

Review Paper: Narrative Review of Posterior Overlay Preparation Designs: Evolution, Trends, and Insights



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ABSTRACT



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Posterior overlays are commonly used in today's dentistry. They are more conservative than crowns and offer better morphology and material options than direct restorations. There is no standard consensus for the optimal overlay design. This study aims to explore the available literature on posterior overlay preparation designs concerning thickness, preparation margins, and retention forms. A comprehensive review of the literature was conducted in the different databases from 1990 to 2024. The inclusion criteria were the peer-reviewed articles and clinical trials comparing the margin, thickness, or retention of the posterior overlay preparations. Published works that included metal overlays alone or were not published in peer-reviewed journals, and case reports, were excluded. In this review, 26 studies met the inclusion criteria. The thicknesses used in the studies ranged from 0.5 to 2mm, with common values including 1mm, 1.5mm, and 2mm across various materials. The preparation margin types, ranked from most to least frequent, included butt joint, shoulder, chamfer, and beveled. Non-retentive and retentive designs were used in a similar number of studies. Conservative anatomic preparations that are 1.5 to 2 mm in thickness are preferred for posterior overlays. This approach has the advantage of preserving tooth structure and giving less invasive as well as more long-lasting restorations. Butt joint margins were most frequently used for non-esthetic, posterior restorations. Consideration should also be given to alternative margin designs, such as chamfer, based on specific conditions and requirements, particularly when incorporating digital methods.

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1. Introduction

For a variety of dental treatments, overlays are suitable as partial indirect restorations. Several key scenarios primarily indicate the use of posterior overlays: covering cusps of endodontically treated teeth; managing extensive cavities with thin remaining cusps; addressing teeth at risk of fracture due to significant loss of tooth structure; restoring large occlusal surfaces compromised by mechanical wear and/or erosion; and performing complete adhesive rehabilitation where restoration of the vertical dimension is necessary (1-3). In general, overlays are good options for teeth that have enough healthy tooth structure to support these restorations but are too damaged to be treated with a direct restoration (4).

Overlays, as dental restoration options, have several important benefits. They preserve more natural tooth structure compared to dental crowns, thus making them a conservative treatment alternative. When compared to full coverage crowns, the quantity of tooth structure removed during overlay and partial crown preparation in posterior teeth can be decreased by more than 40% (4, 5). This indicates that dentists can preserve a considerable part of the patient's tooth structure through these less invasive alternatives while providing an effective restorative option. By maintaining more of the original tooth, overlays also help maintain the tooth's natural strength and function, contributing to the long-term success of the restoration (5, 6).

On the other hand, overlays, as indirect restorations, are able to develop a better occlusal morphology as well as better control of contact points and emergence profiles compared to direct restorations (7, 8). They can also be made with various materials with their own advantages and disadvantages, giving patients and dentists options to make the best selection for their specific needs. The choice of material—ranging from high-strength ceramics to composite resins—allows customization based on factors such as the patient's bite, esthetic demands, and budget. However, the selection process must consider the material's properties, like fracture strength, wear resistance, bonding capabilities, and compatibility with the

remaining tooth structure, which directly influence the restoration's performance and longevity (9-11). Although overlay designs have been the subject of numerous studies, unlike crowns, there is no clear consensus or standard for overlay design (12).

This review highlights certain important factors, such as thickness considerations, preparation margins, and retention mechanisms, they have a major impact on the longevity and success rate of dental restorations. Knowledge of optimal preparation thickness helps in the selection process to avoid excessive removal of tooth tissue while enhancing the durability of the restoration (8, 13). Understanding various preparation margins also aids in preserving tooth structure and promoting the longevity of restorations (12, 14, 15). Likewise, insights into retention concepts, from traditional forms to more conservative adhesive ones, eventually equip a dentist to be able to create durable restorations with optimal mechanical support without jeopardizing healthy tooth structure (8, 16).

Since the last guidelines in this field, there have been some updates and changes (1, 8, 13). This review aims to present an updated analysis of studies to bring into perspective the evolution and current trends in posterior overlay preparation designs. As technology and materials evolve, new preparation techniques are emerging that emphasize minimally invasive principles while enhancing mechanical properties. It is imperative that the various preparation designs for overlays are well understood in order to enhance their performance and durability. By staying informed about the latest advancements and integrating them into practice, clinicians can provide patients with the highest standard of care, ensuring both the functional and esthetic success of overlay restorations.

2. Materials and Methods

A comprehensive literature search was performed on topic of posterior overlay preparation designs. Databases searched included PubMed, Scopus, Web of Science, and Google Scholar. The search terms included "posterior overlay preparation," "overlay preparation designs," "adhesive indirect restoration design," "posterior indirect restoration preparation," "overlay preparation margins," "Occlusal thickness

in overlays" "overlay preparation thickness," "Margin adaptation in overlays" "conservative overlay preparation," and "retention in dental overlays." Studies published between 1990 and 2024 were considered.

Peer-reviewed articles and clinical trials pertaining to posterior overlay preparations, studies assessing different preparation margins, thicknesses, and retention forms, research that was either or both in vitro (laboratory) and in vivo (clinical), and articles published in English were included. Studies

focusing solely on metal overlays, non-peer-reviewed articles, opinion pieces, case reports, and research not addressing specific aspects of overlay preparation design, such as margins, thickness, and retention were excluded. The data about thickness considerations, preparation margins, and retention forms were extracted.

3. Result

In this study, 26 studies satisfied the inclusion criteria and their data was extracted ([Table 1](#)).

Table 1. Data extraction of included studies.

