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Laminate Cementation, Passed up to Now: An Overview

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Abstract: - Having well-aligned and brightly white teeth are the two most preeminent components of an appleaing smile. During the 1980s, John Calamia introduced porcelain laminate veneers at New York University in the United States. Currently, Indirect restoration has become a common method for reconstructing damaged teeth. This involves using dental cement to attach the restoration to the tooth and fill the gap, preventing any displacement. The cementation process of ceramic laminates is a critical final step that requires careful handling. Cement thickness is one factor that influences the shear bond strength of luted veneers. Many factors govern cement thickness, one of them being the cement space provided either digitally or by the die spacer thickness and the number of coats applied. Success in this process has been attributed to a clinician's skill in proper case planning, selecting the appropriate ceramics, materials, and methods for cementation, conservative tooth preparation, impeccable finishing and polishing, and effective planning for ongoing restoration maintenance.

Keywords: Cementation, Ceramics, Porcelain laminate veneers, Prosthodontics.

I. INTRODUCTION

Having well-aligned and brightly white teeth are the two most important components of an attractive smile. There has been a steady surge in patients' enthusiasm for enhancing their smiles through various treatment options. The options available for restoring the aesthetic appearance have been increasing similarly (1). There are various methods for addressing this concern, both direct and indirect. Direct-filling materials are an efficient and affordable option for many patients, but they do have their limitations. For example, these fillings may result in long-term discoloration and carry a heightened risk of recurrent caries. (2). A treatment that is frequently utilized by many involves the application of crown restorations, which fully cover the structure of the tooth. In the past, when it came to improving the appearance of teeth, crown restorations were frequently favored over direct fillings due to their superior ability to offer better retention and esthetics. In spite of this fact, it is worth noting that the preparation process for these restorations can be invasive and in specific cases, a considerable amount of healthy tooth structure may need to be removed.(3, 4).

Porcelain laminate veneers were first introduced by John Calamia during the 1980s at New York University in the United States. Ceramic restorations known as veneers are used to cover the front and sides of the anterior teeth, which enhances their appearance and requires gentle handling. They offer a myriad of benefits, including exceptional aesthetics, superior biocompatibility, and impressive durability (5, 6). Advancements in materials and techniques, coupled with an increased demand for aesthetic restorations and emphasis on conservative tooth structure preservation, have led to a rise in the usage of bonded indirect restorations. Ceramic laminate veneers (CLV), inlays, onlays, and full ceramic crowns are some of the dental restorations available for patients. The use of CLV as an esthetic restoration for anterior teeth has increased due to the discovery and understanding of the advantages of bonding ceramic over etched enamel. Although direct restorations are the preferred method for treating damaged posterior teeth due to their ability to preserve maximum tooth structure, Indirect restorations like inlays and onlays are advantageous when it comes to restoring posterior teeth that have undergone extensive damage. The advantages consist of enhanced natural tooth shape, more precise biting points, superior physical characteristics, and contour (7, 8).

Laminate veneers are a popular and conservative option for improving the appearance of anterior teeth with severe discolorations, diastema, or enamel defects. Over the years, they have become one of the most popular restorations in esthetic dentistry. However, the cemented restoration's weakest point is the cement-tooth interface. In addition, in vitro studies have shown that the cervical enamel/luting composite interface is more susceptible to microleakage than the incisal enamel/luting composite interface (9, 10).

When it comes to bonding laminate veneers to dental structures, the preferred method involves using a cementing agent that is activated by light. Specifically, photo-activated cement is the most effective choice for achieving optimal results. The duration of workability for this substance surpasses that of dual-cured or chemically activated cement. Therefore, it becomes easier to eliminate any surplus cement before the polymerization process, leading to a reduction in the amount of time required for finishing after the cementation process. Additionally, the use of resin adhesive systems for cementation can improve the fracture resistance of both teeth and restorations, while

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minimizing the likelihood of fracture formation. This is a crucial factor in achieving a successful outcome. Furthermore, these systems exhibit superior color stability compared to dual-cured or chemically activated systems. (11). Indirect restorations require a cementation phase, and manufacturers provide various shades of resin cement for clinicians to choose from. This allows them to select a color of cement that will achieve the desired esthetic result for the veneer. Nevertheless, the final esthetics of laminate veneers have been a topic of debate in literature due to the contentious nature of the impact of cement color. (12).

