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PhD THESIS

RESEARCH ON THE INFLUENCE OF NOVEL DESIGN OF CERAMIC VENEERS OVER THE LONGEVITY AND PREDICTIBILITY OF MODERN PROSTHETIC TREATMENT

A B S T R A C T

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A B S T R A C T

Ceramic veneers are thin prosthetic restorations that are bonded to the facial surface of the anterior teeth and are regarded as a conservative solution for improving the shape, color, or position of the teeth. Once bonded with a resin cement, ceramic veneers become an inherent part of the tooth morphology, thus actively participating at the adsorbtion of the loading stress generated by the functional and parafunctional activities.

The cosmetic restoration of anterior teeth has always posed a difficulty for dentists. The indication of ceramic laminate veneers has increased due to increased patient awareness and demand. However, because they are subjected to multiple stresses, the durability of ceramic veneer has always been questioned. The appropriate case selection, the dental substrate, the tooth preparation design, as well as the ceramic thickness, the technological veneer fabrication, the luting materials, and last, but not least, the functional and parafunctional activities are a few of the variables that could affect the long-term prognosis of ceramic veneers.

Preparation design is one of the most contentious factors that influence the success rate of the ceramic veneers. The occlusal load is another essential factor affecting the longevity of the minimally invasive restorations.

There are numerous modern ceramic materials reinforced with leucite, zirconium dioxide, lithium disilicate and aluminum oxide that can be used to fabricate 0.1 – 0.5 mm thick prosthetic restorations, that require minimal or no tooth preparation. Due to these variations, material selection is regarded as one of the most important factors in determining the efficacy of extra-coronal and intra-coronal restorations. Despite the fact that most of their clinical distresses with restorations are linked to material properties, like strength, aesthetics and marginal fit, some dentists remain uninspired by dental materials science. The marginal adaptation is another decisive factor that influences the longevity of ceramic veneers. No material can assure a perfect seal of the tooth-restoration interface; therefore, it is essential to minimize the marginal gap aiming to block the exposure of the resin cement to the saliva, which would result in eventual microleakage, recurrent decays, tooth discoloration and fracture or debonding of the luted veneers.

In addition, the external marginal fit is crucial for the lasting success of ceramic veneers; it is defined as the distance between the margin of the veneer and the finish line of the preparation, in vertical plane. The internal marginal adaptation is regarded as a direct measurement of the luting cement thickness localised beneath the restoration, which is significantly influenced by the fabrication process's precision. Microleakage was also deemed as an indicator of the durability of bonded restorations for many years. The request for ceramic veneers has skyrocketed in both general and specialized dental practices due to

an increase in aesthetic-driven patients, as well as to their clinical success and minimal-invasiveness. The developing of novel bonding systems, metal-free materials, and fabrication techniques, especially pressed and computer-aided design and CAD-CAM) technology, has altered our approach to these prosthetic restorations.

Literature in the field demonstrates annual anterior veneer failure rates spanning from 0% to 5%. Because clinical trials frequently lack precise documentation of tooth preparation designs and dentin exposure levels, it is impossible to make a correlation between the amount of residual enamel and the clinical success. Moreover, numerous other variables, such as the adhesive system, luting cement and protocol, mode of light-curing, clinical procedures, and patient-related factors, may also influence clinical outcome.

Clinically, numerous predisposing factors have been linked to ceramic veneer fracture. These variables include the design of incisal preparation, the ceramic type, the luting agent, and the luting composite thickness, among others.

Concerning the tooth preparation technique, there are numerous classification systems to distinguish the various preparation designs for PLVs, of which the well-known three-type classification: butt-joint, overlap and window is frequently used. The window preparation is characterised by not reducing the incisal edge, and is recommended for teeth with adequate incisal length. The other two types of preparations are recommended for patients who require incisal length and translucency modification. Depending on whether a palatal chamfer is prepared, the varieties are further classified as overlap or butt-joint type. By conducting an accurate and suitable tooth preparation design, the dentist can have a significant effect on the survival rate of the prosthetic rehabilitation.