Authors	Publication Year	Type of Study	Sample Size	Endodontic treatment	Material	Thickness	Preparation Margins	Retention forms	Conclusion
Dejak et al.(34)	2007	In vitro (finite element)	8	No	leucite reinforced glass ceramic	1 to 2 mm	Butt joint and rounded shoulder	Retentive: 3 and 5 mm isthmuses	The contact stresses between restoration and tissues in the onlays with a rounded shoulder margin were more favorable.
Clausen et al.(35)	2010	In vitro	64	No	leucite reinforced and lithium disilicate glass ceramic	0.5 to 2 mm	chamfer and straight-beveled	Non-retentive	The design of the finishing line did not influence the fracture resistance.
Van Dijken et al.(45)	2010	In vivo	228	With and Without endodontic treatment (Vital and non-vital)	Leucite reinforced glass ceramic	At least 1.5 mm	No shoulder (butt joint), shoulder and chamfer	Minimal retentive or non-retentive	Restorations without traditional retentive design showed advantages like less destruction of healthy tissue, avoiding of endodontic treatment and/or deep cervical placement of restoration margins to obtain retention, and good esthetics.
Murgueitio et al.(18)	2012	In vivo	210	With and Without endodontic treatment (Vital and non-vital)	leucite reinforced glass ceramic	1.5 to 2 mm	Butt joint	-	The thickness of the restorations influenced restoration failures (most failures happened under 2 mm thickness).
Guess et al.(6)	2013	In vitro	144	No	lithium-disilicate glass ceramic	0.5, 1 and 2 mm	Chamfer	Retentive: MOD box	Reduced ceramic thicknesses of 1.0 and 0.5 mm did not impair the fracture resistance of pressable

Al Khalifa et al.(36)	2016	In vitro	90	No	lithium disilicate glass-ceramic, composite resin or feldspathic porcelain	1 and 1.5 mm	Shoulder (anatomical) and butt joint (concave and flat)	Retentive: isthmus and proximal boxes	lithium-disilicate ceramic onlay restorations but resulted in lower failure loads in complete veneer (overlay) restorations. The concave tooth preparation should be avoided and as there is no advantage to removing precious enamel, anatomical preparation is recommended.
Abu-Izze et al.(31)	2018	In vitro (finite element)	60	No	Zirconia reinforced lithium disilicate ceramic (ZLS) and Ceramic reinforced composite (PIC)	0.5 and 1 mm	Butt joint (table top restoration)	Non-retentive	Thin ZLS presented lower fatigue strength when compared with 1.0-mm thick PIC; and the concentration of ZLS stresses at the adhesive interface was higher when compared with that for PIC.
Lima et al.(32)	2018	In vitro (virtual model)	40	No	Ceramic reinforced composite	2 mm	Butt joint (modified) and shoulder (conventional)	Retentive: 2 mm occlusal and mesial boxes	Conventional preparation improved marginal adaptation compared to modified preparation. Conservative preparation resulted in higher fracture strength, increased fracture resistance, reduced stress concentration, and demonstrated more favorable fracture modes.
Vianna et al.(16)	2018	In vitro	48	No	leucite reinforced and lithium disilicate glass ceramic	1.5 mm	shoulder	Non- retentive (conservative) and retentive with boxes (conventional)	A veneer thickness > 0.8 mm may represent a suitable threshold for this type of restoration.
Baldissara et al.(33)	2019	In vitro	60	No	Lithium disilicate glass ceramic	0.5, 0.8 and 1.2 mm	-	Non-retentive (Occlusal veneer)	Minimally invasive occlusal veneers made of each materials can be applied to correct occlusal tooth wear. The differences
Ioannidis et al.(28)	2019	In vitro	80	No	Zirconia, lithium disilicate glass ceramic and, Ceramic reinforced composite	0.5 or 1 mm	Butt joint (table top)	Non-retentive	

									found between different materials are clinically irrelevant, since the mean values obtained surpassed normal force spans.
Emam et al.(10)	2020	In vitro	60	No	Lithium disilicate glass ceramics , Ceramic reinforced composite and resin composite	1 mm	Chamfer and butt joint	Non-retentive	All tested materials in both preparation designs whether before or after fatigue loading, exhibited marginal gap distance not exceeding that described in the literature as acceptable range.
									Occlusal reduction alone may sufficiently provide adequate fracture
Falahchai et al.(30)	2020	In vitro	50	No	Zirconia reinforced lithium disilicate ceramic	1.5 (fissure) to 2 mm (cuspal area)	Shoulder and butt joint	Non-retentive or retentive (central groove)	resistance for teeth requiring occlusal surface reconstruction and there would be no need for retentive or more invasive preparation margin and designs.
Falahchai et al. (29)	2020	In vitro	40	No	Zirconia reinforced lithium disilicate glass ceramic	1.5 (central fossa) to 2 mm (cusp tips)	Butt joint and rounded shoulder	Non-retentive or retentive (central groove)	The group with the most complex design (shoulder margin + central groove) showed the lowest marginal adaptation for ZLS overlays.
Luciano et al.(19)	2020	In vivo	43	With and Without endodontic treatment (Vital and non-vital)	lithium disilicate glass ceramic	0.5 to 2 mm	-	-	Lithium disilicate's biomechanical characteristics allowed us to work on minimal thicknesses values of 0.7 mm without affecting the strength.
Yang et al.(26)	2020	In vitro	10	No	Ceramic reinforced composite	1.5 mm	heavy chamfer on the functional cusp, and a contrabevel on the nonfunctional cusp (traditional) or	Retentive: MOD box	The traditional preparation design offered better marginal adaptation.

butt joint									
Alassar et al.(27)	2021	In vitro	55	No	Zirconia and Ceramic reinforced composite	2 mm	Butt joint (conventional) and shoulder (conservative)	Retentive: MOD box	Conventional (butt joint) groups showed the least fracture load, whereas the highest value was recorded in conservative (shoulder) groups.
Ferraris et al.(15)	2021	In vitro	70	No	lithium disilicate glass ceramic	1 mm	butt joint, full Bevel (45 degrees) and, shoulder	Retentive: proximal boxes	The Full Bevel group showed higher fracture strength than all the other groups.
Gomes et al.(25)	2021	In vitro (finite element)	-	Yes	lithium-disilicate glass ceramic and Ceramic reinforced composite	2 mm on functional cups and 1.5 mm on non-functional cusp	Butt joint and shoulder (traditional)	Non-retentive and retentive with occlusal isthmus	Non-retentive, butt joint design showed the best mechanical behavior
Channarong et al.(22)	2022	In vitro	48	No	Zirconia reinforced lithium disilicate ceramic	2 mm	Shoulder and bevel (contrabevel)	retentive with MOD box	Type of margin used in ceramic overlays had no significant influence on the fracture resistance of the restorations.
Chen et al.(21)	2022	In vitro	70	Yes	lithium disilicate glass ceramic and composite resin	1 mm for lithium disilicate glass ceramic and 1.5 mm for composite resin	shoulder	retentive with MOD box	All restorative patterns had no difference in survival curves.
Chen et al.(12)	2023	In vivo	180	Yes (Non vital)	lithium disilicate glass ceramic	1.5 to 2 mm	Butt joint and rounded shoulder	Non-retentive and retentive with proximal boxes	No significant differences in performance characteristics among the groups were found.
Hasan et al.(20)	2023	In vitro	30	No	lithium disilicate glass ceramic	1.5 mm	Butt joint and hollow chamfer	Non-retentive and retentive with occlusal boxes	It is suggested that the non-retentive preparations are more suitable for overlay restoration of posterior teeth due to less marginal gap.
Omar et al.(11)	2023	In vitro	32		Zirconia reinforced lithium disilicate ceramic and Ceramic reinforced composite	1 mm	Chamfer and butt joint	Non-retentive	Zirconia reinforced lithium disilicate ceramic built with chamfer margins has superior marginal accuracy.
Jurado et al.(23)	2024	In vitro	90	With and without endodontic treatment	zirconia	1 mm	Chamfer and butt joint	Non-retentive and retentive (endodontic access)	Overlays of distinct preparation designs presenting endodontic

