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Material Type, Restoration Thickness and Marginal Adaptation of Occlusal Veneers: A Narrative Review

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Abstract

The preservation of natural tooth structure represents a fundamental principle in contemporary restorative dentistry. Occlusal veneers, also known as tabletop restorations, have emerged as a conservative treatment modality for managing worn posterior teeth, offering the advantage of maximum preservation of sound tooth structure while restoring function and aesthetics. The long-term clinical success of occlusal veneers depends critically on marginal adaptation, as inadequate marginal fit exposes the luting cement to the oral environment, leading to cement dissolution, microleakage, secondary caries, and eventual restoration failure. Advances in dental materials and fabrication technologies have expanded the available options for occlusal veneer construction, including lithium disilicate glass-ceramics, polymer-infiltrated ceramic network (PICN) hybrid ceramics, and additively manufactured composite resins. Restoration thickness represents another critical parameter, particularly in the context of minimally invasive preparations where reduced material volume may compromise marginal integrity. This narrative review synthesizes the current evidence on the effect of material type and restoration thickness on the marginal adaptation of occlusal veneers, examining the underlying mechanisms, clinical implications, and the influence of thermocycling aging on marginal integrity. The evidence demonstrates that material type significantly affects marginal adaptation, with lithium disilicate exhibiting higher marginal gap values compared to hybrid ceramics and reinforced composites, particularly at reduced thicknesses. Restoration thickness influences marginal adaptation in a material-dependent manner, with thinner restorations generally showing higher marginal gap values. A multimodal approach combining careful material selection, appropriate thickness, and optimal fabrication technique is essential to ensure restoration longevity.

Keywords: Occlusal veneers, marginal adaptation, lithium disilicate, hybrid ceramics, CAD/CAM, 3D printing, thermocycling

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1. Introduction

The preservation of natural tooth structure represents a fundamental principle in restorative dentistry. Over the past decade, the management of occlusal tooth wear has evolved significantly, with minimally invasive approaches gaining widespread acceptance as alternatives to traditional full-coverage restorations [1-2]. Occlusal veneers, also known as tabletop restorations, have emerged as a conservative treatment modality for restoring worn posterior teeth, offering the advantage of maximum preservation of sound tooth structure while restoring function and aesthetics [3-4]. These extracoronal restorations require minimal tooth preparation, primarily guided by interocclusal clearance and anatomical considerations, making them an attractive option for patients with moderate to severe tooth wear [5]. The success of occlusal veneers depends on multiple factors, including the mechanical properties of the restorative material, restoration thickness, adhesive cementation technique, and the quality of marginal adaptation (Figure 1) [6-7]. Among these factors, marginal adaptation is considered a critical determinant of long-term clinical success, as inadequate marginal fit exposes the luting cement to the oral environment, leading to cement dissolution, microleakage, secondary caries, periodontal inflammation, and eventual restoration failure [8-9].

The clinically acceptable range for marginal gaps has been established between 50 and 120 µm, although some authors consider gaps up to 200 µm acceptable under certain conditions [10]. The evolution of dental ceramics has significantly expanded the available options for fabricating occlusal veneers. Lithium disilicate glass-ceramics (IPS e.max CAD and IPS e.max Press) have been extensively studied and demonstrate excellent clinical performance, with survival rates exceeding 95% over 10–16 years in various clinical scenarios [11]. The material's high flexural strength (360–400 MPa) and favorable optical properties enable the fabrication of thin, aesthetically pleasing restorations [3]. More recently, hybrid ceramics, such as polymer-infiltrated ceramic networks (PICN), have been introduced to combine the advantageous properties of ceramics and polymers, offering improved resilience and favorable fracture patterns compared to conventional ceramics (Figure 2) [12]. Advent of additive manufacturing (3D printing) has introduced new possibilities for dental restoration fabrication. Unlike subtractive manufacturing (milling), which removes material from prefabricated blocks, additive manufacturing constructs objects layer by layer, offering advantages including reduced material waste, the ability to fabricate complex geometries, and patient-specific customization (Figure 3) [13-14].

Recent developments in printable hybrid ceramic materials have enabled the fabrication of definitive restorations using digital light processing technology, with materials such as Varseosmile Crown Plus and Ceramic Crown demonstrating promising mechanical properties [14-15]. Restoration thickness is another critical factor influencing the performance of occlusal veneers. While manufacturers typically recommend minimum thicknesses of 1.0–1.5 mm for posterior ceramic restorations, several studies have investigated the feasibility of thinner restorations (0.3–0.8 mm) for minimally invasive applications [16]. However, the relationship between thickness and marginal adaptation remains less explored compared to fracture resistance. Studies have shown that materials requiring post-milling crystallization, such as lithium disilicate, may undergo dimensional changes that affect marginal adaptation, particularly in ultrathin sections [16]. In contrast, hybrid ceramics and 3D-printed composites that do not require firing cycles may exhibit more consistent marginal adaptation across different thicknesses (Figure 4) [1]. This narrative review aims to evaluate the effect of different materials (lithium disilicate, hybrid ceramic, & 3D-printed composite) and two thicknesses on the marginal adaptation of occlusal veneers before and after thermocycling aging, synthesizing current evidence to guide clinical decision-making.

2. Dental Ceramics and CAD/CAM Materials

2.1. Lithium Disilicate Glass-Ceramics

Lithium disilicate glass-ceramics represent a significant advancement in the evolution of dental restorative materials, known for combining exceptional esthetics with high mechanical properties. Introduced commercially in the late 1980s, lithium disilicate glass-ceramics initially gained attention due to their unique microstructure comprising finely distributed needle-shaped lithium disilicate crystals embedded within a glassy matrix. This microstructural arrangement imparts enhanced flexural strength, fracture toughness, and durability compared to earlier glass ceramics, such as leucite-reinforced porcelains [17]. At microstructural level, lithium disilicate ceramics consist predominantly of interlocking rod- or needle-shaped lithium disilicate crystals embedded in a residual glassy matrix. These crystals typically range from approximately 1 to 5 micrometers in length and about 0.5 to 0.8 micrometers in width, depending on the specific formulation and manufacturing process. This characteristic microstructure is created through controlled crystallization of the parent glass during heat treatment, often induced by nucleating agents such as P_2O_5, which promote uniform crystal growth within the glass matrix. The crystalline phase can constitute around 60–70% of the material volume, with the remaining portion being the amorphous glassy phase [18-21]. The chemical composition of IPS e.max CAD, as reported by manufacturers, typically consists of 57–80% SiO_2, 11–19% Li_2O, up to 13% K_2O, up to 11% P_2O_5, up to 8% ZrO_2, up to 8% ZnO, up to 5% Al_2O_3, up to 5% MgO, and coloring oxides [3-12].