The proximal linear margin that outlines the facial contour of the tooth is shared by all tooth preparation techniques described in the literature; we refer to this as conventional (CO) preparation. This design has the disadvantages of a limited contact area with the adjacent enamel and a substantial quantity of sound tooth removal. Many cases of clinical failure have been reported as a result of veneers detaching from dental support. Thus, the purpose of this thesis was to develop a novel veneer design aiming to improve the biomechanical and functional properties, which are crucial for long-term clinical success. Consequently, the investigation was organized in accordance with four primary orientations.

The first objective was to obtain a patent for a novel design of veneers known as crenelated (CR) veneers due to their sinusoidal proximal contour, which was believed to increase the contact surface between the restoration and subjacent dental structure, thereby providing higher bonding strength and superior marginal and internal fit. Moreover, it was anticipated that the peripheral micro-retentions would enhance the veneers' retention on the dental surface, thereby diminishing the risk of their debonding. In addition, the sinusoidal margins were intended to serve as a guide during the luting procedure, preventing the veneer from being improperly positioned on the tooth's adhesive surface. Last but not least, the sinusoidal adhesive interfaces localized along the proximal surfaces would be less visible than the linear conventional ones, thereby improving the cosmetic outcome.

The second objective of the research was to compare the marginal and internal fit of crenelated veneers to those of conventional veneers. Optical microscopy, micro-CT, and optical coherence tomography (OCT) investigations were conducted in order to identify any significant enhancements provided by the novel design of dental preparation and restoration. The results of these imagistic investigations revealed higher internal and marginal adaptation of crenelated (CR) veneers to tooth surface than conventional (CO) veneers, as well as a thinner and more uniform layer of luting cement for the CR samples. In addition to this, the bonded interfaces of the crenelated veneers exhibit accurate interfacial structures with no cement or veneer interior defects.

The third objective was to compare the mechanical and adhesive forces of crenelated and conventional veneers used for prosthetic rehabilitation of anterior teeth, thereby generating useful conclusions regarding the effect of tooth preparation on the veneers' resistance to detachment and fracture. The experimental study revealed that the crenelated ceramic veneers provide higher bonding strength than the conventional ones. In addition, the crenelated dental preparation induced a higher adhesive strength than the conventional preparation, whereas the propagation of the adhesive layer fracture was comparable between crenelated and conventional veeners.

The fourth and final objective of the study was to evaluate clinically 25 crenelated and 25 conventional veneers used to enhance the smile design of 15 patients. Consequently, USPHS criteria (retention, color change, marginal discolorations, secondary decays, restoration wear, restoration fracture, tooth fracture, and lack of marginal adaptation) were evaluated during a 3-year follow-up. The clinical performance of the crenelated veneers was found to be superior to that of the CO veneers; therefore, the crenelated veneers appear to be a successful long-term treatment option in esthetic dentistry and may represent the golden option for reducing the risk of veneer debonding rate from the dental support.

The thesis consists in two parts, namely the first one that describes the current state of knowledge regarding the conventional ceramic veneers and the second one that presents the imagistic and mechanical evaluations, as well as the clincal study of the novel crenelated veneers.

A successful restoration heavily depends on the precise fitting at the margins. Optimal marginal adaptation is crucial to prevent extensive gaps that can lead to leakage, luting agent degradation, plaque accumulation, and potential consequences like caries, pulpal lesions, gingival inflammation, periodontal disease, and restoration failure.

The importance of this finish line lies in its profound impact on the accurate fitting and overall quality of the dental prosthetic. Proper preparation design and restorative material selection enhance marginal adaptation and fracture resistance, contributing to the long-term success. The external marginal adaptation of ceramic veneers, defined by the vertical distance between the prepared tooth's finish line and the fabricated veneers' margin, plays a vital role in their success.

The investigation of marginal adaptation and restoration fit is intricate and varied due to factors such as the areas measured, the number of measurements, and the data collection methods used. Some researchers evaluate horizontal and vertical adaptation, while others combine all measurements into a single absolute marginal gap value.

The optimal method for measuring the marginal gap remains a subject of debate. While sectioning restorations and measuring discrepancies under a light or scanning electron microscope (SEM) is the most common approach, micro-computed tomography (micro-CT) provides a non-destructive evaluation of the marginal gap. However, micro-CT has a lower discriminatory capacity compared to optical or electron microscopes and may produce artifacts from refraction. Additionally, defining the lines between materials with different absorption coefficients becomes more challenging when using micro-CT for marginal gap evaluation.

