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Review

Advantages of Glass Ionomer Cement as A Base Rather than A Varnish in Pulp Capping

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Abstract

Indirect pulp treatment (IPT) or indirect pulp capping (IPC) is a conservative alternative therapy for primary and permanent teeth that have deep carious lesions nearing the pulp in the absence of any symptomatology related to pulp degeneration. This is achieved by removing only weakened, humid dentinal tissue that does not resist manual excavation, and intentionally leaving behind the deepmost layer adjacent to the pulp. The healing mechanism in pulp capping involves the repair in the dento-pulpal complex through the formation of a dentin-like matrix known as tertiary dentin by dental pulp. Several dental materials have been used as IPC agents for the maintenance of vitality of deeply carious teeth. Glass ionomer cement (GIC) offers a combination of strength, rigidity and fluoride dispensing properties of silicate particles along with the biocompatibility and adhesive properties of a polyacrylic acid. The cement's adhesion, based on an ion exchange mechanism with the dental tissue, is a unique phenomenon. Although, the adhesive strength has only been understood scarcely so far, it is known that the occurrence of bond failure in case of GIC is mostly from cohesive breakdown in the cement as opposed to adhesive failure at the dento-cement interface. Due to low amounts of polymerization related material contraction, GIC has proven to retain better than composite resins and provides a superior quality of bacterial seal. This seal prevents the progression of pulpal inflammation by preventing further microleakage of bacteria, endotoxins, and lipopolysaccharides at the dentin and glass ionomer interface. New generations of light cure GIC offer even greater retention to dentinal surfaces than traditional chemically cured GIC. However, the cement is appropriate only as an IPC.

Keywords: *glass ionomer cement, indirect pulp capping, indirect pulp treatment, conservative therapy, restoration*

Introduction

The management of deep carious lesions approaching healthy pulp has always been challenging. Indirect pulp treatment (IPT) or indirect pulp capping (IPC) is a conservative alternative therapy for primary and permanent teeth that have deep carious lesions nearing the pulp in the absence of any symptomatology related to pulp degeneration (1). According to one author, John Tomes, it is favorable to "maintain a layer of discolored dentin for the protection of pulp rather than run the risk of sacrificing the tooth" (2). The technique is based on the belief that in circumstances where the walls around the carious lesion are strong and intact, the presence of a small amount of marginally softened dentin at the base of the cavity does not significantly interfere with the durability of the cap. This is achieved by removing only weakened, humid dentinal tissue that does not resist manual excavation, and intentionally leaving behind the deepmost layer adjacent to the pulp. The healing mechanism in pulp capping involves the repair in the dento-pulpal complex through the formation of a dentin-like matrix known as tertiary dentin by dental pulp. Remineralization of dentin has been visualized in multitudes of studies and this sclerotic dentinal tissue is observed to be of a harder texture, darker hue, and minute concentrations of unviable bacteria (3-5). The paramount goal of IPC is to halt the caries progression and preservation of pulpal vitality by promotion of sclerosis in the infected, intact dentin and stimulation of reparative dentin formation along with the arrest of dentinal demineralization (6).

The foremost benefit of this procedure is the potential avoidance of iatrogenic pulpal exposures. Few researchers have found a greater rate of success in case of IPC as compared to other complex therapies like direct pulp capping and pulpotomies (7-10). In case of primary teeth, this procedure is regarded as a definitive therapy as these teeth have a fixed dental life cycle (9).

Methodology

No specific criteria were selected beforehand to determine which publications would be incorporated in this review. Google Scholar search engine was utilized to look for scientific publications containing "glass ionomer cements" and "pulp capping". After a preliminary scanning of abstracts, full-lengths of relevant articles from peer-reviewed journals were acquired. The references sections of these articles were also screened for pertinent citations which were referred to for additional review.

