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Cementation of indirect partial restorations. Treatment of the inner surface of restorations. Part 1.

Viktoriya Petrova[1], Janet Kirilova[1], Sevda Yantcheva[1], Georgi Iliev[2], Christiyan Bozhkovski[1], Peter Bakardjiev[3]

1. Department of Conservative Dentistry, Faculty of Dental Medicine, Medical University, Sofia, Bulgaria
2. Department of Prosthetic Dentistry, Faculty of Dental Medicine, Medical University, Sofia, Bulgaria
3. Department of Pediatric Dentistry, Faculty of Dental Medicine, Medical University, Sofia, Bulgaria

Abstract

The rapid development of digital technologies has significantly influenced the cementation of indirect partial restorations. This process is determined by two key factors – the treatment of the internal surface of the restoration and the choice of cementing agent. Various techniques are employed to prepare the inner surface of indirect restorations, including acid etching, sandblasting, silane use, tribochemical treatment, laser treatment, and mechanical roughening. This study aims to provide a comprehensive overview of methods for treating the internal surface of different CAD/CAM materials, carries substantial implications for restorative dentistry, paving the way for more effective and durable restorations.

Keywords: *CAD/CAM materials, cementation, adhesion, treatment of material surface*

Introduction

In recent years, the field of dentistry has experienced a rapid evolution of digital technologies. Clinicians are increasingly adopting computer-aided design/computer-aided manufacturing (CAD/CAM) technologies to fabricate inlays, onlays, overlays, partial crowns, and veneers. These technologies, with their high esthetic parameters, excellent accuracy of restorations, and reduction of clinical fabrication time, are setting new standards in the industry. The cementation of partial indirect restorations of the hard dental tissues - inlays, onlays, overlays, and veneers, presents unique challenges and opportunities. This stage requires careful planning to ensure the retention of the partial indirect restorations and the fabrication of the appropriate retention devices and cavity elements for metal cast indirect partial restorations. Composite cement achieves retention through a micromechanical adhesion for esthetic constructions, especially veneers and so-called “table tops” (occlusal overlay). Part of the tooth enamel remains in contact with the oral contents in partial indirect restorations. This requires a stronger bond between the enamel, dentin, and the restoration material. The cementation is a crucial stage for the restoration's durability.

Cementation of the indirect partial restorations is influenced by two factors – the treatment of the internal surface of the restoration and the cementing agent (1,2). The inner surface treatment is essential and specific to different materials. Cementing agents are of various types, such as composite materials and glass-ionomers. They connect inherently different structures: composite material and complex dental structures – enamel and dentin (1,2). This places increased requirements for hope and a long-lasting relationship with enamel and dentin, biotolerance to the dental pulp, esthetics, etc. This is also why developing and applying different generations of composite cementing agents. Good knowledge of their qualities and the precise work protocol is necessary to ensure the sought-after effect of long-lasting and reliable bonding of indirect partial restorations without damage to the underlying dental structures (postoperative sensitivity of the treated teeth and or necrosis of the pulp tissue).

This review presents methods for treating the internal surface of materials for indirect partial restorations before cementation.

Internal surface treatment

The materials used for digital construction have been updated and improved. They are divided into ceramic, composite and hybrid (composite materials with ceramics) (4). Ceramic materials for CAD/CAM are divided into feldspar and glass ceramics (leucite, lithium disilicate and zirconium) (4). Glass-ceramic and hybrid materials have improved physical and mechanical properties and wear resistance (5, 6). Surface preparation of materials by different methods is necessary to improve adhesion.

The presence and size of the marginal gap and the final cementation stage are essential for the durability of esthetic indirect restorations. Microleakage between the edges of the cavity and the restoration depends not only on the accuracy of the inlay but also on the adhesion to the hard dental tissues.

Because of the high conversion degree values (1), composite and hybrid CAD/CAM restorations have limited free double bonds on their surface. Pretreatment of the inner surface of the inlay (7) is necessary for a reliable connection. Several studies have been carried out to determine how the adhesive bond's strength changes with different treatment types (1).