II. TYPE OF CEMENT

Currently, Indirect restoration has become a common method for reconstructing damaged teeth. This involves using dental cement to attach the restoration to the tooth and fill the gap, preventing any displacement. The key to achieving a successful outcome lies in selecting the appropriate dental cement that provides optimal retention and durability (13). Furthermore, certain types of cement may possess untapped properties that could greatly benefit clinical outcomes. Notably, a recently developed hybrid bioactive cement boasts high levels of calcium and a balanced pH and promotes the growth of surface apatite. These qualities immediately impact vital tissue, encouraging regeneration and convalescence (14).

In the present day, a wide range of provisional and long-term cements with varying chemical compositions, properties, and clinical uses exist. Typically, provisional cements are either oil-based or oil-free; historically, eugenol was a common ingredient. However, modern formulations tend to exclude eugenol. These cements tend to have inferior physical properties and a thicker film compared to water-based and polymer-based alternatives (15). It is crucial to ensure that any residual provisional cements are meticulously removed from the tooth prior to the application of final cements. It is advisable to reduce the amount of oil present, as it could have an adverse effect on the solidification process during long-term cementing, leading to a less strong adhesion. Thus, opting for eugenol-free cement is a justifiable choice (16, 17).

Two types of long-term cement are available - water-based and resin-based. Each type serves a unique purpose. The water-based luting cement undergoes an acidic solidification reaction and may become acidic during handling. However, it may also exhibit low bonding strength or be non-adhesive to the hard tissues of the tooth. (18, 19). Water-based luting cements, including zinc phosphate, zinc polycarboxylate, glass-ionomer, and resin-modified cements, are known for their fluoride-releasing properties (20); on the other hand, resin cements share a chemical similarity with composite resins, providing exceptional strength to both the tooth and indirect restoration when bonded with dental adhesives. Additionally, Micromechanical retention can be achieved by surface etching of the restoration when used in conjunction with resinous cement. It is essential to exercise caution during the cementation process despite the advantageous properties of these cements (21, 22). Namely, frameworks, metal copings, or partial restorations are usually cured with water-based types of cement. When a stronger adhesive bonding is required between the dental structure and the restorative material, composite cement is recommended as an alternative to other options (23).

Cements can have varying performances, even among different manufacturers who claim to produce identical products (24). Hence, it is crucial to adhere to the manufacturer's instructions and execute the appropriate surface treatments on the restoration and substrate prior to using luting cement. These cements can be classified into two categories: adhesive and non-adhesive. Non-adhesive cement functions by offering mechanical retention and typically comprises water and reactive fillers. Adhesive cement, on the contrary, forms a glue-like bond with the hard tissues of the tooth as well as the restoration. Additionally, it comprises of non-reactive fillers that are anhydrous and salinized (20, 24).

The optimal types of dental cement are designed to safeguard and preserve the tooth's hard structures. They exhibit exceptional resistance to tensile and compression stresses, are highly durable, and mechanically stable. Additionally, the substances exhibit only slight shrinkage, display strong adhesion to both tooth structures and dental materials, and efficiently hinder the formation of cavities at the bonding interface (20). Meeting specific criteria is essential when it comes to dental cement. The ideal cement should be biocompatible, have antimicrobial properties, offer excellent marginal sealing, possess a low film thickness, be user-friendly, and have good resistance to solubility.

Additionally, it should be translucent and radiopaque, have appropriate working and curing times, and exhibit high fracture strength. Optimal wettability (small wetting angle), sufficient viscosity, and aesthetically pleasing properties are also necessary when combined with restorative materials. Lastly, it should be easy to remove any excess material (25, 26).

III. CEMENTATION AND CURING PROCEDURES

The cementation process of ceramic laminates is a critical final step that requires careful handling. It's important to keep in mind that ceramic laminates need a light-cured luting agent instead of dual-type resin cement used for traditional crowns. This is to prevent any color changes that may occur due to chemical reactions during the curing process. In addition, because the restorations are thin and translucent, similar to contact lenses, it cannot be guaranteed that the resin cement will completely cure, particularly if it does not allow photoactivation (27, 28).