Mancuso et al.(24)	2024	In vitro	100	No	Composite resin	1.5 mm	Butt joint, rounded shoulder and chamfer	Non-retentive	access displayed significantly lower fracture resistance compared to those without endodontic access within the same design, except for the no-margin preparation design (no difference). When, the pre-heated composite resin is selected as luting agent, butt joint or chamfer finish lines are recommended for enhancing the precision of overlays seating.
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Among the 26 studies, four were in vivo (12, 17-19) and 22 were in vitro studies (6, 10, 11, 15, 16, 20-36).

The thicknesses used in the studies ranged from 0.5 mm to 2 mm. Common values include 1 mm (10 studies)(6, 10, 11, 14, 21, 23, 28, 31, 34, 36), 1.5 mm (12 studies)(12, 16, 18, 20, 21, 24-26, 29, 30, 34, 36), and 2 mm (seven studies)(6, 18, 21, 22, 25, 27, 32). Six studies used thickness under 1 mm (6, 19, 28, 31, 33, 35).

Four common types of finish lines were used. Butt joint preparation margin was used in 16 studies (10-12, 18, 20, 23-25, 27-32, 34, 36), shoulder preparation margin (and its derivatives) were used in 12 studies (15, 21, 22, 24, 25, 27-30, 32, 34, 36), chamfer preparation margin (and its derivatives) were used in 10 studies (6,10-12, 15, 20, 23, 24, 26, 35), and beveled preparation margin was used in four studies (15, 22, 26, 35).

Overlay preparation were either retentive or non-retentive. Eight studies used non-retentive preparation design (10, 11, 18, 24, 28, 31, 33, 35), nine studies used retentive preparation design (6, 15, 21, 22, 26, 27, 32, 34, 36), and seven studies used both designs (12, 16, 20, 23, 25, 29, 30).

A total number of 1940 teeth were prepared and

assessed in the 26 studies among which 476 teeth were treated endodontically (12, 18, 21, 25), 1361 teeth were not treated endodontically (6, 10, 11, 15-17, 20, 22, 24, 26-36), and the endodontic status in 103 teeth was not specified (19, 23).

1. The material used in 13 studies were lithium disilicate glass ceramic (6, 10-12, 15, 16, 19, 20, 28, 33, 35, 36), in eight studies were hybrid ceramic (ceramic reinforced composite resin) (10, 11, 25-28, 31, 32), in six studies were Zirconia reinforced lithium disilicate ceramic (11, 22, 27, 29-31), in five studies were leucite reinforced glass ceramic (16-18, 34, 35), in four studies were composite resin (10, 22, 24, 36), in three studies were zirconia (23, 27, 28), and in one study was feldspathic porcelain (36).

4. Discussion

In the present work, a review of the existing literature on the various designs of posterior overlay preparations was done. Our focus was on the analysis of changes in design concepts, thickness, preparation margins, and retention forms.

Posterior overlays have evolved significantly over the years, particularly concerning their design. Initially, more invasive preparation concepts were applied, focusing primarily on stability and durability. However, with the evolution of adhesive

systems and materials, designs have shifted toward more conservative preparations. This shift aims to preserve as much of the natural tooth tissue as possible while still ensuring a durable and functional restoration.

Occlusal tissue reduction depends on: 1) optimal material thickness, 2) reducing unsupported or fragile enamel, 3) considering both enamel and dentin thickness for cusp resistance, and 4) accounting for occlusal functional strain during chewing. Since the molar region experiences the greatest occlusal stress, the restorations need to be strong enough to prevent fractures.

The optimal thickness of posterior overlays has been a topic of ongoing debate. Initially, thicker restorations were recommended for added strength, but this often required excessive tooth reduction. According to Fennis et al. (2004), overlay restorations that were 2 mm thick had a higher static fracture strength than those that were thinner (37). However, recent research suggests that these thicker restorations may also produce more severe and irreversible failures, as the underlying dental tissues become thinner and weaker (19, 28).

The laboratory research and clinical trials provided contradictory findings concerning the thickness of overlay restorations in earlier studies (6, 17). Studies carried out in laboratory conditions from earlier years have provided evidence that the thickness of inlays and onlays may not necessarily have an impact on the fracture risk that happens in dental restorations. In their investigation into the size and thickness of partial crowns composed of pressed lithium disilicate ceramic, Guess et al. (2013) showed that lowering the preparation depth to 1.0 and 0.5 mm had no significant effect on the onlay restorations fracture resistance, but it did reduce the failure loads of complete overlay restorations (6). In a comprehensive literature review, Rocca et al. (2015) demonstrated that an overlay thickness of 1.0 to 1.5 mm is recommended for all contemporary restorative materials, including composite resins, pressed ceramics, and those used in Computer-Aided Design and Manufacturing (CAD/CAM)—except for conventional feldspathic and leucite-reinforced ceramics. They emphasized that the behavior and impact of thinner material

layers on restoration survival is still under research (1). The fatigue behavior of extremely thin ceramic overlay restorations (0.5 to 1 mm) was examined in another study by Abu-Izze et al. (2018) The study concluded that thin overlays are mechanically favorable; however, zirconia-reinforced lithium disilicate ceramics exhibited lower fatigue strength and higher adhesive interface stress compared to hybrid ceramics (31). The fatigue resistance of monolithic lithium disilicate occlusal overlays with thicknesses varying from 0.5 to 1.2 mm was investigated by Baldissara et al. (2019) They concluded that a thickness of over 0.8 mm might represent an appropriate threshold for ensuring the durability of this type of restoration (33). This suggests that even with thinner preparations, these restorations maintained their strength and durability.