The lithium disilicate phase ($Li_2Si_2O_5$) constitutes approximately 70% of the crystalline content, with lithium orthophosphate (Li_3PO_4) forming a minor crystalline phase (20). The chemical structure of lithium disilicate is based on the random network hypothesis proposed by Zachariasen, where SiO_2 serves as the glass network former with bridging oxygen bonds between adjacent silicon atoms. The addition of network-modifying oxides, including alkali metal oxides (Li_2O, K_2O) and alkaline earth metal oxides, disrupts the silica network by creating non-bridging oxygen bonds. This modification influences the viscosity, working temperature, and crystallization behavior of the glass [20-22]. Lithium disilicate restorations can be fabricated via heat pressing (IPS e.max Press) or CAD/CAM milling (IPS e.max CAD). The latter is available as partially crystallized blocks that are soft enough for efficient milling, reducing tool wear and fabrication time. Subsequent crystallization heat treatment transforms the material from its soft, millable state to the final high-strength lithium disilicate phase, increasing flexural strength from approximately 130 MPa to 360–400 MPa [20]. The optical superiority of lithium disilicate is attributable to its microstructure: small, uniformly distributed needle-like crystals within a glassy phase. This configuration minimizes internal scattering and maximizes translucency [23].

The exceptional optical properties of lithium disilicate, combined with high mechanical strength, enable the fabrication of thin, minimally invasive restorations with natural aesthetics. The high flexural strength allows occlusal veneers to be fabricated with reduced thickness (0.5–0.8 mm) while maintaining adequate resistance to occlusal forces [3-24]. The adhesive cementation of lithium disilicate restorations represents another significant advantage. The presence of a glassy matrix enables etching with hydrofluoric acid, creating microretentive surface morphology for resin cement interdigitation. Silane coupling agents further enhance the bond strength by chemically bonding the silica network to resin cement. Combination of micromechanical retention and chemical bonding provides reliable adhesion that strengthens restoration-tooth complex and improves fracture resistance [25]. However, lithium disilicate occlusal veneers have limitations that must be considered. The primary mechanical limitation is the material's susceptibility to brittle fracture under tensile stresses, particularly at reduced thicknesses. Studies have shown that occlusal veneers with thicknesses below 0.7 mm exhibit significantly reduced fatigue resistance and clinical survival rates [26]. The minimum recommended thickness for lithium disilicate occlusal veneers is 0.7–1.0 mm to provide adequate fracture resistance, although some authors have suggested that 0.5 mm may be sufficient for certain clinical situations [24].

2.2. Hybrid Ceramics (Polymer-Infiltrated Ceramic Networks)

Hybrid ceramics, also known as resin-matrix ceramics or ceramic-like materials, represent a relatively new category of dental restorative materials that combine the advantageous properties of ceramics and polymers. Hybrid ceramics are not true ceramics in the strict sense but are ceramic-like materials with a polymer matrix containing inorganic ceramic fillers. The International Nomenclature Committee defines "porcelain" as inorganic refractory material processed through cutting, sintering, or die casting; thus, resin-matrix ceramics are classified as ceramic-like materials rather than conventional ceramics [27]. Hybrid ceramics serve as a bridge between conventional ceramics and resin composites, offering a distinctive blend of aesthetic appeal and functional performance. Their key benefits include the ability to deliver exceptional aesthetics alongside enhanced mechanical properties compared to traditional resin composites. The integration of a polymeric network within ceramic structure or refined grain structure of nanoceramics enhances flexural strength beyond that of traditional resin composites while maintaining adequate wear resistance [28]. VITA ENAMIC is a representative polymer-infiltrated ceramic network (PICN) material that consists of feldspathic ceramic network (86% by weight) infiltrated with a polymer network (14% by weight). This dual-network structure provides a unique combination of properties: ceramic network provides hardness & wear resistance, while polymer network contributes resilience and a modulus of elasticity closer to that of dentin. The material's flexural strength is approximately 150–160 MPa, which is lower than that of lithium disilicate but adequate for many clinical applications [12]. Resin nanoceramics, such as Lava Ultimate, consist of nanoscale ceramic particles dispersed within a resin matrix. These materials contain approximately 80% ceramic fillers by weight and have particle sizes less than 100 nm.

The nanoceramic fillers include silica nanomers (20 nm diameter) and zirconia nanomers (4–11 nm diameter), which are grouped into nanoclusters (0.6–10 μm) and embedded in a crosslinked resin matrix. The resin matrix typically comprises bisphenol A glycidyl dimethacrylate (Bis-GMA), ethoxylated bisphenol A dimethacrylate (Bis-EMA), UDMA, and TEGDMA, with silane coupling agents providing chemical bonding between the ceramic particles and the resin matrix [12-29]. The selection of lithium disilicate or hybrid ceramics for occlusal veneers should be based on a comprehensive assessment of clinical factors, including the extent of tooth wear, occlusal load, aesthetic demands, and patient-specific variables. Lithium disilicate occlusal veneers are recommended for occlusal reconstruction due to their high fracture resistance and favorable wear characteristics. The material's hardness is not much greater than enamel hardness, preventing excessive attrition of opposing teeth, and it can be bonded adhesively to tooth tissues [24]. Hybrid ceramics may be preferred in situations requiring reduced stress concentration and favorable failure patterns. They offer a potential alternative to all-ceramic restorations due to their favorable fracture patterns and the possibility of intraoral repair. The lower elastic modulus may be advantageous for stress distribution, reducing the risk of catastrophic failure and preserving the underlying tooth structure [12].