There remains a lack of agreement in academic publications regarding whether the adhesive system layer on the inner surface of ceramic laminates should be precured or activated simultaneously with the resin cement. Some argue that pre-curing the adhesives can enhance the degree of conversion, but this may negatively impact the veneer fit, depending on the thickness of the applied adhesive layer (29). Alternatively, employing concurrent photoactivation with the resin cement may expedite the clinical process without compromising the restoration's fit. Nevertheless, it remains unknown whether the duration of photoactivation for the adhesive impacts the color stability of thin ceramic laminates (30, 31).

Debates exist on whether to polymerize the dentin bonding agent before cementation. When placing a restoration, it is possible for the dentin-resin hybrid layer which is unpolymerized to collapse under pressure (32). However, if the pre-polymerized dentin binding agent is used, its thickness may be a concern, as it can range from 0 to 500 µm depending on the type of agent (33). Keeping the dentin-binding agent unpolymerized is recommended unless the clinician uses a dentin-binding agent with extremely thin films (34, 35). However, during the seating of restoration, two issues may arise which can compromise the quality of bonding: (a) The penetration of the resin into the microporosities may be hindered by the dilution of the bonding agent due to the outward flow of dentinal fluid, and (b) the pressure of the luting resin can cause the demineralized dentin to collapse (34).

The shear bond strength of luted veneers can be affected by the thickness of the cement used (36). The thickness of cement is determined by several factors, including the digital or die spacer thickness provided, as well as the number of coats applied (37, 38). When the thickness exceeds 40.55 ± 12 µm, it can result in decreased bond strength figures, in particular when subjected to thermal cycling. Notwithstanding this, the final thickness of the cement is more dependent on the degree of internal fit than on the thickness of the die spacer. Several factors, including the lab fabrication process, veneer material, preparation geometry, seating technique, and viscosity of the resin cement, can affect the ceramic/composite ratio of thicknesses (CER/CPR). A more uniform stress distribution in the laminate can be achieved by having a high ratio (>3). This is because the resin cement undergoes lower polymerization shrinkage and there is a mismatch in the coefficient of thermal expansion of the restorative material. However, It may be difficult to achieve the perfect post-cementation scenario in cases where porcelain needs to be thinned to match the natural contour of a restoration, particularly in areas such as the facial and cervical regions (39-41). Achieving a proper internal fit of around 100 µm is crucial in preventing a decline in the ratio below a critical value unless the restoration is over-contoured. However, color reproduction can be challenging in clinical settings due to the way colors interact and overlap between the veneer, cement, and underlying substrate (42).

IV. FACTORS PREDICTING THE SUCCESS OF THE PROCESS

The efficacy of laminate veneers has demonstrated a noticeable degree of diversity, which could be ascribed to a range of factors such as variations in tooth preparation, type of the adhesive agent, adhesion quality, type of the supporting substrate - whether enamel, dentin, or restorative material - and marginal adaptation. The technique's proven success can be attributed to a string of meticulously executed procedures, including (11) case selection, (12) design of preparation, (12) proper selection of ceramics for use, (7) appropriate cementation material and technique, and (8) proper maintenance (43, 44).

The utilization of advanced adhesive bonding techniques and materials, in addition to new ceramics that provide clinically acceptable levels of fit, have resulted in superior clinical outcomes. The positive biological response to dental adhesives and resin-based cement for bonding porcelain laminate veneers (PLVs) to vital tooth structure is due to the minimally invasive preparation procedure, which aims to preserve enamel and avoid exposing large or deep dentin surfaces. While the degree of conversion's dependence on light polymerization techniques remains a topic of debate, the amount of residual monomer should be taken into consideration both biologically and for the retention of the restoration (45). In today's dentistry, adhesives are classified based on their clinical usage: total-etched and self-etch methods. In contrast, some adhesives are not polymerized and are prone to degradation and separation from the resin, leading to toxicity induction through the formation of free radicals and proactive agents. At high concentrations, Methacryloyloxy-dodecyl pyridinium bromide, which is a vital ingredient in adhesive resins, has been discovered to be toxic (46, 47).

PLVs have achieved great success due to their capacity to imitate the mechanical, functional, biological, and esthetic aspects of natural teeth with great accuracy (48). Some of these parameters to consider are reliable and consistent results, exceptional visual appeal, extended color stability, natural translucency, remarkable resistance to wear and tear, outstanding protection against fluid absorption, practical compressive, tensile, and shear strengths, extraordinary precision at the edges, compatibility with gum tissue, preservation of tooth structure with minimal reduction, and long-lasting endurance (49-51).