On the other hand, clinical findings from earlier studies presented a differing perspective, advocating for a minimum thickness of 2 mm when it comes to ceramic overlays. Van Dijken et al. (2010) stated that ceramic thickness of at least 2 mm plays an important role in preventing cusp fracture of IPS Empress overlay restorations (17). Murgueitio et al. (2012) found that the failed (fractured) overlay restorations occlusal surface thickness were less than 2 mm (18). However, according to the most current in vivo investigation conducted by Luciano et al. (2020) The use of high-strength glass ceramics, like lithium disilicate, allows minimal thickness values of 0.7 mm without compromising the strength of the overlay (19). This improvement may be attributed to the evolution of materials used in the studies, transitioning from leucite-reinforced glass ceramics in the first two clinical studies to lithium disilicate glass ceramics in the most recent one. Lithium disilicate glass ceramics offer twice the strength of leucite ceramics, enhancing the durability and performance of the restorations (38). Additionally, there are very few clinical studies on this subject to make a conclusion, and more updated research is needed.

Recent laboratory and clinical research suggests that overlay restorations with thicknesses less than 1.5 mm can offer durability comparable to thicker restorations. The performance of these thinner restorations depends on the evolution of material

used. More recent high-strength ceramics generally exhibit superior performance, although some studies have shown that hybrid ceramics and composites can achieve similar or even better results. Current literature presents conflicting results; Chen et al. (2022) found that 1 mm lithium disilicate glass ceramic overlays were more effective than 1.5 mm machinable composite resin overlays for repairing endodontically treated premolars with MOD defects (21). In contrast, Abu-Izze et al. (2018) reported that zirconia-reinforced lithium disilicate ceramics exhibited lower mechanical properties compared to hybrid ceramics in thin overlays (31). Further research is needed to compare different materials (including composites and hybrid ceramics) at various thicknesses, particularly those under 1 mm, to better understand their relative effectiveness.

We need to balance minimal tooth structure removal with the restoration's durability. Given advancements in materials, a thickness of 1.5 to 2 mm for posterior overlays appears to be effective, as used in the most recent studies (11, 20, 23, 24). However, the use of thicknesses this range requires further investigation to ensure they maintain sufficient strength and longevity.

Preparation margins have also changed from traditional designs requiring significant tooth reduction to more conservative ones. The preparation margins are critical to ensuring the longevity, function, and esthetics of the restorations. The margins, where the restoration meets the tooth, must be carefully prepared to provide a smooth transition, minimize microleakage, and prevent secondary caries (8). All cavity margins should be clearly visible and sharp, giving the best impression quality and leading to better restoration quality and fit (1).

In cases involving posterior overlay procedures, various types of preparation margins can be used based on the adhesive protocol (Figure 1): butt joint, bevel, chamfer, or rounded shoulder, and their derivatives (12, 14, 15). For cases requiring cuspal and buccal coverage (usually maxillary premolars), a vonlay preparation may be used (39, 40). Many clinical and laboratory research findings suggest that there are no discernible differences in mechanical properties between overlays with

different types of finish line preparations in posterior teeth (12, 35, 41), but there are some studies that indicate otherwise (8, 14, 29, 34).

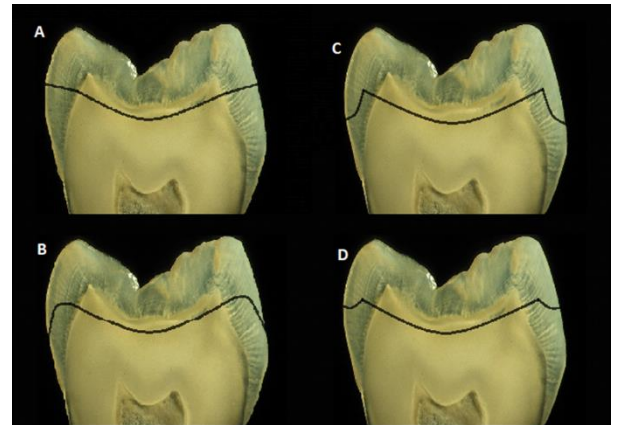


Figure 1. Different overlay finish lines; A. Butt joint finish line, B. Shoulder finish line, C. Bevel finish line, and D. Hollow chamfer (8).

Initially, it was widely believed that incorporating a finish line, similar to crown preparations, was essential for the long-term success of dental overlays. This approach was based on the idea that a defined finish line would provide better marginal stability, fit, and retention, akin to the principles used for full-coverage crowns (6, 34, 35). However, as adhesive technologies and restorative materials advanced, research began to show that using a finish line with overlays did not necessarily improve outcomes. Many studies revealed that butt joint margins, which require less tooth reduction, could perform just as well, if not better, in terms of durability and resistance to occlusal forces. The butt joint margin requires minimal preparation and is indicated for cusp reduction to protect the teeth and prevent cusp fracture, especially in cases of significant cavity, abrasion, or erosion. According to research, the most widely used overlay design is the shoulderless, butt joint form (14, 15). According to a literature review by Ahlersa et al. (2009), "The entire preparation margin should end at an angle as close as possible to 90 degrees because of the material properties of the ceramics." (13) A comprehensive review of randomized clinical trials by Politano et al. (2019), has also supported the need for a butt joint margin design directed towards the tooth center in non-retentive overlays. They further explained that the described configuration results in

minimal stress distribution and even stress during mastication to minimize cyclic fatigue at the adhesive interface (42). Gomes et al. (2021) examined the mechanical performance of different restorative materials and onlay preparation designs in molars that had undergone endodontic treatment. Their study compared onlays with either a butt joint or shoulder preparation margin, along with non-retentive or retentive designs. They concluded that the non-retentive butt joint designs exhibited the lowest fracture load (25). This study yields results comparable to a study by Falahchai et al. (2020), that investigated zirconia-reinforced lithium silicate overlays using three different preparation designs: with or without a shoulder finish line and with or without a retention form. Their findings showed that the design incorporating both a shoulder finish line and a retention form had the worst marginal adaptation. Conversely, the conservative preparation, which excluded both the shoulder finish line (butt joint derivative) and the retention form, exhibited better marginal adaptation. In other words, while the shoulder finish line may affect marginal adaptation, the butt joint margin consistently demonstrated good adaptation, regardless of the presence of a retention form (29, 30). Jurado et al. (2024) conducted a recent investigation on the impact of endodontic access and preparation design on zirconia overlay fracture resistance. The researchers compared groups with either shoulder finish line or butt joint (no finish line), and with or without a retention form. They concluded that restorations with a butt joint margin exhibited lower fracture resistance compared to those with a chamfer finish line (23). It can be assumed that the simple preparation process due to the absence of distinct finishing lines, can contribute to raising resistance to mechanical stress and occlusal forces. On the other hand, the existence of a finishing preparation margin on a sharp line enables the clinician to precisely identify the restoration's end and verify that it is positioned correctly (14). This offers easier placement and adaptation of restoration, leading to improved durability and decrease in the treatment time, and reduction in the risk of marginal leakage over time.