Alothman et al. identify four primary teeth preparation designs frequently discussed in literature: the window (or intraenamel), the feathered edge, the palatal chamfer (or overlapped), and the butt joint (or incisal bevel). These designs can be described as follows:

1. Window preparation: preserves the tooth's incisal edge (also referred to as intraenamel by Chai et al.);
2. Feather preparation: involves buccal-palatal preparation of the tooth's incisal edge without changing its length (also called feather edge by Chai et al.);
3. Bevel preparation: Reduces the tooth's incisal edge length slightly (0.5-1 mm) through buccal-palatal preparation (also described as butt-joint by Chai et al.);
4. Incisal overlap preparation: Decreases the tooth's incisal edge length by about 2 mm via buccal-palatal preparation, allowing the veneer to extend to the palatal aspect of the tooth (referred to as palatal chamfer by Chai et al.).

Along with conventional preparations designs for veneer restorations, no-preparation veneers have gained popularity due to the rising demand for non-invasive, aesthetically appealing, and long-lasting dental restorations, fueled by the introduction of advanced ceramic materials in the market. The thinner dimensions required by these novel biomimetic ceramics, along with effective bonding to enamel and dentin, result in a substantial reduction in preparation invasiveness. This approach aligns with the principles of minimally invasive dentistry and provides better management of various mechanical and clinical concerns by reducing flexing stress and strain within restorations, minimizing exposed dentin, and ensuring a larger enamel substrate for adhesion.

Previous studies have indicated that suitable marginal adaptation figures for restorations ought to range between 100 and 120 micrometers to avert cement degradation and issues. Different research has shown that under clinical circumstances, tolerable marginal adaptation figures might differ, with up to 300 micrometers deemed satisfactory for ceramic restorations.

Limiting the preparation to enamel is deemed a crucial factor for favorable bonding strength and, consequently, a more durable outcom. Furthermore, maintaining the interproximal contact is advised in the majority of literature and research due to the preservation of additional enamel and tooth structure, which enables a secure seat for cementation using a conservative method. Nevertheless, clinicians may encounter specific situations where eliminating the interproximal contact can yield improved aesthetic outcomes, such as misaligned teeth or diastemata. Additionally, the labial reduction amount should range between 0.4-0.7 mm for ceramic veneers. This is because the enamel thickness in anterior teeth, as stated by Ferrari et al. (1991), varies in the incisal third between 1.0 to 2.1 mm, the middle third (0.6-1.0 mm), and at the gingival third (0.3-0.5 mm), making minimal preparation advisable.

Today, a variety of advanced ceramic materials reinforced with leucite, lithium disilicate, zirconium dioxide, and aluminum oxide exists for producing minimally invasive restorations with thicknesses ranging from 0.1 to 0.7 mm, requiring minimal or no tooth structure preparation. Material selection is considered a critical factor determining the success of extra-coronal and intra-coronal restorations, as many clinical concerns are related to attributes like strength, fit, and aesthetics.

IPS e.max CAD, a lithium disilicate glass-ceramic system ($Li_2O_2SiO_2$), is among the most commonly used materials for creating PLVs and was introduced in 2007 by Ivoclar (Schaan, Liechtenstein), employing CAD/CAM technology for production. The blocks are formed through grand casting of transparent glass ingots, and defects (pores and pigment accumulation) are minimized using a continuous glass technology-based manufacturing process. The partial crystallization process results in lithium metasilicate crystals, contributing to the material's remarkable processing characteristics, edge stability, and relatively high strength.

More recently, in 2013, zirconia-reinforced lithium silicates (ZLSs) (e.g., VITA SUPRINITY) were introduced by VITA Zahnfabrik (Bad Sackingen, Germany). ZLS materials are lithium silicate glass ceramics strengthened with approximately 10% zirconia crystals by weight. Initial *in vitro* tests of these new materials revealed that they possess excellent optical and physical properties similar to lithium disilicates due to their unique fine-grained and homogeneous structure.

