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Original Research Paper

Endodontics

UNVEILING RISKS: A DETAILED REVIEW OF CALCIUM HYDROXIDE ACCIDENTS IN ENDODONTIC THERAPY

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ABSTRACT Calcium hydroxide paste is widely used as a provisional root canal filling material. When extruded inadvertently into the periapical region, it may lead to several complications. Clinicians should remain vigilant regarding the extrusion of intracanal medicaments and the potential for injury to the maxillary sinus or inferior alveolar canal. Care must be taken when administering calcium hydroxide into the canal to prevent any injury to the underlying nerves. These accidents, arising from various factors such as incorrect placement techniques and inadvertent extrusion, manifested a spectrum of complications, from minor discomfort to significant tissue damage. Management of these incidents necessitated meticulous interventions and occasionally surgical procedures to address the severe consequences. It underscores the critical role of precision and interdisciplinary cooperation in managing calcium hydroxide accidents effectively.

KEYWORDS : Calcium hydroxide, accidents, endodontics, intracanal medicament

INTRODUCTION

Introduced by Hermann in 1920, calcium hydroxide has long been regarded as the gold standard intracanal medicament in the field of endodontics. The material has gained popularity as a temporary dressing agent or medicament in various procedures owing to its antiseptic and low cytotoxic properties (Siqueira et al., 2001). As there are challenges in applying calcium hydroxide paste at the root canal apex, an injectable form of calcium hydroxide paste was developed. One of the most frequently employed pastes in clinical endodontic practice is Calcipex II (Morita, Osaka, Japan). The paste has a viscous formulation with water serving as the base material. Its components consist of calcium hydroxide, barium sulfate, propylene glycol, and distilled water (Shin et al., 2016).

An endodontic mishap is a procedural accident that results in an unpleasant experience for both the treating dentist and the patient (Elnager, 2017). Until now, there have been relatively few case reports and case series documenting adverse reactions resulting from displaced calcium hydroxide during root canal therapy (Mojarrad et al., 2022).

In the realm of endodontics, there is currently a lack of clear guidelines regarding the causes and treatment approaches for calcium hydroxide accidents. Studies have been conducted based on case reports to explore potential risk factors and treatment strategies, yet standardized reporting methods are still lacking. Although calcium hydroxide accidents are rare, their consequences can be significant. This article aims to consolidate dispersed information regarding calcium hydroxide accidents from various published sources. It seeks to enhance understanding of the etiology, prevalence, distribution, management, and preventive measures associated with these incidents.

Mechanism of Action of Calcium Hydroxide

The effectiveness of calcium hydroxide as an intracanal dressing can be attributed to its ionic effect (Athanassiadis et al., 2007). This occurs as calcium hydroxide dissociates chemically into calcium and hydroxyl ions, which then act on both tissue and bacteria, eliminating a wide range of bacteria and maintaining efficacy over an extended period. Some researchers have emphasized the potential osteoblastic effect of directly injecting calcium hydroxide into the periapical lesion, potentially affecting the epithelial cystic lining or inflamed tissue (Tronstad, 1981). The effectiveness of antibacterial activity relies on the diffusion of hydroxyl ions throughout the root canal system, which necessitates efficient delivery (Húngaro Duarte et al., 2009). The antimicrobial potency of calcium hydroxide correlates directly with its high pH level (12–13) (Shin et al., 2016).

Etiology

The amount of extruded material is influenced by various factors related to material including its composition and viscosity, and those related to the system used to deliver the material such as the type, gauge, and depth of placement of the needle (Gluskin et al., 2020). Similar to endodontic irrigants, the amount of extruded material is also affected by the canal taper and apical diameter. Additionally, the operator's technique and the pressure applied to the syringe plunger play crucial roles in controlling the volume of material

extruded. Naturally, a higher tendency of extrusion is observed with lower-viscosity materials, further accentuated by the use of high-pressure irrigation needles. (Gluskin et al., 2020).

Excessive instrumentation of the root canal can lead to the breakdown of the apical barrier, allowing root canal instruments or materials to extend into the alveolar bone or potentially into the sinus space (Elnager, 2017). This situation is typically linked to reduced potential for periapical lesion repair and an increased risk of inadvertent damage (Gluskin, 2005).

