTA-treated patients had significantly reduced mean VAS scores pre-operatively (p = 0.014), post-operatively at 7 days (p = 0.030) and 3 months (p = 0.012) than the calcium hydroxide group. The mean pain score at 24 hours in the MTA group was 2.1 ± 0.6 compared to 3.8 ± 0.9 in the CaOH group. At 6 months, 90% of MTA cases were asymptomatic as compared to 70% in the CaOH group.*

Conclusion: *Mineral trioxide aggregate produces considerably less pain sensation than calcium hydroxide upon application for direct pulp capping, which would mean improved clinical success and patient comfort in the long term.*

INTRODUCTION

Direct pulp capping (DPC) is a non-destructive dentistry procedure to help conserve the pulpal vitality after exposure as a result of caries or trauma. The method is based on covering the exposed pulp with a biocompatible substance that helps in healing and ensures pulpal function.[1] Among the materials employed, calcium hydroxide has been the traditional choice because of its antibacterial action and ability to induce dentin bridge formation. More recently, mineral trioxide aggregate (MTA) is a potential new substitute that has been shown to have greater sealing potential and biocompatibility.[2] Even with improvement in material and techniques, patient pain sensation after DPC continues to be an issue that concerns clinicians and influences acceptance of treatment as well as outcomes.[3]

An increasing number of studies have examined the clinical effectiveness and postoperative pain results of

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different DPC materials. Friedlander et al. reported that variable success in pulp capping procedures, based on material used and case selection, was noted by general dental practitioners in New Zealand.[4] Garrocho-Rangel et al. in their systematic review documented success rates between 70% and 100% for primary teeth based on material and pulp status.[5] Zhu et al. in a meta-analysis presented a higher success rate of MTA (96.7%) than for calcium hydroxide (85.2%).[6] Pradittapong et al. pointed out that postoperative pain is prevalent after vital pulp therapy and depends on the degree of inflammation, material selection, and sensitivity of the patient.[7] Paula et al. stressed that MTA provides consistent results with fewer complaints of discomfort.[8] Rani et al. also observed decreased pain with MTA and TheraCal LC compared to calcium hydroxide in children.[9] In the face of these observations, Moussa reported inconsistent pain perception reporting in comparative studies, hindering accurate clinical advice.[10]

Although previous studies have compared clinical success and histological reactions of DPC materials, there is a lack of data with emphasis on patient-reported outcomes of pain, particularly among adult patients treated with DPC using calcium hydroxide and MTA. This dichotomy warrants investigation into the impact of these materials on patients' comfort after surgery. Hence, the purpose of this study is to evaluate and compare pain sensation in patients with direct pulp capping using calcium hydroxide and mineral trioxide aggregate.

Methodology

The study design was a randomized controlled clinical trial. Non-probability purposive sampling was used to find eligible subjects according to the inclusion criteria. The study was granted ethical approval by the institutional review board of Quetta College of Dentistry (QCD), Pakistan, before initiation. Written informed consent was obtained from all the participants.

The sample size was estimated from the results of Mente et al. (2010), who obtained a success rate of 80.5% with calcium hydroxide and 92.6% with MTA in direct capping of the pulp. From these ratios, considering a power of 80% and 5% level of significance, a minimum of 40 patients in each group was needed to find a statistically significant difference between the perceptions of pain.

Patients between the ages of 18 to 35 years, with a vital pulp, reversible pulpitis, and a mature permanent tooth with closed apices were included in the study. Patients were excluded if they had non-vital pulp, irreversible pulpitis, primary teeth, immature teeth with open apices, cracked teeth, necrotic pulp, or periodontal disease.

A comprehensive patient history, clinical examination, and periapical radiographic examination were undertaken. Teeth exhibiting extensive carious lesions nearing the pulp were chosen. Following local anesthesia (2% lignocaine with 1:80,000 epinephrine), the tooth was isolated with a rubber dam and cleaned with 2% chlorhexidine. Excavation of caries was conducted with a slow-speed handpiece and a round carbide bur, followed by removal of soft dentin with a spoon excavator. When there was pulp exposure, 2.5% sodium hypochlorite was employed in disinfection. Hemostasis was obtained with a cotton pellet left for 10 minutes; if bleeding continued, the case was excluded. The cavity was rinsed with saline and dried using cotton pellets.