However, CAD/CAM approaches also have specific drawbacks. Milling thin margins, particularly less than 300 micrometers thick, on ceramic restorations like porcelain veneers can be problematic, with potential marginal inconsistencies or defects significantly affecting marginal adaptation. Another disadvantage is the material waste; CAD/CAM milling discards more material than 3D printing, as leftover material from milling processes cannot be reused. Additionally, constraints are present in the choice of shade and color for CAD-CAM fabricated veneers owing to the limited palette of the milling blocks reserved for this category of restoration.

To summarize the conclusions from Badami et al., assessment encompassing the comparison of marginal adaptation among traditional feldspathic veneers, CAD-CAM, and heat-pressed veneers, marginal precision was deemed to be clinically satisfactory. Feldspathic veneers displayed superior marginal adaptation relative to CAD-CAM veneers. However, in the comparison of CAD-CAM fabricated and pressed veneers, various outcomes were observed. Owing to scarce literature, it was not viable to determine a hierarchy for distinct systems or execute a thorough comparison.

Despite the increasing utilization of intraoral scanners in dental practices, traditional impressions remain the most prevalent technique and continue to be recognized as the gold standard in impression taking. Yet, even following tooth preparation and impression taking, it remains a multistep journey to the final restoration, filled with numerous potential pitfalls, including the impression itself, casting, and indirect digitalization. Consequently, the selection of impression material, along with the chosen impression technique, disinfection protocol, transportation, reset time, type of gypsum, and even the time interval between individual steps, all impact the precision.

Digital impressions have become increasingly popular in prosthodontic fixed restorations, particularly for porcelain veneers, due to their advantages in terms of accuracy, efficiency, and patient comfort. Among numerous digital solutions for the fabrication of porcelain laminate veneers, following technologies such as intraoral scanners are encountered, which capture direct optical impressions, eliminating the need for traditional impression materials and provide high-resolution, 3D digital models that can be immediately viewed and manipulated on a computer screen; along with others such as CAD/CAM Systems and Virtual Smile Design. These systems are capable of producing restorations with high precision, saving time and reducing the potential for errors that can occur with manual techniques.

Veneer debonding in dental porcelain refers to the dislodging of the veneer from the tooth's surface. Several factors can lead to this issue, such as insufficient bonding between the veneer and tooth, excessive biting forces, or dental injury.

Frequent failure modes linked to laminate veneers involve fracture or debonding, with the intensity and orientation of the load considerably impacting their long-lasting success. Multiple studies have demonstrated that stress accumulates at the adhesive boundary between the luting cement and enamel. Shear stress provokes veneer displacement, imposing compressive stress on the most fragile regions (incisal or gingival margin). This event may generate microcracks that evolve and affect the fracture or separation of veneers. A majority of fractures result from adhesive failure at the porcelain/cement interface due to complete debonding or veneer fracture. During the polymerization shrinkage of the composite resin cement, the porcelain experiences minimal deformation, thus producing residual stress at the interface.

A meta-analysis of *in vitro* studies on ceramic veneers with various preparation designs revealed that ceramic veneers with the butt-joint preparation have the least impact on tooth strength, and veneers with the palatal chamfer (PC) preparation are most prone to ceramic fractures based on static load-to-failure testing.

Other *in vitro* studies directly comparing ceramic veneers with the feather edge and and butt-joint preparation designs either revealed no statistically significant difference in load-to-failure values between the two designs or a statistically higher load-to-failure value with the butt-joint preparation design.

The differing outcomes imply that ceramic veneer fatigue testing depends on factors such as loading frequency, magnitude, distance, direction, and sample tooth quality. It is crucial to note that standardized protocols for simulating clinical ceramic veneer fractures do not exist. Finite element analyses by Zarone et al. revealed stress concentrations primarily at the incisal edge and cervical tooth region, while Li et al. observed stress concentrations on the labial cervical third.

Zirconia veneers displayed remarkable resilience, with the fewest fractures and the highest rate of complete debonding. In contrast, feldspathic porcelain veneers demonstrated a higher propensity for fractures and a lower rate of complete debonding. These findings are crucial for guiding clinical decision-making and improving the longevity and performance of veneer restorations.