Success in this process has been attributed to a clinician's skill in proper case planning, selecting the appropriate ceramics, materials, and methods for cementation, conservative tooth preparation, impeccable finishing and polishing, and effective planning for ongoing restoration maintenance. When applied appropriately, these principles have demonstrated great efficacy in addressing diverse clinical issues, which include rectifying tooth alignment and shape, closing gaps between teeth, replacing existing composite restorations, repairing teeth with worn or eroded incisal edges, covering up enamel defects, and minimizing discolorations such as those caused by fluorosis and tetracycline staining (51-53).

Ensuring an accurate fit around the prepared tooth is essential for effective dental restoration. The finish line is the area that encompasses the prepared tooth, and optimal preparation design and restorative material selection can improve marginal adaptation and fracture resistance, leading to long-term success. The distance between the internal surface of the restoration and the finish line of the preparation is called the marginal gap. Veneers are bonded to the tooth with resin cement, which makes them a unified part of the tooth, capable of withstanding masticatory forces, temperature fluctuations, and chemical and moisture contamination-induced hydrolytic degradation. The proximity between the veneer and tooth interface strengthens the resin cement against unrestrained exposure to oral conditions (54, 55).

V. POST-CEMENTATION COMPLICATIONS

While laminate veneers offer the benefit of preserving a more natural tooth structure, it is important to note that they are not without their challenges. Various factors can affect the success rate of these restorations, including the design of the preparation, the vitality of the tooth, the type of porcelain material used, and the adhesive system selected. Additionally, parafunctional activities like bruxism can also have an impact on the longevity of PLVs. Should issues arise, potential problems may include porcelain fracture, tooth fracture, debonding, periodontal disease, and caries (2). Fractures and debonding have been identified as the primary causes of PLV failure in several clinical trials (56, 57).

One common issue is when porcelain becomes disjointed, often during the cementation process, due to a restoration that does not fit correctly, a resin that is too thick (viscous), or a resin that has begun to set prematurely. This can happen if the resin is exposed to ambient or unit light for too long (2). After cementation, cohesive failure may occur due to an occlusion that is poorly planned or an injury that is traumatic. It is worth noting that these types of fractures typically occur within the porcelain material and seldomly spread to the point where the porcelain and cement meet (58). In case a veneer breaks during its placement, it is possible to temporarily place the restoration since the pieces usually fit closely. The patient is informed promptly about the problem, and a follow-up appointment is scheduled to remove the fractured veneer and create an impression for the final replacement (59, 60). The use of adhesive cementation has been proven to enhance the resistance of restored teeth and bonded ceramic restorations against fracture (61, 62).

There are several geometric-mechanical risk factors that can cause issues during or after cementation, leading to the loss of structure and/or detachment of the PLV (63). Fractures may arise when there is insufficient room for the ceramic material and inadequate preparation. Interestingly, even with sufficient thickness, patients with bruxism experience a significant increase in fracture occurrences. The likelihood of debonding is nearly three times higher. The aforementioned findings imply that any circumstances that result in overloading, such as an imbalanced allocation of occlusal contacts or harmful anterior guidance, might cause mechanical malfunctions of the restorations (such as fractures or chipping), particularly if the veneer is firmly attached. (64). Direct trauma can cause damage, just as adhesive fractures can arise from bonding issues. For patients with parafunctional habits or who participate in contact sports, it is essential to perform an occlusal adjustment promptly, and it is suggested that they wear a mouthguard. It is also crucial to advise them to avoid hard foods, chewing on ice or nails, and any activities that can cause micro-trauma or overload (2, 45). Encountering a cohesive fracture in the composite or bulk fracture that spans less than 50% of the restoration is considered the most optimal type of failure from a clinical perspective. This type of failure allows for repair options within the oral cavity. On the other hand, the majority of failure types involve more than half of the entire restoration (65-67).