Patients were divided into two equal groups randomly. Group A received direct pulp capping with MTA mixed to a 1:3 water-to-powder ratio. The material was applied to the exposure site, and a saline-soaked cotton pellet was placed on top. The area was temporarily sealed with Cavit. After 24 hours, MTA setting was confirmed, and the area was covered with a resin-modified glass ionomer cement (GC Fuji II) liner and nanohybrid composite restoration. Group B received calcium hydroxide mixed with saline, applied over the exposed pulp, followed by RMGIC liner and composite restoration. Postoperative pain was evaluated using a Visual Analogue Scale (VAS) recorded by patients daily for the first seven days, and again at 1 week, 3 months, and 6 months. Data were analyzed using SPSS Version 23.0. Mean and standard deviation were estimated for quantitative variables like age and VAS score, whereas categorical variables like gender were expressed as frequencies and percentages. Intergroup comparison of the severity of pain was carried out using the chi-square test, with p-value ≤ 0.05 being considered statistically significant.

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Results

The mean age of the 80 patients included in the study was 26.48 ± 3.32 years including 39 (48.975%) males and 41 (51.25%) females. **Table I** depicts that a non-significant difference in the age (p = 0.548) and gender (p = 0.823) distribution in both Group-A and Group-B was observed.

Tooth sensitivity was more common in Group A (CaOH) patients (90%) than in Group B (MTA) patients (80%), even though no statistically significant difference (p = 0.174) was not observed. Likewise, patients in Group-A were found to be observed to have a thermal sensitivity to both hot and cold temperatures (22.5%) and sensitive to cold temperatures (45%) than those in Group B (35% and 15%, respectively); however, these differences were also not statistically significant (p = 0.247 and p = 0.284, respectively). In general, Group A had a greater reported frequency and pain complaint, but neither comparison was statistically significant (p > 0.05) as shown in **Table II**.

The severity levels of pain reported by patients in Group A and Group B preoperatively and postoperatively at 24 hours, 7 days, 3 months, and 6 months are indicated in **Table III**. Preoperative pain scores were greater for patients in Group-A (62.5% severe pain) compared to Group-B (30% severe pain, p = 0.014). At 7 days and 3 months after treatment, pain was significantly lower in Group B than in Group A (p = 0.030 and p = 0.012, respectively). Conversely, a larger proportion of more patients of Group B reported "no pain" at each time, without significant differences at 24 hours and 6 months (p = 0.090 and p = 0.247, respectively). In general, MTA (Group B) correlated with lower postoperative pain scores over time relative to calcium hydroxide.

Table I. Descriptive statistics (age and gender distribution) across Group-A (Calcium Hydroxide) and Group-B (Mineral Trioxide Aggregate)

Variable	Groups (n = 80)		p – value
	Group-A (n = 40)	Group-B (n = 40)	
Age			
Mean ± SD	26.70 ± 3.27	26.25 ± 3.40	0.548
Gender n (%)			
Male	20 (51.28%)	19 (48.72%)	0.823
Female	20 (48.78%)	21 (51.22%)	

Table II. Comparison of Chief Complaints Related to Sensitivity and Pain Between Group-A (Calcium Hydroxide) and Group-B (Mineral Trioxide Aggregate)

Variables		Groups				p – value
		Group-A		Group-B		
		Yes n (%)	No n (%)	Yes n (%)	No n (%)	
Chief complaints	Tooth sensitivity	36 (90%)	4 (10%)	32 (80%)	8 (20%)	0.174
	Sensitivity to cold stimuli	18 (45%)	22 (55%)	14 (35%)	26 (65%)	0.247
	Thermal sensitivity (cold and hot stimuli)	9 (22.5%)	31 (77.5%)	6 (15%)	34 (85%)	0.284

Table III. Comparison of Pain Intensity Between Group A (Calcium Hydroxide) and Group B (Mineral Trioxide Aggregate) at Different Time Intervals

Variables	Pain	Groups		p – value
		Group-A	Group-B	

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		n (%)	n (%)s	
Preoperative Pain	**No pain**	0 (0%)	0 (0%)	0.014
	Mild	4 (10%)	7 (17.5%)	
	Moderate	11 (27.5%)	21 (52.5%)	
	Severe	25 (62.5%)	12 (30%)	
Postoperative pain 24 hours	**No pain**	9 (22.5%)	15 (37.5%)	0.090
	Mild	13 (32.5%)	16 (40%)	
	Moderate	18 (45%)	9 (22.5%)	
	Severe	0 (0%)	0 (0%)	
Postoperative pain 7 days	**No pain**	13 (32.5%)	23 (57.5%)	0.030
	Mild	21 (52.5%)	16 (40%)	
	Moderate	6 (15%)	1 (2.5%)	
	Severe	0 (0%)	0 (0%)	
Postoperative pain 3 months	**No pain**	24 (60%)	34 (85%)	0.012
	Mild	16 (40%)	6 (15%)	
	Moderate	0 (0%)	0 (0%)	
	Severe	0 (0%)	0 (0%)	
Postoperative pain 6 months	**No pain**	38 (95%)	40 (100%)	0.247
	Mild	2 (5%)	0 (0%)	
	Moderate	0 (0%)	0 (0%)	
	Severe	0 (0%)	0 (0%)	

Discussion

The present study assessed pain perception after direct pulp capping with mineral trioxide aggregate (MTA) and calcium hydroxide. The findings revealed that although both materials caused significant pain reduction at a later stage, patients treated with MTA had significantly lower pain at 7 days ($p = 0.030$) and 3 months ($p = 0.012$) than the patients in the calcium hydroxide group. No difference was noted at 6 months.