Discussion

Several dental materials have been repurposed as IPC agents for the maintenance of vitality of deeply carious teeth. IPC is not regarded as a technique primarily contingent on the dental material alone. The lining substance is important due to its inherent biochemical composition as in the case of direct pulp capping, in addition to its ability to provide a marginal seal, whose function is to prevent, firstly, further dentinal ingress of bacterial substrate, and secondly, the stoppage of caries-induced destruction in the patient's oral cavity (11). Nonetheless, the biological endurance of the pulp to liners and bases in IPC is still important due to their proximity to pulp. In addition, in deep cavities, it is not always possible to determine if pulpal exposures have taken place (12). An adequate level of tolerance to the liner or base is highly beneficial under such circumstances. Pulp capping with calcium hydroxide is the gold standard for IPT as it encourages the creation of a reparative dentinal tissue by inducing odontoblastic differentiation, secreting extracellular matrix and mineralizing the laid matrix subsequently (13). However, the use of calcium hydroxide as pulp capping agent has certain drawbacks. Studies performing extended follow ups have found that the reparative dentin formed via calcium hydroxide induced pulp capping slowly disintegrates and also develops tunnel defects (14). Due to this reason, a number of other dental materials including glass ionomer cements (GIC) have found additional purpose in restorative dentistry as IPC agents.

GIC was developed in an attempt to overcome the flaws of silicate cements while retaining their advantages. This cement is a combination of strength, rigidity and fluoride dispensing properties of silicate particles along with the biocompatibility and adhesive properties of a polyacrylic acid. The resultant is a hybrid silicate/polycarboxylate cement made of calcium fluoroaluminosilicate glass powder, and polyacrylic and itaconic acid liquid (15). GIC poses one major disadvantage as the setting of the cement relies on an acid-base reaction whose initial phases are hydrolytically unstable (16). Due to this, these cements are very sensitive to dehydration and imbibition for a minimum duration of one-hour post-mixing (15). However, these shortcomings are not as significant in the use of GIC as a liner or base in IPT. The advantages of GIC are numerous in situations where the cement is not under heavy occlusal pressure (17). The cement's

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adhesion, based on an ion exchange mechanism with the dental tissue, is a unique phenomenon. Although, the adhesive strength has only been understood scarcely so far, it is known that the occurrence of bond failure in case of GIC are mostly cohesive breakdown in the cement as opposed to adhesive failure at the dento-cement interface (18). Of significant importance is the fluoride releasing properties of the cement which additionally inhibit carious processes (19). Fluoride has been observed to encourage tertiary dentin formation in IPT. Nakade and colleagues found that micromolar fluoride levels aid in stimulation of proliferative and alkaline phosphatase activity in pulpal tissues (20). At this scale, the ion encourages thymidine to incorporate in cellular DNA of pulpal cells. This enhances the activity of alkaline phosphatase and also raises the type I collagen production thereby facilitating the synthesis of the extracellular matrix. With regards to marginal adaptation, the clinical performance mirrors that of composite resins. In fact, GIC has proven to retain better than composite resins and provides a superior quality of bacterial seal (21). This seal prevents the progression of pulpal inflammation by preventing further microleakage of bacteria, endotoxins, and lipopolysaccharides at the dentin and glass ionomer interface (22). This is due to the lesser polymerization shrinkage in case of GIC as compared to composite resin, owing to a slower setting period and lower resin proportion in the former. The mechanism underlying the reduced appearance of polymerization related losses involves compensation through the transfer of pulpal fluid via an absorption surface formed adjacent to the dentinal tubules. This counters the effect of the restorative material induced polymerization shrinkage, aiding in the maintenance of the marginal seal (23). This is attested by its presence in the demineralized sections exhibiting significant bonding of GIC to the tooth structure (24). In fact, this secure bond, both in terms of shear and tensile strength, is believed to be the primary reason for the popularity of GIC as a pulp capping agent (25). Not only does this prevent the penetration of bacteria and their products in the compromised pulp, but also grants enhanced protection to expansive restorations with deficient adhesion at the cavosurface margins from bacterial invasion via fluoride release (24). The acid and powder components of the cement have undergone multiple alterations since its formulation including the incorporation of radiopaque particles (15). The incorporation of certain ingredients has also allowed the creation of light cured GIC drastically improving its setting characteristics over conventional GIC (26). Light-cured version of GIC allows for adequate lengths of working time as well as expeditious formation of early strength, resulting in moisture-tolerant reaction product. Further, light-cured cements have an edge over conventional GIC with regard to ease of repair of cement damages and defects as well as an enhancement in adhesion to appropriately prepared dentinal surfaces (26). New generations of light cure GIC offer even greater retention to dentinal surfaces than traditional chemically cured GIC (24). Histological section analyses have shown little to no contraction gaps in light photocured GIC. Further, as these cements can adhere directly to composite resin, they have utility as the intermediate dental material in the “sandwich” technique used in IPC where GIC is placed between the prepared dentinal surface and overlying restoration, commonly a composite restoration (27). Few research studies have indicated the benefits of the sandwich technique over the solitary use of GIC or composite resin stating potential advantages of the technique in overcoming the flexure forces transmitted across the entire restorative structure (28). Further, GIC offers the sclerosed dentinal tissue a large number of calcium ions. This technique also helps with reducing the overall polymerization shrinkage, dispensing fluoride, and providing an exterior polished surface. Nevertheless, the technique has certain drawbacks as it increases the length of the procedure, the complexity, and the requirement of precision to place the two materials (23).