3. Milling and 3D Printing Technologies

3.1. Subtractive Manufacturing

Computer-aided design and computer-aided manufacturing technology has revolutionized restorative dentistry by enabling precise fabrication of dental restorations through digital workflows [30]. Subtractive manufacturing, commonly known as computer numerical control milling, remains the predominant production method in dentistry, characterized by cutting restorations from prefabricated blocks or discs of various materials [31]. This technology operates on the principle of removing material from a larger solid block until desired three-dimensional form is achieved, utilizing a series of commands that control cutting tools and dictate magnitude and direction of movement [32]. The milling process can be performed in wet or dry modes depending on the material being processed. Wet milling is employed for hard materials such as metals, densely sintered zirconia, lithium disilicate, and composite resins to prevent overheating and cracking [33]. Dry milling, or soft milling, is indicated for materials like pre-sintered zirconia, cobalt-chromium alloys, & wax, offering advantages in streamlining the process and enhancing time efficiency. Modern chairside milling machines can finish a single zirconia crown in less than five minutes, demonstrating significant improvements in production efficiency [34]. Despite its widespread adoption, subtractive manufacturing presents several limitations. The process results in substantial material waste, with up to 90% of the prefabricated block being discarded, representing both economic & environmental concerns [35]. Milling burs are subjected to continuous wear and damage, requiring constant replacement, and technology is inherently limited in fabricating hollow structures or intricate internal geometries due to restricted drill accessibility [36]. Additionally, the grinding of certain materials, such as dental ceramics, can generate micro-cracks within internal structures, potentially compromising restoration integrity [37].

3.2. Additive Manufacturing

Additive manufacturing, commonly known as three-dimensional (3D) printing, has emerged as an alternative to subtractive methods in dentistry, offering distinct advantages including reduced material waste, the ability to fabricate complex geometries, and patient-specific customization [30-38]. Unlike subtractive manufacturing, additive manufacturing creates objects by adding material layer by layer, with approximately 10% material waste compared to 90% waste in milling, representing a significant environmental and economic benefit [39]. Among the various 3D printing technologies, vat photopolymerization techniques, including stereolithography (SLA) and digital light processing (DLP), are most widely utilized in dental applications due to their high resolution and ability to produce smooth-surfaced models [40-41]. SLA uses a laser to cure liquid resin point by point, while DLP projects an entire layer of light simultaneously, making it faster but potentially less detailed depending on the projection system's resolution [42]. Both technologies have demonstrated the ability to fabricate highly accurate dental restorations, including crowns, bridges, surgical guides, and orthodontic appliances [38]. The adoption of additive manufacturing in restorative dentistry has been accelerated by the development of printable hybrid ceramic materials intended for permanent restorations [43]. These materials, which combine ceramic fillers with polymer matrices, offer enhanced mechanical properties, dentine-like elastic modulus, and shock-absorbent characteristics compared to traditional ceramics [35].

Commercial materials such as Varseosmile Crown Plus, Ceramic Crown, and P-Crown V2 Ceramic are now available for fabricating definitive restorations using DLP technology [15]. However, 3D printing presents several challenges. Layer-by-layer construction can introduce cumulative errors leading to deviations from intended geometry, especially in complex areas [44]. Post-processing procedures, including washing and curing, are essential but can introduce distortion due to polymerization shrinkage and uneven light exposure [35]. Additionally, ensuring biocompatibility of materials remains critical, as residual monomers from incomplete polymerization can lead to cytotoxic effects. The technology also requires significant initial investment and specialized digital equipment, and regulatory compliance for custom devices necessitates stringent testing to ensure safety and efficacy [40]. The accuracy of dental restorations fabricated by both subtractive and additive manufacturing methods is typically assessed in terms of trueness—how closely the fabricated object matches its digital reference—and precision, the repeatability of results across multiple fabrications [41].

Comparative studies have consistently demonstrated that subtractive manufacturing produces restorations with significantly higher trueness but lower fitness (marginal and internal adaptation) compared to 3D printing [35]. The higher trueness of milled restorations can be attributed to the use of pre-polymerized blocks that ensure high-dimensional accuracy due to the stability and homogeneity of the material [45]. Since blocks are fully polymerized, additional post-processing is not required, minimizing the risk of introducing distortions or structural flaws [35]. Conversely, 3D-printed restorations exhibit lower trueness due to cumulative errors from layer-by-layer construction, polymerization shrinkage during post-curing, and potential warping from thermal and photopolymerization distortions [46]. The improved fitness of 3D-printed crowns, despite their lower trueness, can be explained by the relationship between trueness and seating of the restoration. When a highly accurate intaglio surface (as seen in milled crowns) is seated onto its abutment, excess cement may accumulate on the occlusal surface due to insufficient escape space, hindering complete seating and increasing marginal discrepancies [47]. In contrast, the lower trueness of printed crowns creates more deviation from the CAD design, which may reduce friction with the abutment, minimize hydraulic pressure, enhance cement flow, and lead to improved overall fitness [48].

4. Marginal Adaptation of Occlusal Veneers

4.1. Definition and Clinical Significance

Marginal adaptation is defined as the dimensional accuracy with which a restoration interfaces with the prepared tooth structure, commonly measured as the vertical distance between the restoration margin and the finish line of the preparation. This parameter is considered a critical determinant of the long-term clinical success and survival of indirect restorations [9-49]. The clinical significance of marginal adaptation stems from its direct influence on the biological and mechanical integrity of the tooth-restoration complex. Inadequate marginal fit allows for cement dissolution, bacterial microleakage, plaque accumulation, and the subsequent development of secondary caries, periodontal inflammation, and pulpal pathology [9]. The clinically acceptable range for marginal gaps has been established between 50 and 120 μm, although some authors consider gaps up to 200 μm acceptable under the certain conditions [10].

4.2. Effect of Material Type on Marginal Adaptation

The choice of restorative material significantly influences the marginal adaptation of occlusal veneers. Studies have consistently demonstrated that lithium disilicate occlusal veneers exhibit higher marginal gap values compared to hybrid ceramics and reinforced composites. Bedair (2024) compared the marginal adaptation of occlusal veneers fabricated from three CAD/CAM materials: lithium disilicate (IPS e.max CAD), hybrid ceramic (Vita Enamic), and nano-ceramic reinforced resin composite (Lava Ultimate), at two thicknesses (0.5 mm and 1.0 mm). For 0.5 mm thickness, the study found that IPS e.max CAD presented statistically significantly higher mean marginal gap values (62.1 μm) compared to Vita Enamic (53.48 μm) and Lava Ultimate (57.64 μm). For 1.0 mm thickness, no significant differences were observed among the materials. The authors attributed the inferior marginal adaptation of lithium disilicate to dimensional changes occurring during the post-milling crystallization stage, where the material undergoes shrinkage that increases the marginal gap, particularly in ultrathin sections [50]. Salah (2023) investigated the marginal accuracy of occlusal veneers fabricated from lithium disilicate (Rosetta SM) and hybrid ceramic (Vita Enamic) with two preparation designs (planar and chamfer).