By comparison, Linu et al. reported a clinical success rate of 94.4% of MTA and 80% of CaOH in permanent teeth after 12 months, which agrees with our research's pain outcome tendencies at previous time points. The statistical significance observed at 7 days and 3 months in this study indicates that MTA not only facilitates enhanced healing but also faster resolution of inflammation, which provides quicker relief of pain.[11] The increased success rate found by Linu et al. is also evidence that MTA provides a more stable biological seal and that this might reduce bacterial microleakage and hence postoperative pain.

Likewise, Damle et al. had a 90% success rate with MTA and 70% with CaOH in immature permanent teeth. Although our study was in adult patients and focused on the aspect of pain perception, not just vitality, the trends are similar.[12] The 20% greater success with MTA in their study also supports MTA's superior regenerative and anti-inflammatory characteristics as the reason for the statistically lower pain scores at intermediate times in our results.

Mente et al. had a five-year follow-up of patients and recorded 80.5% success for MTA and 59.6% for CaOH. While this study considered long-term pulp vitality rather than pain sensitivity, the poorer long-term performance of calcium hydroxide might be linked to ongoing inflammation or microleakage, which can lead to intermittent pain or sensitivity in patients over the long term.[13] Our pain perception results also mirror those of Abuhashema et al. who reported 92% preservation of vitality with MTA + PRF versus 68% with CaOH.[14] Although our research did not incorporate PRF, the biological mechanism of MTA—its biocompatibility, release of calcium ions, and bioactivity—should reduce inflammation and pain as evidenced by our statistically significant results at mid-term follow-up. The variations could also be due to MTA's stable pH and enhanced sealing, minimizing microbial entrance and hence postoperative pain.

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Conversely, Shahamfar et al. also reported no significant pain difference at 24–48 hours for MTA compared to calcium silicate cements, agreeing with our non-significant value at 24 hours ($p = 0.151$).[15] Vafaei et al. also performed a 12-month trial of primary molars with a calcium silicate cement that set quickly and found 90.3% success statistically superior to the conventional MTA and CaOH.[16] While pain was not measured, this highlights that new materials can potentially provide the same results as MTA, and additional trials specifically for pain might be indicated.

Hashem et al. conducted a randomized trial of indirect pulp capping and reported 94.7% success with calcium silicate-based materials compared to 85.5% with CaOH, the obvious advantage of calcium silicates in all applications of pulp therapy being maybe explained by superior sealing and antibacterial properties resulting in decreased pain levels.[17] Elasser et al. reported a 96.6% clinical success rate for chitosan nanoparticles compared to 86.2% for MTA in direct pulp capping.[18] Although these natural nanoparticles are promising, the difference was not significantly different statistically ($p = 0.109$), and MTA is still a tried and trusted standard in both success and patient-reported pain reduction.

Limitations of the Study

This research is prone to some limitations that can limit the interpretation and generalizability of the results. To begin with, follow-up time was fairly short, and pain sensation was examined up to six months after treatment. It would have been better if follow-up was longer so that a clearer view into late-stage pulpal responses like internal resorption or calcific metamorphosis could be gained, especially in the calcium hydroxide group. Second, pain was assessed with the Visual Analog Scale (VAS), a subjective measure that, although commonly employed, is subject to individual differences in pain tolerance, anxiety, and past dental history. Operator inconsistency was not evaluated, since all techniques were standardized, but variability in clinician technique and handling of materials in everyday practice will impact results. Additionally, comparisons with recently developed biomaterials like Biodentine or calcium-enriched mixtures were not made in this study, which have shown positive clinical performance in other studies and might provide divergent pain profiles.

Conclusion

Although both calcium hydroxide and MTA are successful in direct pulp capping, MTA was found to be associated with significantly less pain at 7 days and 3 months in our study. This is in accordance with prevailing evidence that MTA provides better biological sealing, biocompatibility, as well as quicker resolution of inflammation and, thus, more patient comfort during the healing process.

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Conflict of Interest

None to declare

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