Like earlier studies, some recent ones continue to explore the use of finish lines, particularly in

specific clinical scenarios. The beveled margin is similar but has an inclined bevel on the outer part, usually at 45 degrees for 1 to 1.5 mm, to allow for a more gradual transition between the restoration and the tooth and a larger external enamel surface. The full bevel variation may include beveling the proximal ridges and the entire periphery of the tooth (15). The fracture resistance of several posterior indirect adhesive restoration designs was examined in a study by Ferraris et al. (2021) Three groups of margin design were created: shoulder, full Bevel, and butt joint. They determined that the full-bevel preparation design group outperformed all other groups in terms of fracture strength (14). However, studies on the beveled margin type are limited and require further investigation. Although a beveled margin can be a good option for esthetic zones due to its ability to blend with the tooth surface, it may complicate the impression taking and fabrication of the overlay as it is less clearly defined compared to other margin types.

Common in overlay preparations, Chamfer or rounded shoulder margins are known to provide a round edge that minimizes stress concentrations in the margin and helps prevent fractures. Chamfer margins are easy to detect and give favorable visibility during impression taking and cementation than the beveled margin (12). The results from a study by Dejak et al. (2007), comparing onlay designs with butt joint and rounded shoulder margins, indicated that onlays featuring a rounded shoulder margin demonstrated superior strength and a favorable distribution of contact stresses (34). In their study, Yang et al. (2020) compared a shoulder (butt joint) preparation on both cusps with a conventional preparation that had a heavy chamfer on the functional cusp and a contra-bevel on the nonfunctional cusp. The heavy chamfer demonstrated superior marginal adaptation, they determined (26). In the study done by Alassar et al. (2021) regarding the fracture resistance and failure patterns of onlays with shoulder margins, and butt joint margins, the authors found that the shoulder margin, which has the effect of a ferrule, provided better stress distribution that led to higher fracture strength (27). The impact of finish line designs on the vertical marginal fit of two distinct CAD/CAM (computer-aided design/computer-

aided manufacturing) hybrid ceramic overlays was also examined by Omar et al. (2023)

They concluded that a chamfer finish line provided superior marginal fit compared to a butt joint. Most studies have not examined the relationship between finish line design and material type, highlighting the need for further research on this topic (11). All the studies mentioned in this paragraph utilized digital impression techniques and/or computer-aided design/computer-aided manufacturing CAD/CAM for overlay restorations. Due to the sensitivity of margin readability in digital methods, these studies likely observed better results with more clearly defined margins, such as rounded shoulder or chamfer, compared to other margin types. This result is not consistent across all studies that use digital methods.

In addition, Veneziani and Magne (2010, 2017), in two separate reviews, recommend preparing axial walls using hollow chamfer margins—characterized by a gentle, rounded, concave bevel at the edge of the butt joint preparation, less deep and pronounced than chamfer margin (Figure.1-D). Given the high value of these two publications, this assertion should be highly considered and investigated (8, 43).

On the other hand, several results from clinical and laboratory studies indicate that there is no significant difference in the mechanical properties of overlays with different types of finish lines regardless of the material used. The aim of Clausen et al. (2010)'s study was to compare how different preparation designs affected all-ceramic onlays. Non-retentive preparations with either a straight-beveled or chamfer finish line were used in this investigation. According to their findings, fracture resistance was unaffected by the finish line's design (35). These results align with those of another laboratory study conducted by Jalalian et al. (2018) to evaluate the impact of sloped shoulder finish lines and deep chamfer on the marginal adaption of zirconia restorations. It proved that both deep chamfer and sloped shoulder preparation designs could be effectively employed and were clinically acceptable in terms of marginal adaption. There was no discernible difference between these two groups' internal and marginal gaps (41). Channarong et al. (2022) conducted a study on the fracture resistance

of bonded ceramic overlay restorations with various margin designs, including shoulder and beveled margins. They concluded that the type of margin used did not significantly impact the fracture resistance of the restorations (22). 43 In a clinical study by Chen et al. (2023), overlays were prepared with and without continuous and rounded shoulder, with a depth and width of approximately 1 mm along the periphery of the occlusal surface. They assumed that designs with a rounded shoulder on the peripheral occlusal surface provide the largest enamel surface, which helps with bonding and retention. Although, they discovered no significant difference between the two overlay variations (rounded shoulder and butt joint) (12). Hasan et al. (2023) also investigated the impact of various preparation designs on the marginal adaptation of indirect lithium disilicate overlay restorations. The study compared non-retentive designs with different margin configurations (hollow chamfer and butt joint) to retentive designs featuring an occlusal box. They concluded that non-retentive designs exhibited smaller marginal gaps, regardless of the margin type (20). In a more recent study by Mancuso et al. (2024) on the seating accuracy of resin composite CAD/CAM overlay restorations, various preparation designs—rounded shoulder, chamfer, and butt joint—were evaluated, along with different luting materials. The study concluded that when using pre-heated composite resin (which is more viscous than resin cement) as the luting agent, both butt joint and chamfer finishing lines are recommended to enhance the precision of overlay seating (24).