The study revealed that hybrid ceramic occlusal veneers demonstrated superior vertical marginal fit, with total mean gap values of 21.43 μm compared to 26.85 μm for lithium disilicate, a difference that was statistically significant. The authors attributed this finding to the high edge stability of hybrid ceramic materials after milling, which ensures precision fit and excellent marginal seal, in contrast to the 0.2–0.3% shrinkage that lithium disilicate undergoes during the crystallization process [51]. Abbass (2025) assessed the marginal adaptation of occlusal veneers constructed from lithium disilicate (IPS e.max CAD), zirconia-reinforced lithium silicate (Celtra Duo), and resin matrix ceramic (Shofu HC) materials with two restoration thicknesses (1.0 mm and 1.5 mm). The results demonstrated that Celtra Duo showed the highest marginal adaptation with mean gap values ranging from 6.69 to 10.19 μm, while IPS e.max CAD showed the lowest marginal adaptation with values between 12.36 and 14.63 μm. The authors explained that the 10% zirconia content in Celtra Duo, which is completely diluted in the amorphous glass phase, creates a fine-grained structure of 0.5–1 μm crystallites that undergoes less linear shrinkage after firing compared to the larger crystallites (2000–4000 nm) in IPS e.max CAD [52].

Rizk (2024) evaluated the marginal adaptation and fracture resistance of occlusal veneers fabricated from reinforced composite (Brilliant Crios) and advanced lithium disilicate (CEREC Tessera) with two thicknesses (0.6 mm and 0.9 mm). The study found that CEREC Tessera showed significantly higher marginal gap values (76.6–94.6 μm) compared to Brilliant Crios (56.7–78.3 μm) both before and after thermodynamic aging. The authors attributed the superior performance of the reinforced composite to its higher resiliency, greater stress-dissipating effect, and the absence of post-milling firing cycles that could cause dimensional changes [6]. Elbadawy. (2022) evaluated the marginal and internal fit of occlusal veneers using microCT scans, comparing hybrid all-ceramic (Vita Enamic) and zirconia-reinforced lithium silicate glass-ceramic (Vita Suprinity) materials with different cement space settings. The results demonstrated that hybrid all-ceramic material exhibited smaller marginal and internal discrepancies than zirconia-reinforced lithium silicate glass-ceramic, although the differences were not statistically significant. Both materials showed marginal gaps within clinically acceptable ranges (Figure 5) [49].

4.3. Effect of Restoration Thickness on Marginal Adaptation

Restoration thickness has been identified as a factor that may influence the marginal adaptation of occlusal veneers, particularly in relation to the dimensional changes that occur during processing and the ability of the material to maintain accurate margins. Abouhagar (2022) assessed the marginal adaptation of two glass-ceramic occlusal veneer materials (IPS e.max CAD and Celtra Duo) at thicknesses of 1.0 mm and 1.5 mm after thermodynamic aging. The study found that the effect of material type was significant, with IPS e.max CAD showing higher marginal gap values (39.30 µm) than Celtra Duo (31.52 µm). Regarding thickness, 1.0 mm samples showed significantly higher marginal gap values (36.78 µm) compared to 1.5 mm samples (34.04 µm). However, within the IPS e.max CAD group, the difference between thicknesses was not significant, while for Celtra Duo, the 1.5 mm thickness showed significantly better marginal adaptation than the 1.0 mm thickness [53]. These findings suggest that the effect of thickness on marginal adaptation may be material-dependent.

Materials that undergo dimensional changes during processing, such as the crystallization shrinkage of lithium disilicate, may be more susceptible to thickness-related variations in marginal adaptation. In contrast, materials that do not require post-milling firing cycles may exhibit more consistent marginal adaptation across different thicknesses. Sirous (2022) conducted a systematic review on the effect of preparation design on marginal adaptation and fracture strength of ceramic occlusal veneers. The review reported that various preparation designs are proven to have clinically acceptable fracture strength and marginal adaptation. The authors concluded that fracture resistance of occlusal veneers is higher than normal mastication force, and it is sufficient to prepare the occlusal surface, use a self-etching primer for bonding, and maintain an acceptable minimum ceramic thickness. The review emphasized that extensive reduction is not necessary for achieving satisfactory marginal adaptation, which supports the use of thinner occlusal veneers as a conservative treatment option (Figure 6) [10].

4.4. Effect of Fabrication Technique on Marginal Adaptation

The choice of fabrication technique, subtractive manufacturing (milling) versus additive manufacturing (3D printing), significantly influences the marginal adaptation of occlusal veneers. Tartuk (2026) compared overlay restorations fabricated from zirconia-reinforced lithium silicate (ZLS) and 3D-printed resin with two preparation designs. Although the study focused on overlays rather than occlusal veneers, the results showed that fabrication technique had no significant effect on marginal gap values (milling vs. 3D printing). For occlusal-only preparation, mean marginal gap values were 63.21 µm for ZLS and 59.07 µm for 3D-printed resin. All groups demonstrated marginal gaps within the clinically acceptable range (< 120 µm). Notably, restorations fabricated using additive manufacturing tended to exhibit slightly smaller marginal gaps than milled restorations, suggesting that 3D printing technology could be a viable alternative for producing accurate restorations [54].

4.5. Effect of Preparation Design on Marginal Adaptation

The preparation design significantly influences the marginal adaptation of occlusal veneers. Hassan (2025) investigated the effect of different preparation designs on the marginal fit of IPS e.max CAD occlusal veneers. The butt joint design registered the lowest mean vertical marginal gap (99.2 µm), followed by the hollow chamfer design (104.92 µm), while deep chamfer design recorded highest marginal gap (118.38 µm). Although difference between butt joint and hollow chamfer designs was not statistically significant, both showed superior marginal fit compared to deep chamfer design. Authors suggested that simple preparation features of the butt joint design, including flat, smooth occlusal reduction and fewer internal angles, facilitate digital workflow by enabling milling burs to replicate restoration details more accurately, thereby reducing marginal gap [55].

5. Clinical Considerations and Implications

5.1. Material Selection for Occlusal Veneers

The selection of appropriate materials for occlusal veneers should be based on a comprehensive assessment of clinical factors, including the extent of tooth wear, occlusal load, aesthetic demands, and patient-specific variables. Lithium disilicate occlusal veneers are recommended for occlusal reconstruction due to their high fracture resistance and favorable wear characteristics. The material's hardness is not much greater than enamel hardness, preventing excessive attrition of opposing teeth, and it can be bonded adhesively to tooth tissues [24]. However, the inferior marginal adaptation of lithium disilicate, particularly at reduced thicknesses, should be considered when planning ultrathin restorations. The presence of severe wear and parafunctional habits may influence material selection. Lithium disilicate complete and partial coverage restorations demonstrated excellent survival in patients with severe wear, including those requiring re-establishment of occlusal vertical dimension. The material's high fracture resistance and low annual failure rate (0.1%) support its use in this challenging patient population [55].