The literature describes several techniques for preparing the inner surface of indirect restorations: acid etching (phosphoric, hydrofluoric), sandblasting, use of silane, tribochemical treatment (coating the surface with a silica-based agent), laser treatment, and mechanical roughening (1, 8). The indirect construction material determines the method for preparing the inner surface of indirect restorations.

Treatment of the different materials by chemical agents such as hydrofluoric acid (HF) aims to increase the roughness and free energy of the surface (1), which leads to an improvement of the micromechanical connection (2). Different concentrations of hydrofluoric acid used for this purpose are described in the literature (2,3) – from 5% to 9% (1-3). The application time is 90 seconds, and the rinse time is 60 seconds (2). Other authors apply hydrofluoric acid for a shorter period – 15-20 sec (1,3). Excessive acid etching can damage the material's surface and reduce the adhesive bond's strength (2). HF is effective for acid-sensitive materials containing glass particles, such as ceramics and polymers (leucite ceramics and silica-based hybrid materials) (1, 2). Hydrofluoric acid has been studied to dissolve and remove the surface layer of silica, silicates and leucite crystals, forming pores of 3-4 μm (2).
Lithium disilicate ceramic is a dental glass ceramic. It is a two-phase structure in which the binding phase is glass, and the reinforcing phase is lithium disilicate crystals. Lithium-disilicate crystals neutralise the development of cracks in the glass phase, which explains the great strength of this glass ceramic (12, 13). Research by Malament KA et al. 2020 found a 97.7% survival of inlays and overlays made of lithium disilicate material over ten years (14). Most studies in the literature report that treating the lithium disilicate surface with hydrofluoric acid before cementation, followed by silane application, is most appropriate (13,14). Etching creates roughness on the adhesion surface, which improves the bond between hard tooth tissues and the restoration (13). Hydrofluoric acid is recommended for 20 sec (15).

Sandblasting is a surface preparation method that aims to improve mechanical retention by creating roughness using aluminium oxide Al2O3 (1). Most research shows that this approach is unsuitable for processing ceramic materials due to the formation of microcracks (14, 16). Some authors recommend that the particle size be smaller than 50 μm (2, 17). Cracks are observed on the material's surface with a larger size of Al2O3 (17). Sandblasting should not exceed 30 sec again due to the risk of cracks, according to Tekce et al. (2, 17). The pressure that is used also affects the adhesive bond. According to Kim et al., excessive pressure leads to stress concentration in certain areas and the formation of sharp edges (18). In most studies, the pressure is between 1 and 2.5 bar (14).
As for composite materials, many studies indicate that sandblasting, silane or a combination of both are most suitable for them (8, 19). Similar results were obtained by Soares et al., 2004, and in their study, the combination of sandblasting and silane gave statistically better results (9). The Al2O3 particle size is 50 μm, and the pressure varies from 2 to 4 bar. This gives us reason to suggest that when cementing composite indirect restorations, treatment with Al2O3 and subsequent application of silane should be used.
Cerasmart (GC Europe, Leuven, Belgium) was created in 2014. It consists of 71% by weight units of silica (20 nm) and barium (300 nm) glass particles that are bonded to a polymer matrix (20). In terms of composition, it approaches conventional laboratory composites. In 2021, Cerasmart 270 was developed, which has the same composition, but through a unique technology ("full coverage silane coating"), it achieved a more even distribution of the filler (20). Composite blocks with ceramic particles (Cerasmart) have mechanical properties suitable for restoring significant defects. They have a high tensile strength and a modulus of elasticity similar to the dentin (20). D' D'Arcangelo et al. investigated the differences in micro tensile strength under different composite surface treatment protocols (8). The authors obtained the best results when treated alone with Al2O3 and combined with silane. No change in bond strength was observed after hydrofluoric acid etching.
Crowntec from NextDent (SAREMCO Dental AG, Rebstein, Switzerland) is a 3D printing material with a polymer matrix. The literature describes surface treatment approaches, including sandblasting and subsequent silane application (21).
Zirconia ceramics are biocompatible ceramics. It has high hardness and tensile strength - 900-1200 MPa, fracture resistance and compressive strength. Its initial modifications for application in dentistry showed a