VI. POST-CEMENTATION HYPERSENSITIVITY

Occasionally, patients who receive fixed prostheses may experience post-cementation hypersensitivity or postoperative tooth sensitivity in vital abutment teeth. It has been observed that the luting agent is most likely the culprit when hypersensitivity arises after the cementation of a full coverage restoration (68). In 2003, a survey conducted among dentists on the internet found that post-cementation sensitivity had an incidence rate of less than 2% (69). It can be uncomfortable for both the dentist and the patient when post-cementation hypersensitivity occurs. According to an Internet survey, around 59% of participants considered selecting the appropriate luting agent to be crucial in preventing post-cementation sensitivity (69). Zinc phosphate and glass ionomer cement are commonly used as luting agents, and their effectiveness in reducing post-cementation hypersensitivity has been investigated in clinical studies (68, 70).

Post-cementation hypersensitivity can occur in vital teeth as a result of chemical or thermal stimuli that are experienced during a provisional phase or after the placement of indirect restorations (71, 72). Typically, post-cementation hypersensitivity is a temporary condition that resolves within approximately 24 months of the indirect restoration's cementation. A study was carried out to investigate the prevalence of post-cementation hypersensitivity in vital teeth with full coverage restorations, using a double-blind and split-mouth design. The study revealed that IDS application significantly decreased post-cementation hypersensitivity up to one month after cementation, compared to the DDS technique (71). However, at the 6- and 24-month follow-ups, there was no variation in post-cementation hypersensitivity. Another study examining post-cementation hypersensitivity after full coverage restorations placed on healthy teeth also found comparable results (71). The findings align with laboratory studies indicating that applying adhesive resin immediately after tooth preparation can reduce dentin permeability. However, a clinical trial that studied inlay and onlay restorations in posterior teeth found no significant difference in post-cementation hypersensitivity between restorations bonded with IDS and those bonded with DDS during a follow-up period of one week, three months, and 12 months. Exposed dentinal tubules are a significant outcome of tooth preparations for full-coverage restorations, which may explain the variations in clinical findings related to post-cementation hypersensitivity across different types of restorations investigated (72-74).

DDS AND IDS TECHNIQUE

The process of conventional indirect restoration involves a number of complex steps. These types of restorations are made in a laboratory and require two separate appointments. The first appointment involves preparation and taking an impression/model fabrication, while the second appointment is for luting (75). In the first meeting, the dentist will prepare the tooth and take an impression. Afterward, a temporary restoration will be fitted in place. In the second appointment, the temporary restoration will be removed, and a bonding agent will be applied to the dental substrate. Following that, a resin luting agent will be applied for the adhesive luting process once the indirect restoration is ready. This technique, known as delayed dentin sealing (DDS), involves dentin hybridization after the provisional restorations and just prior to the indirect restoration luting process. However, there are some drawbacks to this technique, such as the possibility of residual temporary cement remaining on the dental surface and some of the cement constituents potentially infiltrating the dental surface. As a result, the definitive restoration may not always bond well to freshly prepared dentin but rather to contaminated dentin, which can lead to hybridization failure and decreased bond strength (76).

To avoid this issue, dentists recommend using the immediate dentin sealing (IDS) method. This technique involves applying an adhesive system directly onto the recently cut dentin before placing the provisional phase (77). An adhesive system is applied to dentin immediately after tooth preparation, before impression, in a process known as immediate dentin sealing (IDS). The aim of IDS is to hybridize the dentinal surface soon after tooth preparation and prior to the luting processes (78). This method ensures strong adhesion to freshly cut and uncontaminated dentin, making it highly beneficial for bonding. Furthermore, it effectively protects against bacterial invasion and dentin sensitivity during the provisional phase. An additional advantage is that the thickness of the dentin bonding agent is taken into account prior to the tooth preparation impression. Theoretically, this technique can be utilized with any adhesive system, resulting in significantly improved bond strength compared to DDS (79, 80).

VII. CONCLUSION

Whether the procedure is inappropriate for mechanical, biological, or aesthetic reasons, it can lead to difficulties. Clinicians must be aware, nevertheless, that every action taken before cementation—including tooth preparation, case selection and treatment planning, impression-taking, and appropriate restorative material selection—may contribute to risk factors that affect the quality of cementation. Because these restorations are so thin, deviating from recognized guidelines can have an impact on adhesion quality as well as aesthetics and biomechanics. The methodical implementation of this process is guided by scientific data in order to produce predictable results.

ETHICAL STATEMENT

We the undersigned declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere. We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

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There is no conflict of interest.

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