Hybrid ceramics may be preferred in situations requiring reduced stress concentration and favorable failure patterns. They offer a potential alternative to all-ceramic restorations due to their favorable fracture patterns and the possibility of intraoral repair. The lower elastic modulus may be advantageous for stress distribution, reducing the risk of catastrophic failure and preserving underlying tooth structure [12]. Additionally, the superior marginal adaptation of hybrid ceramics, particularly at reduced thicknesses, makes them an attractive option for minimally invasive occlusal veneers. In contrast, performance of hybrid ceramics in patients with severe wear and parafunctional habits requires further investigation with long-term clinical studies [55]. 3D-printed composite restorations offer advantages of additive manufacturing, including reduced material waste and ability to fabricate complex geometries. The favorable marginal adaptation of 3D-printed restorations, despite their lower trueness, suggests that additive manufacturing could be a viable alternative for producing accurate restorations (Table 1) [35-54].

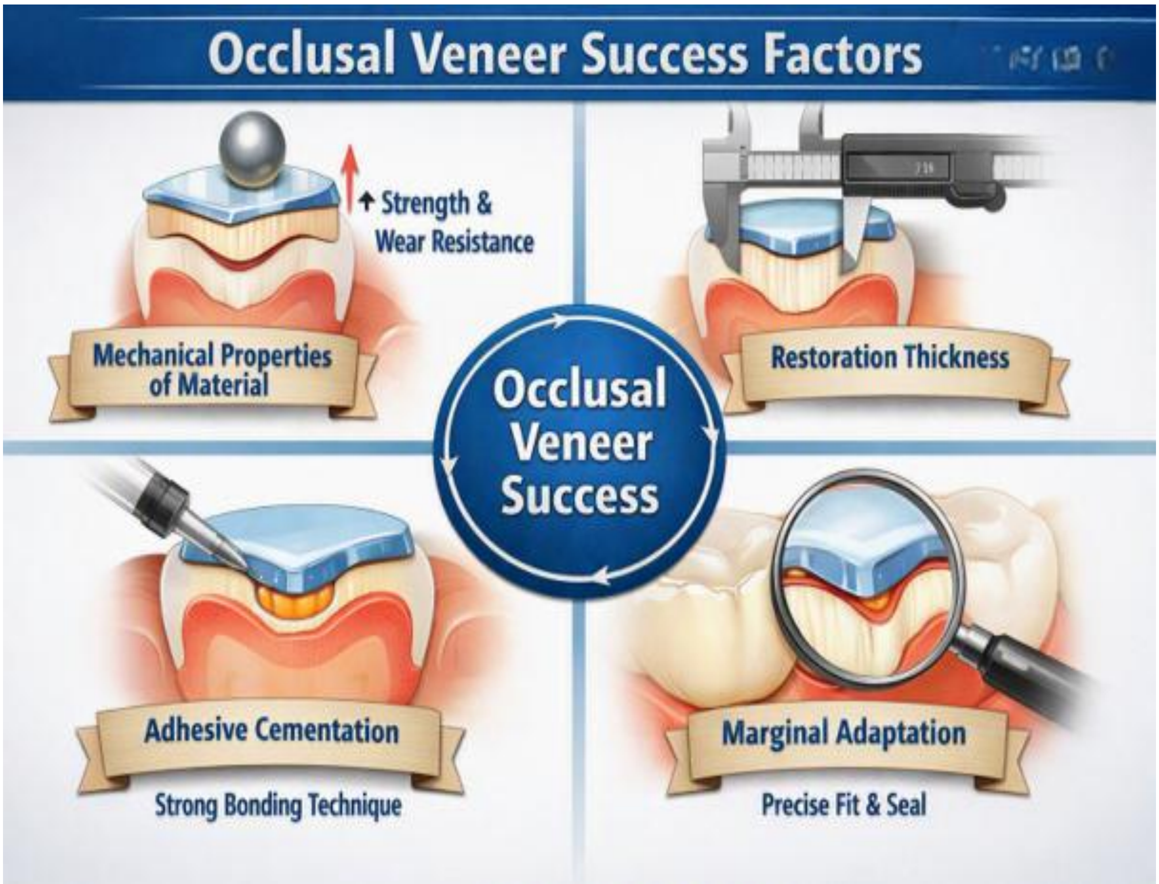

Figure 1: Factors influencing the clinical success of occlusal veneers, including material mechanical properties, restoration thickness, adhesive cementation, and marginal adaptation