Extrusion from the teeth in the posterior mandibular region can cause injury to the inferior alveolar nerve due to its close proximity to the tooth apices (Shin et al., 2016). The mandibular posterior teeth are particularly vulnerable to damage. There are two main causes of nerve damage in endodontics: chemical neurotoxicity from paste components and mechanical pressure from the filling material in the mandibular canal (Scolozzi et al., 2004). Increased vessel permeability in the acute stage can lead to blood supply obstruction, resulting in ischemia in the nerve tissue and swelling, potentially causing irreversible damage when prolonged tensile force and compression are applied (Shin et al., 2016).

Prevalence

The foremost case reporting adverse reaction to apically extruded calcium hydroxide was reported in 2000 which was followed by a series of cases to date (De Bruyne et al., 2000). Until now, there have been relatively few case reports and case series documenting adverse reactions resulting from displaced calcium hydroxide during root canal therapy (Mojarrad et al., 2022). Recent research indicates that, while variations exist based on gender, age, and inferior alveolar canal size, proximity of the teeth to the inferior alveolar nerve canal (Kim et al., 2002).

Clinical Manifestations

De Bruyne et al. (2000) observed gingival necrosis when the calcium hydroxide paste extruded through a perforated root of the maxillary central incisor. Another case was reported by Kim et al. (2002) wherein a substantial amount of the material leaked into the maxillary sinus. Such an extrusion can impair normal physiological functions by damaging the Schneiderian membrane and its removal is challenging due to adsorption with the sinus membrane (Sharma et al., 2017).

Sharma et al. (2017) documented two severe instances where accidental extrusion of calcium hydroxide from the maxillary and mandibular molars led to significant necrosis in the scalp, skin, and mucosa, and paraesthesia of the infraorbital nerve and necrosis of the palatal mucosa. Ahlgren et al. (2011) documented paraesthesia and alterations in the surrounding bone following extrusion through the apex of a mandibular premolar tooth. Bramante et al. (1987) reported an irregular necrotic zone in the buccal mucosa three days following administration of calcium hydroxide therapy for controlling root resorption in a maxillary lateral incisor.

The superior margin of the mandibular canal is situated approximately 3.5 to 5.4 mm inferior to the root apices of the molars. Debilitating symptoms such as pain, altered sensation, or paresthesia in the lower lip and chin region may occur as a consequence of damage to the inferior alveolar nerve. (Kim et al., 2002).

To date, the majority of Nicolau syndrome cases reported have occurred following the application of crystalloid suspensions, one such crystalloid suspension is calcium hydroxide paste (Mojarrad et al., 2022). Nicolau Syndrome, or embolia cutis medicamentosa, presents a unique challenge in the medical field due to its rarity and lack of comprehensive understanding and is clinically characterized by intense pain post-injection, followed by a reticular erythematous patch progressing to a necrotic ulcer and scarring. The underlying causes of Nicolau syndrome are still not fully understood (Mojarrad et al., 2022).

Management

Several studies have indicated that the extrusion of calcium hydroxide through the apical foramen does not typically lead to significant disturbances. This perspective highlights the potential therapeutic effects of calcium hydroxide extrusion in promoting healing and disinfection in the periapical region. As long as calcium hydroxide paste does not have prolonged or close contact with soft tissues, any reactions are generally mild and transient (Kim et al., 2002). It has been suggested that the periapical extrusion of calcium hydroxide may compromise periapical healing. Excessive instrumentation of the root canal using either hand or mechanically driven files can result in perforation of the canal. Tissue damage occurs when calcium hydroxide is inadvertently applied outside the confines of the root canal space (Shin et al., 2016).

When neurotoxic symptoms arise from injected endodontic materials, clinicians may decide between a conservative wait-and-see approach (Haas et al., 1989; Rosen et al., 1989) or immediate surgical debridement (Kim et al., 2002; Littner et al., 1986). Various therapies ranging from thrombolytic agents to steroids to antibiotics have been demonstrated to promote tissue reperfusion, reduce inflammatory responses, and prevent infections (Sharma et al., 2017). The healing periods in the six reported cases ranged from 15 days to six months (Gluskin, 2005).