It is important to consider that factors such as the impression and manufacturing method, margin placement, overlay material, and cement type can all influence the choice of finish line. Further specific studies are needed on each of these factors, as current research has produced varied and sometimes conflicting results, preventing a definitive recommendation. As such, we recommend the use of butt joint margins and their derivatives for non-esthetic posterior restorations in order to preserve as much tooth tissue as possible. Additionally, these margins may provide better resistance to occlusal forces, simplify the preparation process, and reduce the risk of marginal leakage over time. They also

offer easier placement and adaptation of restoration, leading to improved durability and decrease in the treatment time. This conclusion is not definitive; it ought to be studied further, and decisions must be tailored to specific circumstances and considerations (such as when esthetics are more important). Attention should also be given to other designs, such as chamfer, depending on specific conditions and requirements, including the use of digital methods.

The origins of traditional cavity design can be traced back to preparations intended for non-adhesive restorations. These restorations employed traditional cavity preparation designs that depended on the formation of shoulders, occlusal boxes, retentive occlusal or proximal boxes, and occasionally pins. However, this design strategy led to the removal of significant portions of dental tissue, exposing sound dentin (8, 13, 25). Although suitable for non-adhesive restorations, conventional cavity preparation presents some problems with adhesive cementing. It is suggested not to use occlusal slots, pins, and other secondary mechanical retention forms because these methods are less conservative, inadmissible in adhesive treatments, and lead to the unnecessary exposure of dentin (8, 42).

According to the findings of several studies, conservative overlay preparations that do not include retention forms such as boxes and isthmuses are as effective or even superior to conventional preparations. Research indicated that these conservative overlays preserve more tooth structure, which means less stress concentration and more resistance to fractures (16, 44, 45).

In their literature review, Ahlersa et al. (2009), do not agree that a parallel-walled isthmus is required to improve retention in adhesive bonding. They claimed that such isthmuses lead to unwanted reduction of the tooth tissue and may cause stress on ease of insertion (13). Viana et al. (2018), assessed the influence of cavity preparation on stress distribution, tooth strain, fracture resistance, and mode of fracture, comparing conventional preparations with boxes to conservative ones without boxes. The study also established that conservative onlays had better fracture strength, less stress concentration, and more desirable failure

patterns than conventional onlays (16). In addition, in a systematic review by Goujat et al. (2019), titled “Marginal and Internal Fit of CAD-CAM Inlay/Onlay Restorations”, they stated that a non-retentive cavity preparation provided better fit than a retentive preparation (46). Additionally, Falahchai et al. (2020) conducted a study on zirconia-reinforced lithium silicate overlays, exploring various preparation designs, including configurations with and without a shoulder finish line and with or without a retention form (central groove). Their results indicated that the group with both a shoulder finish line and retention form exhibited the poorest marginal adaptation. In contrast, the conservative preparation without a shoulder finish line and retention form demonstrated favorable marginal adaptation (29). Furthermore, These results are in agreement with the results of another study by Chen et al. (2023), in the clinical study described above, they created overlays with and without box/dovetail retention to a depth of up to 1.5 mm, and the study revealed that there was no significant difference in performance characteristics between the two groups (12). Hasan et al. (2023), also, studied the impact of various preparation designs on the marginal adaptation of indirect lithium disilicate overlay restorations. The study included non-retentive designs with different margin configurations and retentive designs featuring an occlusal box. They concluded that non-retentive designs are more clinically suitable for posterior overlay restorations compared to the retentive group (20). Jurado et al. (2024) investigated the fracture resistance of non-retentive and retentive overlays, including designs with endodontic access as the retentive feature. Their findings revealed that overlays with endodontic access generally exhibited significantly lower fracture resistance compared to those without endodontic access within the same design, with the exception of the no-margin preparation design (23).

In summary, conservative preparations that avoid the use of retention forms, such as boxes and isthmuses, are not only effective but may be even more effective than conventional overlay preparations with more complex designs. These conservative designs preserve more tooth structure, which is crucial for higher strength of both the tooth

and the restoration. Their simpler design reduces stress concentration by minimizing sharp stress points, thereby enhancing fracture toughness. The use of modern adhesives and high-strength material combined can provide sufficient bond strength and durability without the use of mechanical retention forms. In conclusion, one can confidently state that conservative overlay preparations without retention forms are the superior choice. This outcome is generally independent of the material type, thickness, or margin design, with only a few exceptions noted in the literature.

5. Conclusion

For posterior overlays, we generally recommend a conservative preparation with a thickness ranging from 1.5 to 2 mm, depending on the material used. However, additional research is needed to evaluate the adequacy of strength and durability for thicknesses below this range. The preparation does not require conventional retention forms such as retentive boxes and isthmuses. This approach preserves the natural integrity of the tooth, thus leading to less invasive and maybe longer-lasting restorations. In that respect, what this review emphasizes is that there is no ultimate unanimous agreement on which margin design is the best; however, the trend nowadays seems to be toward

butt joint margins and their derivatives for non-esthetic posterior restorations due to the potential to save healthier tooth structure. In conclusion, it is thus necessary that, for the best clinical outcome, an anatomic conservative approach be followed using proper margins and thickness considerations.

Ethical Considerations

Compliance with ethical guidelines

Not applicable.

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Authors' contributions

Paria Shams: Conceptualization; Investigation; Data curation; Writing - original draft; and Writing - review & editing

Conflict of Interests

The authors declare no conflict of interest.