Porcelain veneer success is substantially impacted by the durability and persistence of the connection established among the three distinct elements of the bonded veneer composite: the surface of the tooth, the porcelain veneer restoration, and luting agent. Progress in adhesive methodologies has heightened anticipation that the biomechanical and structural robustness of the enamel-dentin composite can be partially replicated using porcelain veneers. Accomplishing effective bonding to dental structures relies on the appropriate preparation and treatment of the participating surfaces, encompassing ceramics and mineralized dental tissues

When it comes to the surface treatments of the tooth structures, the enamel surface must undergo conditioning with 37% phosphoric acid. This process enhances the surface energy of the structure, resulting in optimal surface wetting with the bond. During this phase, precautions should be taken to prevent contamination from saliva or breath moisture, which can reduce enamel's surface energy. Consequently, isolating with a rubber dam is highly advised, as it lowers the stress input during the clinical procedure.

In cases where dentin is exposed, the recommendation is to seal the structure using a dentin bonding agent immediately post tooth preparation and before the ultimate impression itself as the newly prepared dentin is optimal for adhesion. This strategy, termed as the "resin-coating technique," involves the application of a layer of low-viscosity resin between the dental substrate and the luting cement. This process seems to lead to enhanced bond strength, decreased crack development, bacterial penetration, and postoperative sensitivity, as it allows acid conditioning of the enamel whilst avoiding dentin conditioning and facilitating better control over enamel conditioning.

Owing to the inherent fragile nature of ceramics, adhesive cementation is employed to enhance fracture resistance by infiltrating imperfections and irregularities on internal surfaces, reducing crack expansion, and facilitating more efficient stress transfer from the restoration to the underlying tooth structure. Luting cements, being versatile substances, can achieve exceptional aesthetic outcomes and are recommended for the cementation of veneers, inlays, onlays, and all-ceramic restorations as well as fiber posts, owing to their bonding potential with the tooth and restorative materials such as ceramics and composite resin. The organic component of cements is typically constituted of similar composite resin monomers, whereas the inorganic part (to a lesser extent, to offer material viscosity and fluidity) comprises of silanized particles, typically of glass or silica.

In a study by Kusaba et al. (2018), the impact of three preparation designs on the marginal and internal adaptation of translucent zirconia laminate veneers was assessed. The preparation design influenced both marginal discrepancy and internal space values. The window preparation group exhibited the smallest marginal discrepancies at incisal, mesial, and distal margins, as well as the smallest internal spaces at the incisal location. Conversely, the incisal palatal chamfer preparation group demonstrated the highest values for these tested parameters.

Relative to the overlap designs (incisal shoulder preparation and incisal palatal chamfer preparation groups) for translucent zirconia laminate veneers, the non-overlap design (e.g., without incisal reduction, such as the window preparation group) displayed superior marginal (at incisal, mesial, and distal margins) and internal (at the incisal margin) adaptation.

Regarding the adaptation at the incisal areas, the non-overlap design (window preparation) may be more appropriate for translucent zirconia laminate veneers. The three preparation designs resulted in comparable marginal adaptation at cervical locations and internal adaptation at cervical and central locations. This suggests that the adaptation of cervical areas was likely unaffected by milling or sintering during laminate veneer fabrication. Marginal discrepancy values ranged from 54.7 to 73.0 micrometers, while internal space fluctuated between 53.4 and 70.4 micrometers. Despite limited evidence, a marginal discrepancy of 120 micrometers has been proposed as the optimal threshold for restoration longevity. For internal adaptation, an internal space of 50–100 micrometers has been recommended for the ideal clinical performance of resin-based luting materials.

Aiming to enhance the mechanical and adhesive properties of the ceramic veneers, the main purpose of the PhD thesis was to patent a novel tooth preparation design deemed to considerably improve the survival rate of the minimal-invasive prosthetic restorations and to further investigate their both *in vitro* and *in vivo* behaviour.

Thus, the doctoral research activities were initiated by elaborating the patent of the crenelated veneers and continued with several *in vitro* studies in order to determine their mechanical and functional behaviour, as well as with a 3-year follow-up *in vivo* study which triggered valuable conclusions regarding the clinical performance of the crenelated veneers.

The crenelated novel design was projected aiming to enhance the mechanical and functional properties of the current conventional dental veneers, subsequently increasing the survival rate of these conservative prosthetic restorations.