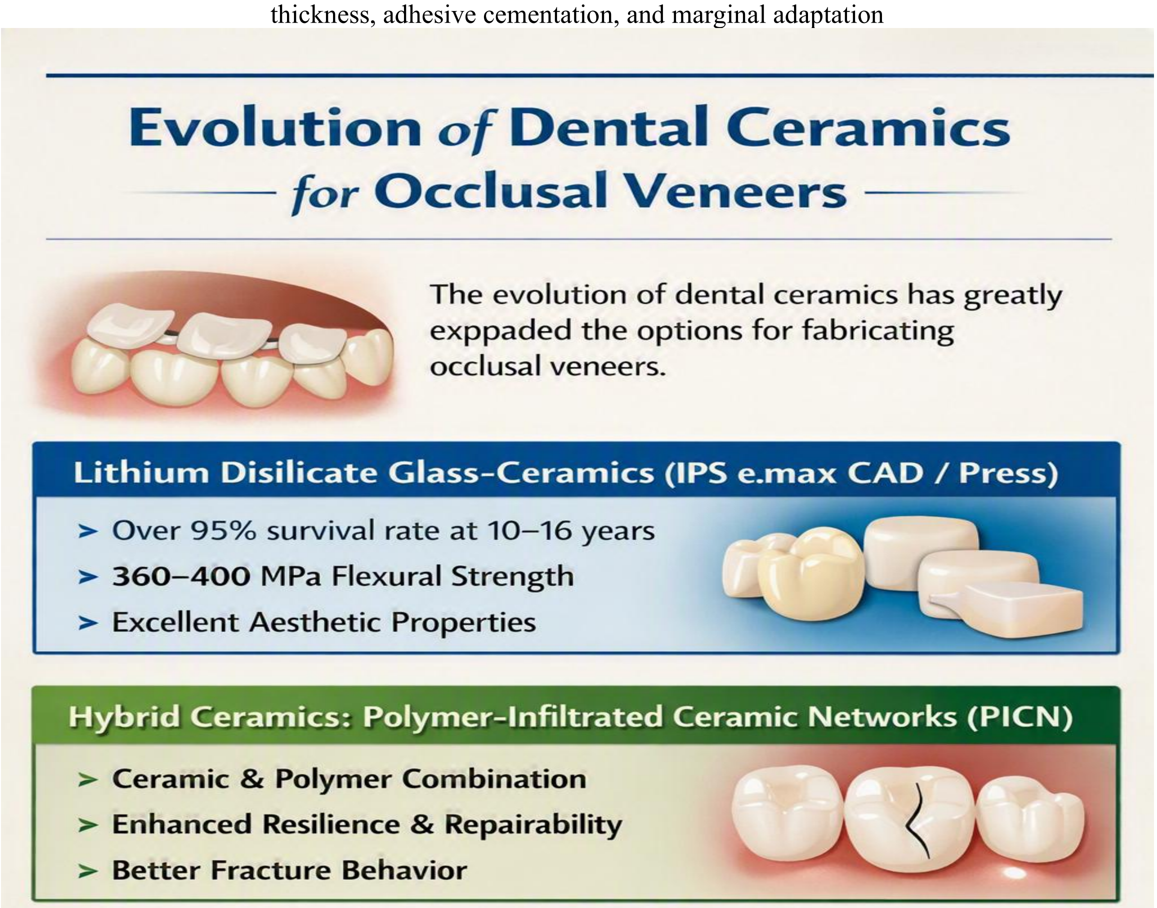

Figure 2: Evolution of dental ceramic materials for occlusal veneers, highlighting the clinical properties of lithium disilicate glass-ceramics and polymer-infiltrated ceramic networks (PICNs)

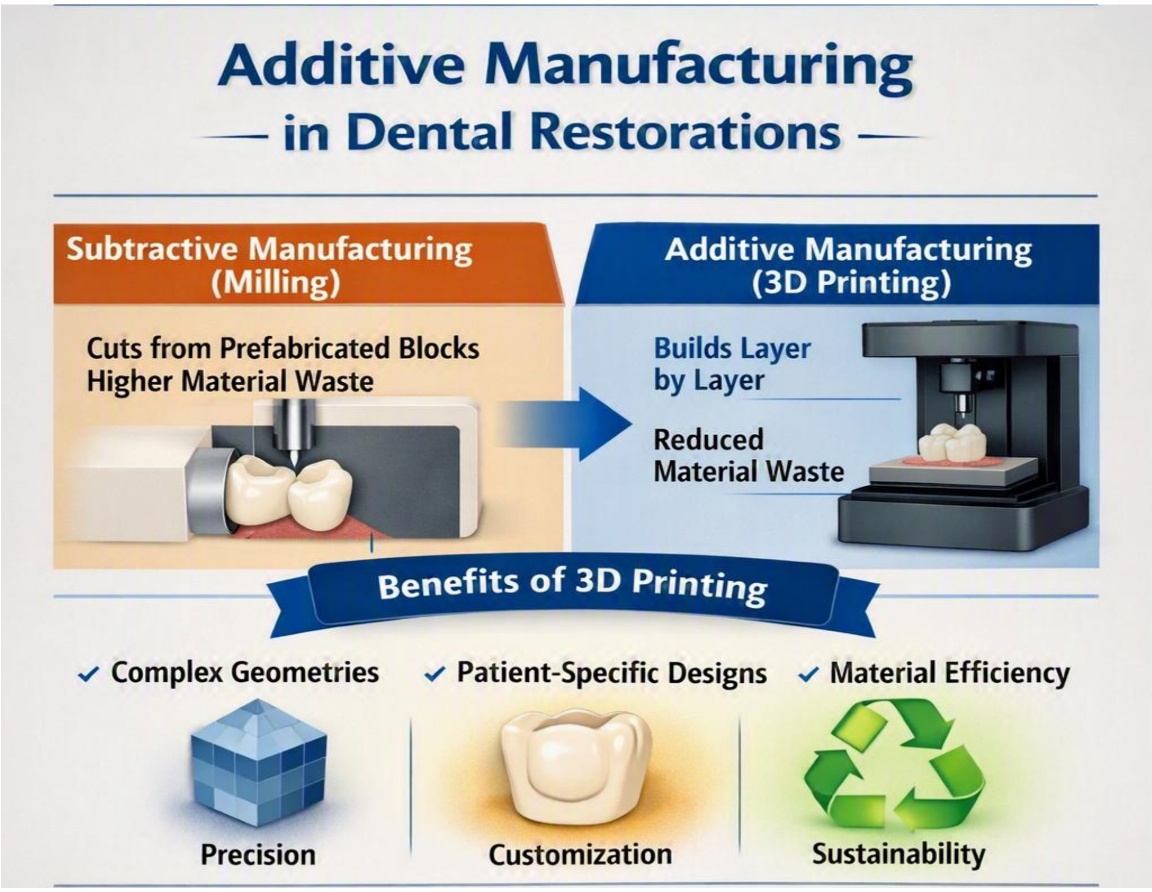

Figure 3: Comparison of subtractive and additive manufacturing techniques for dental restorations, highlighting the advantages of 3D printing in terms of material efficiency, precision, complex geometries, and patient-specific customization