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References

1. Rocca GT, Rizcalla N, Krejci I, Dietschi D. Evidence-based concepts and procedures for bonded inlays and onlays. Part II. Guidelines for cavity preparation and restoration fabrication. *Int J Esthet Dent*. 2015;10(3):392-413. [PMID]
2. Hegde VR, Joshi SR, Hattarki SA, Jain A. Morphology-driven preparation technique for posterior indirect bonded restorations. *Journal of Conservative Dentistry*. 2021;24(1):100-4. [DOI: 10.4103/JCD.JCD_489_20] [PMID] [PMCID]
3. Flores M, Garza NE, Coronado J. Indirect ceramic overlay restorations as a minimally invasive alternative for posterior rehabilitation. *J App Dent Scien*. 2022;8:79-83. [DOI: 10.22271/oral.2022.v8.i1b.1411]
4. Wang B, Fan J, Wang L, Xu B, Wang L, Chai L. Onlays/partial crowns versus full crowns in restoring posterior teeth: a systematic review and meta-analysis. *Head Face Med*. 2022;18(1):36. [DOI: 10.1186/s13005-022-00337-y] [PMID] [PMCID]
5. Edelhoff D, Sorensen JA. Tooth structure removal associated with various preparation designs for posterior teeth. *International Journal of Periodontics & Restorative Dentistry*. 2002;22(3). [PMID]
6. Guess PC, Schultheis S, Wolkewitz M, Zhang Y, Strub JR. Influence of preparation design and ceramic thicknesses on fracture resistance and failure modes of premolar partial coverage restorations. *The Journal of prosthetic dentistry*. 2013;110(4):264-73. [DOI: 10.1016/S0022-3913(13)60374-1] [PMID] [PMCID]
7. Bergman MA. The clinical performance of ceramic inlays: a review. *Australian dental journal*. 1999;44(3):157-68. [DOI: 10.1111/j.1834-7819.1999.tb00217.x] [PMID]
8. Veneziani M. Posterior indirect adhesive restorations: updated indications and the Morphology Driven Preparation Technique. *Int J Esthet Dent*. 2017;12(2):204-30. [PMID]
9. Fron Chabouis H, Prot C, Fonteneau C, Nasr K, Chabreran O, Cazier S, et al. Efficacy of composite versus ceramic inlays and onlays: study protocol for the CECOIA randomized controlled trial. *Trials*. 2013;14:1-10. [DOI: 10.1186/1745-6215-14-278] [PMID] [PMCID]
10. Emam ZN, A Aleem NA. Influence of different materials and preparation designs on marginal adaptation and fracture resistance of CAD/CAM fabricated occlusal veneers. *Egyptian Dental Journal*. 2020;66(1-January (Fixed Prosthodontics, Dental Materials, Conservative Dentistry & Endodontics)):439-52. [DOI:10.21608/edj.2020.79120]
11. Omar BN, Ghany OSA, Mekki WOE. Effect of Finish Line designs on Vertical marginal fit of two different CAD/CAM

- occlusal veneers. *Al-Azhar Journal of Dentistry*. 2023;10(3):7. [DOI:10.58675/2974-4164.1560]
12. Chen S, Lu M, Zhu Z, Chen W. Clinical performance of two onlay designs for molars after root canal treatment. *Journal of Oral Science*. 2023;65(3):171-5. [DOI: 10.2334/josnusd.22-0450]
 13. Ahlersa M, Mörigb G, Blunckc U, Hajtód J, Pröbstere L, Frankenbergerf R. Guidelines for the Preparation of CAD/CAM Ceramic Inlays and Partial Crowns Richtlinien für die Präparation CAD/CAM-gefertigter Keramikinlays und-teilkronen. *International journal of computerized dentistry*. 2009;12(4):309-25. [PMID]
 14. Ferraris F. Posterior indirect adhesive restorations (PIAR): preparation designs and adhesthetics clinical protocol. *Int J Esthet Dent*. 2017;12(4):482-502. [PMID]
 15. Ferraris F, Sammarco E, Romano G, Cincera S, Giulio M. Comparison of posterior indirect adhesive restorations (PIAR) with different preparation designs according to the adhesthetics classification. Part 1: Effects on the fracture resistance. *International Journal of Esthetic Dentistry*. 2021;16(2). [PMID]
 16. Vianna ALSdV, Prado CJd, Bicalho AA, Pereira RAdS, Neves FDd, Soares CJ. Effect of cavity preparation design and ceramic type on the stress distribution, strain and fracture resistance of CAD/CAM onlays in molars. *Journal of Applied Oral Science*. 2018;26:e20180004. [DOI: 10.1590/1678-7757-2018-0004] [PMID] [PMCID]
 17. van Dijken JW, Hasselrot L. A prospective 15-year evaluation of extensive dentin-enamel-bonded pressed ceramic coverages. *Dental materials*. 2010;26(9):929-39. [DOI: 10.1016/j.dental.2010.05.008] [PMID]
 18. Murgueitio R, Bernal G. Three-year clinical follow-up of posterior teeth restored with leucite-reinforced IPS Empress onlays and partial veneer crowns. *Journal of Prosthodontics: Implant, Esthetic and Reconstructive Dentistry*. 2012;21(5):340-5. [DOI: 10.1111/j.1532-849X.2011.00837.x] [PMID]
 19. Luciano M, Francesca Z, Michela S, Tommaso M, Massimo A. Lithium disilicate posterior overlays: clinical and biomechanical features. *Clinical oral investigations*. 2020;24:841-8. [DOI: 10.1007/s00784-019-02972-3]
 20. Hasan SA, Abdul-Ameer ZM-H. Effect of three different preparation designs on the marginal adaptation of indirect overlay restoration fabricated from lithium disilicate ceramic material: An in-vitro comparative study. *The Saudi Dental Journal*. 2023;35(4):372-7. [DOI: 10.1016/j.sdentj.2023.03.013] [PMID] [PMCID]
 21. Chen Y, Chen D, Ding H, Chen Q, Meng X. Fatigue behavior of endodontically treated maxillary premolars with MOD defects under different minimally invasive restorations. *Clinical Oral Investigations*. 2022;26(1):197-206. [DOI: 10.1007/s00784-021-03991-9]
 22. Channarong W, Lohawiboonkij N, Jaleyasuthumkul P, Ketpan K, Duangrattananprathip N, Wayakanon K. Fracture resistance of bonded ceramic overlay restorations prepared in various designs. *Scientific Reports*. 2022;12(1):16599. [DOI: 10.1038/s41598-022-21167-7]
 23. Jurado CA, Afrashtehfar KI, Robles M, Alaqueely RS, Alsayed HD, Lindquist TJ, et al. Effect of preparation design and endodontic access on fracture resistance of zirconia overlays in mandibular molars: An in vitro study. *Journal of prosthodontics*. 2024. [DOI: 10.1111/jopr.13865]
 24. Mancuso E, Gasperini T, Maravic T, Mazzitelli C, Josic U, Forte A, et al. The influence of finishing line and luting material selection on the seating accuracy of CAD/CAM indirect composite restorations. *Journal of Dentistry*. 2024;148:105231. [DOI: 10.1016/j.jdent.2024.105231] [PMID]
 25. Gomes de Carvalho AB, de Andrade GS, Mendes Tribst JP, Grassi EDA, Ausiello P, Saavedra GdSFA, et al. Mechanical behavior of different restorative materials and onlay preparation designs in endodontically treated molars. *Materials*. 2021;14(8):1923. [DOI: 10.3390/ma14081923] [PMID] [PMCID]
 26. Yang Y, Yang Z, Zhou J, Chen L, Tan J. Effect of tooth preparation design on marginal adaptation of composite resin CAD-CAM onlays. *The Journal of prosthetic dentistry*. 2020;124(1):88-93. [DOI: 10.1016/j.prosdent.2019.08.010] [PMID]
 27. Alassar RM, Samy AM, Abdel-Rahman FM. Effect of cavity design and material type on fracture resistance and failure pattern of molars restored by computer-aided design/computer-aided manufacturing inlays/onlays. *Dental Research Journal*. 2021;18(1):14. [PMID] [PMCID]
 28. Ioannidis A, Mühlemann S, Özcan M, Hüsler J, Hämmerle CH, Benic GI. Ultra-thin occlusal veneers bonded to enamel and made of ceramic or hybrid materials exhibit load-bearing capacities not different from conventional restorations. *Journal of the mechanical behavior of biomedical materials*. 2019;90:433-40. [DOI: 10.1016/j.jmbbm.2018.09.041] [PMID]
 29. Falahchai M, Babaee Hemmati Y, Neshandar Asli H, Neshandar Asli M. Marginal adaptation of zirconia-reinforced lithium silicate overlays with different preparation designs. *Journal of Esthetic and Restorative Dentistry*. 2020;32(8):823-30. [DOI: 10.1111/jerd.12642] [PMID]
 30. Falahchai M, Babaee Hemmati Y, Neshandar Asli H, Rezaei E. Effect of tooth preparation design on fracture resistance of zirconia-reinforced lithium silicate overlays. *Journal of Prosthodontics*. 2020;29(7):617-22. [DOI: 10.1111/jopr.13160] [PMID]
 31. Abu-Izze F, Ramos G, Borges A, Anami L, Bottino M. Fatigue behavior of ultrafine tabletop ceramic restorations. *Dental Materials*. 2018;34(9):1401-9. [DOI: 10.1016/j.dental.2018.06.017] [PMID]
 32. Lima FF, Neto CF, Rubo JH, Santos Jr GC, Santos MJMC. Marginal adaptation of CAD-CAM onlays: Influence of preparation design and impression technique. *The Journal of prosthetic dentistry*. 2018;120(3):396-402. [DOI: 10.1016/j.prosdent.2017.10.010]
 33. Baldissara P, Monaco C, Onofri E, Fonseca RG, Ciocca L. Fatigue resistance of monolithic lithium disilicate occlusal veneers: a pilot study. *Odontology*. 2019;107:482-90. [DOI: 10.1007/s10266-019-00417-7] [PMID]
 34. Dejak B, Mlotkowski A, Romanowicz M. Strength estimation of different designs of ceramic inlays and onlays in molars based on the Tsai-Wu failure criterion. *The Journal of prosthetic dentistry*. 2007;98(2):89-100. [DOI: 10.1016/S0022-3913(07)60042-0]
 35. Clausen J-O, Abou Tara M, Kern M. Dynamic fatigue and fracture resistance of non-retentive all-ceramic full-coverage molar restorations. Influence of ceramic material and