The initial objectives of the current research work have been throughly fulfilled by pursuing the proposed four main directions: obtaining the patent for crenelated veneers, imagistic investigations of the adhesive interfaces, mechanical evaluations of crenelated versus conventional veneers and clinical performance evaluation of the novel veneers.

The main conclusions triggerd by the *in vitro* and *in vivo* studies that have been conducted during the doctoral research are presented below.

The Patent entitled „Fațete dentare crenelate", no. RO 131840 B1, issued by OSIM on 30th of December 2020, describes a novel and unique marginal contour of dental veneers, that is deemed to improve both the mechanical and aesthetical results of frontal teeth cosmetic rehabilitation. The clinical failures caused by the conventional veneers, including veneer debonding, marginal microleakage, ceramic fracture, improper marginal and internal fit, and inappropriate in situ placement of the veneers during the luting operation, gave rise to this idea.

The crenelated veneers display a unique sinusoidal marginal contour that is projected to provide the following advantages:

- Augments the adhesive forces between the ceramic and tooth surface, due to the proximal micro-retentions that form precise intricate adhesive joints, hence preventing the debonding of the veneers, as well as the marginal microleakage and secondary decays;
- Provides better contact on the surfaces, thus combining both adhesive and mechanical forces that prevent the veneer debonding;
- Assures a more accurate positioning of the veneers in situ during the luting procedure;
- Facilitates a more appropriate color adaptation along the adhesive interfaces.

The novel crenelated veneers were further investigated regarding the marginal and internal fit, debonding strength and clinical performance in comparison to the conventional veneers.

The influence that the crenelated design has over the marginal and internal adaptation of the veneers in comparison to the conventional design was investigated in two *in vitro* studies. The first one, entitled MICRO-CT AND MICROSCOPY STUDY OF INTERNAL AND MARGINAL GAP TO TOOTH SURFACE OF CRENELATED VERSUS CONVENTIONAL DENTAL INDIRECT VENEERS [23], which was published in Medicina Journal IF= 2.43, indexed in PubMed, as part of the Special Issue New Concepts for Dental Treatments and Evaluation and is available online: https://www.mdpi.com/1648-9144/57/8/772. The second one, entitled Crenelated versus Conventional Ceramic Dental Veneers: Microscopy and Micro-CT Evaluations of Marginal and Internal Fit to Tooth Surface, which was published in ISI Proceedings SPIE, DOI:10.1117/12.2607522.

The conclusions triggered by these imagistic investigations were the following:

- Crenelated ceramic dental veneers, with their marginal sinusoidal contour, display a higher marginal adaptation (60 μm) than the conventional (with linear margins) veneers (230 μm);
- The internal adaptation is considerably better for the crenelated veneers in comparison with conventional ones, as the clinically accepted cement thickness/width of up to 120 μm covered 81.5% of the tooth surface for CR compared to 64.5% for CO;
- Such a thinner and more uniform layer of luting cement which is specific for the crenelated adhesive interfaces creates the premises for better protection of

restorations from cement shrinkage, microleakage, tensile forces beneath the veneers and, eventually, debonding or fracture;

- The homogeneity of the luting cement is similar for both crenelated and conventional veneers;
- Micro-CT proves to be a reliable and precise tool to evaluate the internal adaptation of the restorations, as well as the porosities localized in the luting cement. Moreover, it has the advantage of providing 3D information on the entire volume of dental cement (i.e., the interface between dental support and veneers).

The marginal and internal fit of the novel crenelated veneers was also investigated using Optical Coherence Tomography (OCT) working in Time Domain (TD), as it is presented in the *in vitro study* entitled OPTOELECTRONIC EVALUATION OF INDIRECT DENTAL VENEERS INTERFACES, published in ISI Proceedings SPIE Volume 10831, 2018, Seventh International Conference on Lasers in Medicine; 108310O (2018) https://doi.org/10.1117/12.2282648.