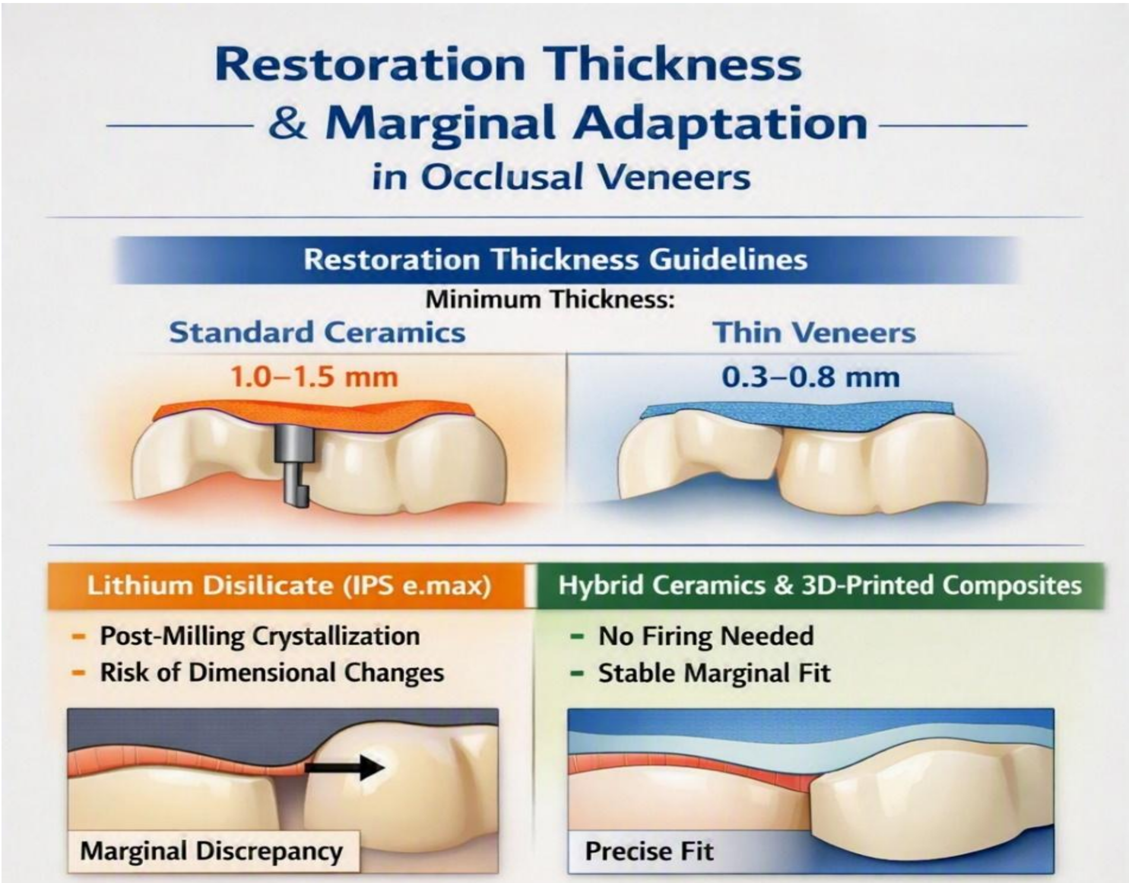

Figure 4: Effect of restoration thickness and material type on the marginal adaptation of occlusal veneers, illustrating thickness guidelines and differences in marginal fit between lithium disilicate and hybrid ceramic/3D-printed composite restorations

Figure 5: Key advantages of occlusal veneers, highlighting high strength, improved fracture resistance, and enhanced aesthetic outcomes for durable restorative treatment

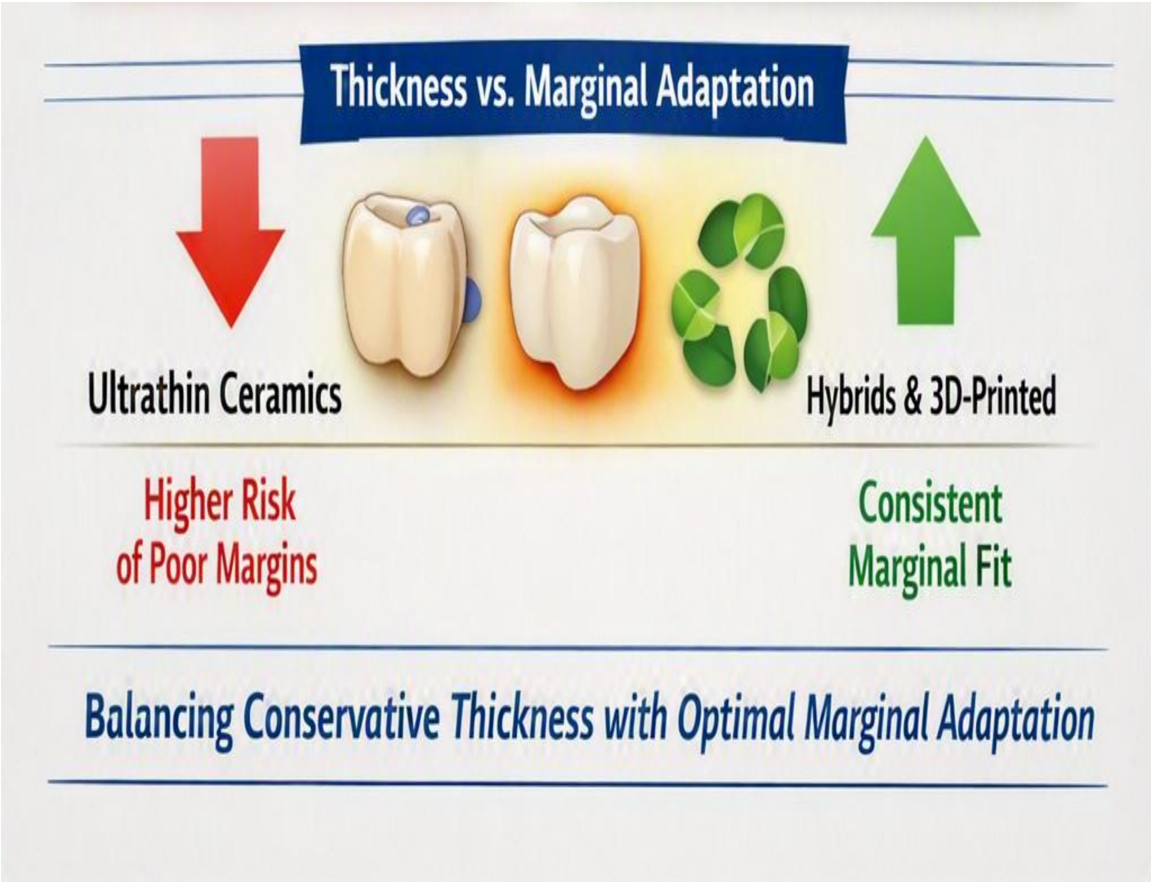

Figure 6: Relationship between ceramic restoration thickness and marginal adaptation, illustrating the increased risk of poor marginal fit with ultrathin ceramics and the more consistent marginal adaptation associated with hybrid and 3D-printed materials

Table 1: Comparison of lithium disilicate, hybrid ceramics, and 3D-printed composite materials regarding their key properties, clinical indications, advantages, and limitations in minimally invasive and restorative dentistry