lack of colour aesthetics and poor transparency (22). Modern zirconia ceramics vary widely. They are stabilised with iridium and lower tensile strength – 800 MPa; with ultra-translucent and multi-layered qualities, improving their colour characteristics (23). The latest generations of zirconia ceramics have improved quality and aesthetics and expanded indications of application – ranging from inlays, onlays, overlays, single tooth crowns and more extensive restorations. In modern generations of zirconia ceramics, the high-strength zirconia 3Y-TZP (3mol%yttria-stabilized tetragonal zirconia polycrystal) and the highly translucent zirconia 5Y-TZP (5 mol% yttria-stabilized tetragonal zirconia polycrystal) are combined specially. Zirconia 5Y-TZP has a flexural strength and translucency parameter between those of 3Y-TZP and lithium disilicate (23). The short-term and long-term adhesion to dental tissues of 5Y-ZP and 3Y-TZP are similar to lithium disilicate. 5Y-ZP did not demonstrate measurable material wear and reverse enamel wear like all other materials tested (24,25,26). Sintered zirconia can be treated with hydrofluoric acid to produce microroughs, similar to ceramic materials (26). The information found in the literature regarding treating the internal surface of zirconia materials can be summarised as follows: the best protocol is again Al2O3 sandblasting or tribochemical treatment (19, 27). Some authors suggest applying ceramic primers containing MDP (10-methacryloyloxydecyl dihydrogen phosphate) (23) before cementation to increase the strength of the adhesive bond.

Silane is a bifunctional monomer containing silanol (2, 14). It interacts with the ceramic surface and the methacrylate groups of the organic matrix (14). Silane can be applied after hydrofluoric acid etching or sandblasting. Most studies show that this approach significantly increases the strength of the adhesive bond (14, 28). CAD/CAM materials containing glass particles show considerably higher values of adhesive bond strength when etched with hydrofluoric acid and subsequently coated with silane (14). Materials containing a polymer matrix bond better after sandblasting and subsequent application of silane (14, 29).

Lasers are another method of surface preparation to improve adhesion (1). Various studies have examined the effect of laser type and intensity on adhesive bond strength (1). The most used lasers are Er: YAG, Er, Cs: YSGG, and Nd: YAG (1, 30). Kaptan et al. find no statistically significant change in bond strength with Lava ultimate (3M ESPE, Seefeld, Germany). They observed a difference between the control and laser groups when Vita Enamic (Vita Zahnfabric, Bad Säckingen, Germany) was treated(1, 30).

Another treatment method is **tribochemical** - coating the surface with a silica-based agent (1). This approach roughens the surface and coats it with silica particles that can bond with silane. Papadopoulos et al. found no difference when examining the bond strength between Lava Ultimate hybrid composite and cement using sandblasting and tribochemical treatment (2). Altan et al. claim that tribochemical processing gives statistically better results in a study of zirconia ceramics (27).

Conclusion

Within the limitations of the present study, it could be concluded that the surface treatment of CAD/CAM structures depends on the type of material. Glass ceramics bond best with the cementing agent after hydrofluoric acid etching and subsequent silane application. As for composite materials, most studies found in the literature indicate that sandblasting, silane application, or a combination of the two are most suitable for them. Zirconium materials are only subjected to sandblasting or tribochemical treatment.

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Corresponding author:

Janet Kirilova
Department of Conservative Dentistry, Faculty of Dental Medicine
Medical University, Sofia;
1, St. Georgi Sofiiski blvd., 1431 Sofia, Bulgaria.
e-mail: janetkirilova@gmail.com

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