The conclusions drawn after performing the OCT evaluation were the following:

- The bonded interfaces of the crenelated veneers display accurately interfacial structures with no inner defects of the cement or veneers;
- The cement layer has the same homogenous thickness all over the sinusoidal junctions, thus proving a proper internal and marginal adaptation of the crenelated veneers to the enamel;
- The internal and marginal adaptation of the crenelated veneers to the dental support is accurate, with no gaps or inner defects identified along the interfaces. Therefore, the failure rate due to marginal percolation, secondary decays, or sheer detachments of the veneers may be significantly reduced by elaborating this particular type of indirect restorations;

The assessment of the influence that the crenelated design has over the interfacial adhesive forces and mechanical resistance to detachment of veneers in comparison to the conventional design was described in the *in vitro* experimental study entitled THE INFLUENCE OF A NOVEL, CRENELATED DESIGN OF CAD-CAM CERAMIC VENEERS ON THE DEBONDING STRENGTH, which was published in Materials Journal IF= 3.74, indexed in PubMed, as part of the Special Issue Biomaterials and Mechanics in Dentistry and is available online: https://www.mdpi.com/1996-1944/16/10/3694.

According to the results obtained, the following final afirmations can be stated:

- Crenelated ceramic veneers, with their proximal sinusoidal contour, display a higher bonding strength than the conventional veners, as the recorded maximum force increased by 14.07%;
- Accurate conditioning of ceramic and enamel during luting procedure is of paramount importance for preventing veneer debonding; moreover, the remnant adhesive layer covering almost the entire surface of the crenelated samples after veneer debonding underlines the superiority of the novel preparation;
- Crenelated dental preparation triggers higher adhesive strength than the conventional one, as the maximum peeling stress increased by 25.06% for the crenelated samples;
- The propagation of the adhesive layer fracture is similar between crenelated and conventional veeners and the type of tooth preparation does not influence the values of the maximum stress that is generated within the adhesive interface during functional loading.

The clinical performance of the crenelated versus conventional veneers was evaluated during a 3-year follow-up period, from September 2019 until September 2022. The restorations were evaluated at baseline and after every 6 months, according to modified United States Public Health Service (USPHS) criteria for retention, marginal adaptation, color change, marginal discoloration, restoration fracture, tooth fracture, restoration wear, secondary decays, postoperative sensitivity, patient satisfaction. The clinical steps of the crenelated dental preparation, digital impression technique, veneers' design elaboration and luting procedure are described in the clinical case report entitled CHAIR-SIDE CAD/CAM CERAMIC VENEERS WITH A NOVEL PREPARATION that was publised in Medicine in Evolution 2018; XXIV (4) : 335-341, indexed BDI.

The clinical evaluation consisted of visual inspection and patient satisfaction survey and it provided the following conclusions:

- The debonding strength provided by the crenelated veneers is higher than the conventional ones, as no case of veneer debonding was observed. Thus, the crenelated dental preparation enhances the mechanical properties of the veneers, which is of paramount importance for the long-term success of the prosthetic rehabilitation;

- The design of the proximal contour of the dental preparation, whether linear or sinusoidal, does not determine the colour change of the ceramic veneer, tooth fracture and restoration wear;
- The microleakage risk of the crenelated veneers is lower than the conventional ones, as marginal discolorations were less observed along the crenelated in comparison to the conventional veneers;
- The crenelated marginal contour of the dental preparation triggers higher marginal fit of the veneers to the enamel, as no secondary decays were identified along the adhesive interfaces, whereas several secondary decays were identified at the teeth restored with conventional veneers, even though the same unfavorable oral conditions were observed in some cases;
- The crenelated design of the tooth preparation does not influence the adhesive interface integrity, as the type of veneer fracture was cohesive, within the thickness of the ceramics, caused by external factors;
- Dental sensitivity after luting the crenelated veneers is substantially lower, which is an indirect parameter for better marginal and internal fit;
- Although the clinical inspection of the veneers during the 3-year follow-up period revealed some cases of insatisfactory evolution or even failure, all patients expressed their high satisfaction with the treatment outcome, both functionally and aesthetically;
- As a final conclusion, the clinical performance of the crenelated veneers is better than the CO ones, according to the criteria provided by the modified USPHS rating system; in addition to this, the crenelated veneers seem to represent a successful long-term treatment option in esthetic dentistry and they may represent the golden option for diminishing the detachment rate of the veneers from the dental support.