Material Type	Key Properties	Clinical Indications	Advantages	Limitations / Considerations
Lithium Disilicate (e.g., IPS e.max CAD/Press)	High fracture resistance; hardness close to enamel; adhesive bonding capability	Occlusal reconstruction, severe wear cases, re-establishment of occlusal vertical dimension	Excellent strength and wear compatibility; low annual failure rate (~0.1%); predictable adhesive bonding	Inferior marginal adaptation at reduced thickness; dimensional changes after crystallization; caution in ultrathin restorations
Hybrid Ceramics (e.g., PICN, CEREC Tessera)	Lower elastic modulus; favorable fracture pattern; high marginal adaptation	Minimally invasive veneers; cases requiring stress distribution and repairability	Reduced stress concentration; intraoral repair possible; superior marginal fit at thin sections	Limited long-term data in severe wear and parafunctional habits; lower strength than lithium disilicate
3D-Printed Composites (e.g., Varseosmile Crown Plus, Ceramic Crown)	Additive manufacturing; polymer-ceramic composite; good marginal adaptation	Patient-specific restorations; complex geometries; digital workflows	Reduced material waste; customizable designs; consistent marginal adaptation	Lower trueness and mechanical strength compared to ceramics; emerging technology requiring further validation

Table 2: Recommended surface treatment protocols for lithium disilicate, hybrid ceramic, and 3D-printed composite restorations, highlighting the treatment steps, mechanisms of adhesion, and material-specific considerations for achieving optimal resin bonding

Material Type	Surface Treatment Steps	Purpose / Effect	Notes
Lithium Disilicate (e.g., IPS e.max CAD/Press)	1. Etch with hydrofluoric acid (HF) for 20–30 s 2. Rinse and dry 3. Apply silane coupling agent	Creates microretentive surface morphology for resin interdigitation; silane forms chemical bond with silica network	Provides strong micromechanical and chemical adhesion; enhances fracture resistance
Hybrid Ceramics (e.g., PICN, CEREC Tessera)	1. Etch with hydrofluoric acid (shorter time, typically 30–60 s) 2. Rinse and dry 3. Apply silane coupling agent	Similar bonding mechanism to lithium disilicate but requires adjusted etching time due to different microstructure	Etching time varies by manufacturer; excessive etching may weaken surface
3D-Printed Composites (e.g., Varseosmile Crown Plus, Ceramic Crown)	1. Sandblast with aluminum oxide (50 µm) 2. Clean and dry 3. Apply universal adhesive	Promotes micromechanical retention; adhesive provides chemical bonding	No glassy phase—HF etching is ineffective; surface roughening essential

5.2. Surface Treatments and Cementation

The adhesive cementation of occlusal veneers represents a critical step that influences marginal adaptation and long-term clinical success. For lithium disilicate restorations, the presence of a glassy matrix enables etching with hydrofluoric acid, creating microretentive surface morphology for resin cement interdigitation. Silane coupling agents further enhance bond strength by chemically bonding the silica network to the resin cement. The combination of micromechanical retention and chemical bonding provides reliable adhesion that strengthens restoration-tooth complex and improves fracture resistance [25]. For hybrid ceramics, surface treatment typically involves etching with hydrofluoric acid followed by silane application, similar to lithium disilicate. However, the etching time may differ due to the different composition and microstructure of these materials. For 3D-printed composites, surface treatment typically involves sandblasting with aluminum oxide particles followed by application of a universal adhesive. Absence of a glassy phase in these materials precludes use of hydrofluoric acid etching (Table 2).

5.3. Preventive Strategies and Multidisciplinary Approach

The long-term success of occlusal veneers depends not only on material selection and clinical technique but also on preventive strategies and patient management. Patient education on oral hygiene, dietary habits, and parafunctional behavior modification is essential to minimize occlusal loading and acid exposure that could compromise restoration integrity. Collaboration with other dental specialists and, when appropriate, medical professionals may be necessary to address underlying etiological factors such as bruxism or eating disorders that contribute to tooth wear.

6. Conclusions

The marginal adaptation of occlusal veneers is influenced by multiple interrelated factors, including material type, restoration thickness, fabrication technique, and preparation design. The evidence synthesized in this review demonstrates that:

1. Material type significantly affects marginal adaptation: Lithium disilicate occlusal veneers consistently exhibit higher marginal gap values compared to hybrid ceramics and reinforced composites, particularly at reduced thicknesses. This is attributed to the dimensional changes (shrinkage of approximately 0.2–0.3%) that occur during the post-milling crystallization process. Hybrid ceramics demonstrate superior marginal adaptation due to their high edge stability after milling and the absence of post-milling firing cycles that could cause dimensional changes.
2. Restoration thickness influences marginal adaptation in a material-dependent manner: Thinner restorations (0.3–0.5 mm) generally show higher marginal gap values, particularly for lithium disilicate materials that undergo crystallization shrinkage. Materials that do not require post-milling firing cycles, such as hybrid ceramics and 3D-printed composites, exhibit more consistent marginal adaptation across different thicknesses.
3. Fabrication technique influences marginal adaptation: While subtractive manufacturing (milling) produces restorations with higher trueness, additive manufacturing (3D printing) may yield improved fitness due to relationship between trueness and seating of restoration. The lower trueness of printed crowns creates more deviation from CAD design, which may reduce friction with the abutment, minimize hydraulic pressure, enhance cement flow, and lead to improved overall fitness.
4. Thermocycling aging affects marginal adaptation: Artificial aging through thermocycling generally results in increased marginal gap distances, although the extent of this effect varies among materials. The thermal fluctuations in the oral environment generate stress formations within restorations, which can negatively affect the sealing integrity of margins and promote microcrack propagation.
5. Preparation design influences marginal adaptation: Simpler preparation designs, such as the butt joint design, facilitate more accurate marginal adaptation compared to more complex designs. The simple preparation features of the butt joint design, including flat, smooth occlusal reduction and fewer internal angles, facilitate the digital workflow by enabling milling burs to replicate restoration details more accurately.

The clinical implications of these findings are significant. For clinicians planning occlusal veneers, particularly in minimally invasive scenarios with reduced restoration thickness, the choice of material should consider not only mechanical properties and esthetics but also the expected marginal adaptation. Hybrid ceramics and 3D-printed composites may offer advantages in terms of marginal adaptation at reduced thicknesses, while lithium disilicate remains a reliable option for thicker restorations where its superior mechanical properties can be fully utilized. A multimodal approach—combining careful material selection, appropriate fabrication technique, optimal preparation design, and preventive strategies—is essential to ensure restoration longevity and patient well-being. Future research should focus on long-term clinical studies to validate the in vitro findings and investigate the effect of other factors, such as occlusal loading and cyclic fatigue, on the marginal adaptation of occlusal veneers fabricated from different materials and thicknesses.

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