Research performed to study if pathogens in the contaminated remaining dentin under the cement maintain viability found a minor quantity of bacteria which were rendered unviable owing to the interruption of their cellular metabolism due to lack of access to substrate (4). This helps in arrest of caries progression in spite of remaining infected dentin close to pulp. Majority of the IPTs are performed on pediatric patients with primary teeth. Due to a well-defined tooth life cycle, primary teeth do not require reopening for inspection of reparative dentin formation after indirect pulp capping (9). In histological studies studying IPTs with GIC, researchers have found hard, remineralized dentin without further lesion spread (4, 5). Hence, in case of primary dentition, GIC based IPCs are considered as definitive dental therapies. Studies have shown high rate of success with use of resin modified GIC (RMGIC) in IPT owing to the merging of adhesive and biological characteristics. RMGIC provides longer working times, reduced intolerance to moisture and allows for polishing to be carried out in the same sitting (29).

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GIC is a water-based cement with bioactive features (30). They have an acidic nature which facilitates adhesion via self-etching on interaction with humid dentinal surfaces due to ionic exchanges creating an intermediate zone obtained from both substrates. However, the cement is appropriate only as an IPC (31). When directly placed as in direct pulp capping, they can worsen an already poor histopathological pulpal state due to their cytotoxic nature (32). This is more prominent in the case of chemically cured GIC as compared to light cured GIC due to the possibility of uncured acidic cement lowering the pH in the vicinity of the pulp for prolonged durations and thereby irritating the pulpal tissues (24). Although, an overlying composite restoration is typically provided to improve mechanical strength, durability, and appearance, a strong base or liner is crucial for the longevity of the restored tooth (33). A minimum amount of compressive strength is required for the restored tooth structure to withstand forces created during functional and parafunctional movements. This strength provides resistance to fracture. In studies comparing calcium hydroxide to GIC, it was observed that as a base material, GIC suffered less deformation than calcium hydroxide (34). Therefore, in cases were remaining dentin thickness is low and extensive loss of dentinal tissue has taken place, GIC provides a more supportive base (34). Another major advantage of GIC over calcium hydroxide is its ability to undergo acid-etching, roughening the dentinal surface and thereby providing a strong mechanical adhesion to the overlying composite restoration (35). The need for acid etching and subsequent "acid erosion" is lessened for bond formation (35). Lower exposure to acidic environment equates to less pulp damage. Extended stage of setting reaction of GIC is mirrored in the primary rapid increase in pH over the first quarter of hour (36). The pH progressively elevates at a much slower rate over the course of following 24 hours. Persistence of an acidic milieu with pH around 2 for five minutes or longer has been observed to adversely affect pulpal recovery (37). Therefore, GIC must not be applied when very little dentin remains over the pulp or pulpal exposure is suspected.

Conclusion

Although GIC undergoes wear over time and under occlusal load as they are weak in nature, together with composite resins, as an intermediary "sandwich" layer in the IPC, they provide several advantages. In contrast to calcium hydroxide, the GIC can be used as a thick base material in teeth where substantial dentin has been lost. This is in addition to use as a thin liner similar to calcium hydroxide in cases where the remaining dentin thickness is high. The recent generations of GIC display superior compressive strengths over classical and novel calcium hydroxide derived products. The acidity, however, is a cause for concern in cases where pulpal exposure is suspected, or a very thin dentinal layer remains after manual excavation of the soft and humid overlying infected tissue. Solutions for clinical challenges related to GIC such as its intolerance to oral humidity and limited working time have been achieved through the devise of light cured GIC which extends the working time and gives control of the setting time to the clinician thereby limiting damage to the material from moisture.

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There is no conflict of interest

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Data availability

Data that support the findings of this study are embedded within the manuscript.

Author contribution

All authors contributed to conceptualizing, data drafting, collection, analysis and final writing of the manuscript.

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