- preparation design. *Dental materials*. 2010;26(6):533-8. [\[DOI: 10.1016/j.dental.2010.01.011\]](#) [\[PMID\]](#)
36. Al Khalifah SAM. The Influence of Material Type, Preparation Design, and Tooth Substrate on Fracture Resistance of Molar Onlays: UCLA; 2016. [\[Link\]](#)
 37. Fennis WM, Kuijs RH, Kreulen CM, Verdonchot N, Creugers NH. Fatigue resistance of teeth restored with cuspal-coverage composite restorations. *International Journal of Prosthodontics*. 2004;17(3):313-7. [\[PMID\]](#)
 38. Lohbauer U, Fabris DCN, Lubauer J, Abdelmaseh S, Cicconi M-R, Hurle K, et al. Glass science behind lithium silicate glass-ceramics. *Dental Materials*. 2024;40(5):842-57. [\[DOI: 10.1016/j.dental.2024.03.006\]](#) [\[PMID\]](#)
 39. Shanmugasundaram N, Anirudhan S, Koshy M, Varghese R, Rajamanickam N. Successful Management of Fractured Premolar with Veneerlay Following Morphology-driven Preparation Technique Principles. *Journal of Operative Dentistry & Endodontics*. 2024;7(2):28-32. [\[DOI: 10.5005/jp-journals-10047-0125\]](#)
 40. Boukhris H, Touffeha G, M'ghirbi N, Karoui L, Hajjami H. Veneerlays: A suitable Conservative Approach for Restoring Posterior Teeth. *J Dent Med Sci Res*. 2018;2(6):15-9. [\[Link\]](#)
 41. Jalalian EA, Mostofi SN, Shirian AA, Shamshirgar F, Ghane HK, Naseri M. Effect of Sloped Shoulder and Deep Chamfer Finish Lines on Marginal Adaptation of Zirconia Restorations. *Journal of Research in Medical and Dental Science*. 2018;6(1):369. [\[DOI: 10.5455/jrmds.20186160\]](#)
 42. Politano G, Van Meerbeek B, Peumans M. Nonretentive bonded ceramic partial crowns: concept and simplified protocol for long-lasting dental restorations. *J Adhes Dent*. 2018;20(6):495-510. [\[DOI: 10.3290/j.jad.a41630\]](#)
 43. Magne P. Composite resins and bonded porcelain: the postamalgam era? *Journal of the California Dental Association*. 2006;34(2):135-47. [\[PMID\]](#)
 44. Broderson SP. Complete-crown and partial-coverage tooth preparation designs for bonded cast ceramic restorations. *Quintessence International*. 1994;25(8). [\[PMID\]](#)
 45. Van Dijken JW, Hasselrot L, Örmén A, Olofsson AL. Restorations with extensive dentin/enamel-bonded ceramic coverage. A 5-year follow-up. *European Journal of Oral Sciences*. 2001;109(4):222-9. [\[DOI: 10.1034/j.1600-0722.2001.00063.x\]](#) [\[PMID\]](#)
 46. Goujat A, Abouelleil H, Colon P, Jeannin C, Pradelle N, Seux D, et al. Marginal and internal fit of CAD-CAM inlay/onlay restorations: A systematic review of in vitro studies. *The Journal of prosthetic dentistry*. 2019;121(4):590-7. e3. [\[DOI: 10.1016/j.prosdent.2018.06.006\]](#) [\[PMID\]](#)