Serper et al. (1994) reported that calcium hydroxide can completely suppress the action potential. If the contributing factor is removed within 30 minutes, nerve conduction can return to normal amplitude. Early removal of causative factors can facilitate recovery from damage, and if mechanical compression hasn't led to nerve bundle necrosis, prompt action by the dental practitioner can result in a favorable prognosis (Shin et al., 2016). Rosen et al. (1989) concluded that surgical treatment doesn't guarantee full sensation recovery and may carry the risk of causing additional nerve damage.

In cases where surgical intervention is necessary, the surgeon must choose between surgical debridement, nerve graft technique, or nerve sliding technique. Surgical debridement may not suffice for recovery in cases of complete neurotmesis or neuroma. The nerve sliding technique may be suitable and safer when the predicted loss of nerve segments is not extensive. (Shin et al., 2016).

Bramante et al. (1987) advocated for conventional surgery in cases where radiopaque material, such as endodontic material, is present in the maxillary sinus, as it can lead to infection and necrosis of the sinus mucosa. Recent studies have also reported success with sinonasal irrigation and functional endoscopic sinus surgery techniques. The techniques involve creating an opening in the nasal meatus and using a balloon to irrigate and remove the paste from the maxillary sinus (Shin et al., 2016).

To date, Nicolau syndrome lacks a definitive treatment. Treatment options vary based on the severity of tissue damage, encompassing topical medications, pain relievers, antibiotics, systemic steroids, anticoagulants, and surgical interventions. Surgical approaches may include simple debridement for mild cases or plastic surgery for more extensive tissue damage, tailored to address the specific extent of injury in each patient(Al-Sheeb et al., 2022).

Recommended Protocol for Safe Administration of Calcium

Hydroxide

The protocols suggested by Gluskin et al. (2005) and Bhalla et al. (2021) include:

1. Use of radiography technique to gauge the proximity of teeth to the inferior alveolar nerve or sinuses.
2. Ensure the canal is sufficiently enlarged to prevent the needle from binding during injection, and it is recommended to gauge the needle size and depth beforehand.
3. Curved canals require a minimum apical preparation of 25 K-file size, while straight canals should be prepared up to 40 K-file size before medicament placement.
4. Rigid stainless steel files have limited efficacy in curved canals.
5. Lentulo spirals, used at lower speeds (5000 rpm) and placed 2 mm short of the working length, along with compaction using blunt-end paper points, can enhance antimicrobial efficacy.
6. For hand files, a master file with the rubber stopper adjusted to the working length is recommended. When using rotary instruments, adjust the rubber stopper 2 mm short of the working length to prevent displacement of filling material beyond the apex.
7. Inject the material slowly while continuously moving the syringe outward from the canal.
8. Avoid excessive pressure during the placement of any calcium hydroxide formulation to ensure there is enough space for the needle to be maneuvered and removed safely.
9. Confirmation of extrusion by postoperative periapical radiographs.
10. Referral to an oral surgeon or endodontist following careful documentation of the events.
11. In severe cases, surgery may be required to debride and remove calcium hydroxide from the injured neurovascular area.

Alternatively, calcium hydroxide points are gutta-percha points containing over 50% Ca(OH)2, are used as short-term medication in root canals, and are firm and flexible for easy insertion and removal (Mahalaxmi et al., 2019). They provide active ions for 1-3 weeks, with additional points added in oval canals, and can be activated by fluid from the dentinal tubules and apical region without extra water (Mahalaxmi et al., 2019).

CONCLUSION

The inadvertent extrusion of calcium hydroxide during endodontic procedures presents a significant challenge and potential complication in root canal therapy. This review has highlighted the various factors contributing to such accidents, including operator error, improper technique, and anatomical complexities of the root canal system.

Furthermore, the consequences of calcium hydroxide extrusion, ranging from mild irritation to severe tissue damage, underscore the importance of preventive measures and meticulous treatment planning. Strategies such as proper instrumentation, precise delivery techniques and cautious irrigation protocols can help minimize the risk of accidents and ensure patient safety.

Moreover, prompt recognition and management of calcium hydroxide accidents are crucial in mitigating potential adverse outcomes. Clinicians must be equipped with the knowledge and skills to identify signs of extrusion and implement appropriate therapeutic interventions to alleviate patient discomfort and prevent further complications. By embracing a proactive and multidisciplinary approach, the field of endodontics can continue to evolve towards safer and more effective treatments, ultimately ensuring better outcomes and experiences for patients undergoing root canal therapy.

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