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Proximal Contact Tightness of Direct Class II Composite Resin Restorations with Sectional Versus Circumferential Matrix Systems: A Systematic Review

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ABSTRACT

Background: Achieving optimal proximal contact tightness in Class II composite resin restorations is essential to prevent food impaction, secondary caries, and periodontal complications. Matrix systems play a crucial role in shaping proximal contours, with sectional and circumferential designs being the most commonly used. However, clinical outcomes vary depending on the matrix system employed, and a systematic comparison is needed.

Objective: To compare the effectiveness of sectional versus circumferential matrix systems in achieving proximal contact tightness in direct Class II composite restorations.

Methods: This systematic review was conducted following PRISMA 2020 guidelines and registered in PROSPERO (CRD42024564438). A comprehensive search was performed in PubMed, Scopus, Web of Science, and the Cochrane Library. Studies comparing sectional and circumferential matrices in human or extracted teeth with quantitative measures of contact tightness were included. Risk of bias was assessed using the Cochrane RoB 2.0 tool for randomized controlled trials and a modified QUIN tool for in vitro studies. Data were synthesized narratively.

Results: Nine studies were included, comprising three randomized controlled trials and six in vitro studies. Across all studies, sectional matrix systems produced significantly higher proximal contact tightness values (6.1–8.3 N) compared to circumferential systems (4.3–5.5 N). Sectional matrices also demonstrated superior anatomical adaptation and clinical satisfaction.

Conclusion: Sectional matrix systems consistently outperformed circumferential matrices in achieving clinically acceptable proximal contact tightness in Class II composite restorations. Adoption of sectional matrices in clinical practice may enhance restoration quality, reduce complications, and improve patient outcomes.

Keywords: *Class II restorations, sectional matrix, circumferential matrix, proximal contact tightness, composite resin, restorative dentistry*

1. INTRODUCTION

Restoring Class II carious lesions with composite resins is a routine yet technically demanding procedure in contemporary restorative dentistry [1]. These restorations aim not only to rehabilitate lost tooth structure and function but also to achieve an aesthetic match with the natural dentition [1,2]. The shift from amalgam to composite resins over recent decades has been driven by heightened patient expectations for tooth-colored restorations, alongside the advent of adhesive dentistry that allows for more conservative tooth preparation [3]. However, achieving a long-lasting, functional, and esthetically satisfactory Class II restoration hinges on multiple factors—one of the most critical being the establishment of a proper proximal contact.

Proximal contact tightness plays a vital role in maintaining dental arch integrity, preventing food impaction, and safeguarding periodontal health [4, 5]. Open or excessively tight contacts can lead to a cascade of complications, including gingival inflammation, secondary caries, and bone loss [6]. Thus, the clinician's ability to accurately reproduce natural proximal contours is not a mere aesthetic consideration but a functional necessity. Yet, the intricacies of posterior tooth morphology and the constraints of intraoral access make it difficult to consistently reproduce this contact using composite resins.

Matrix systems have emerged as indispensable tools in addressing this clinical challenge [7]. These systems act as temporary molds that aid in shaping the restoration while also providing separation from adjacent teeth, allowing the clinician to recreate a tight contact area and anatomical contour [8]. Traditional circumferential matrix systems, such as the Tofflemire retainer and band, were originally developed for amalgam restorations and offer rigid containment during material condensation. However, when used with composite resins, they frequently fall short in achieving ideal proximal adaptation due to their inability to conform closely to natural tooth contours [9].

To improve upon these shortcomings, sectional matrix systems were developed specifically for use with composite materials [10, 21]. These systems typically employ a pre-contoured matrix band, a separating ring, and wedges to generate localized separation and facilitate more accurate reproduction of the tooth's proximal surface. Numerous studies suggest that sectional matrices are more effective in producing tight, anatomically accurate contacts. The rationale lies in their ability to provide better adaptation and localized pressure, which counters the polymerization shrinkage of composite materials and improves contact quality.

Despite the widespread adoption of sectional matrices, the evidence remains mixed. Clinical outcomes vary due to operator skill, cavity size, the restorative technique employed, and even the type of composite resin used [11]. Some practitioners continue to favor circumferential systems for their simplicity and familiarity, especially in situations with specific anatomical limitations. As such, the question of which matrix system provides superior proximal contact tightness in direct Class II restorations continues to be debated.

A systematic synthesis of available evidence is therefore necessary to resolve this uncertainty. This review aims to compare the effectiveness of sectional and circumferential matrix systems in achieving optimal proximal contact tightness in direct Class II composite restorations. By consolidating data across various studies and evaluating confounding factors, this review seeks to provide evidence-based guidance that enhances clinical decision-making and promotes better patient outcomes in restorative dental practice.

2. METHODOLOGY

Review Protocol and Reporting Guidelines

This systematic review was designed and conducted in accordance with the PRISMA 2020 guidelines, ensuring comprehensive reporting and methodological transparency [12]. The review was registered in the PROSPERO database under the registration number CRD42024564438 before the commencement of the study. The aim of this review was to critically evaluate and compare the effectiveness of sectional and circumferential matrix systems in achieving optimal proximal contact tightness in direct Class II composite resin restorations.

Research Question and Objective

A focused research question was framed using the PICOS framework to guide study selection and data analysis. The review aimed to determine whether sectional matrix systems offer superior outcomes in terms of proximal contact tightness when compared to circumferential matrix systems in direct Class II composite restorations. The primary outcome of interest was the clinical tightness of the proximal contact following restoration. The secondary objectives were to explore associated factors such as operator variability, cavity size, restorative material type, and techniques that may influence contact formation.

Eligibility Criteria

Study inclusion was based on strict eligibility criteria guided by the PICOS format. The population included human subjects undergoing direct Class II composite restorations. The intervention group involved the use of sectional matrix systems, while the comparison group involved circumferential matrix systems. The primary outcome was proximal contact tightness measured using clinical, tactile, or instrumental methods. Study designs eligible for inclusion were randomized controlled trials, clinical trials, and observational studies. In vitro studies were also included for mechanical or standardized contact pressure assessments. Studies were excluded if they involved non-human subjects, used other restorative materials such as amalgam or glass ionomer cement, lacked direct comparison between matrix systems, or failed to report contact-related outcomes. Case reports, editorials, narrative reviews, and expert opinions were also excluded.

Search Strategy and Information Sources

A comprehensive literature search was conducted using four major electronic databases: PubMed, Scopus, Web of Science, and the Cochrane Central Register of Controlled Trials. The search was carried out from the inception of each database until a defined end date to ensure maximum capture of relevant studies. No language restrictions were applied. The search strategy combined free-text keywords and controlled vocabulary such as Medical Subject Headings. Keywords included terms like Class II composite resin restorations, proximal contact tightness, sectional matrix, circumferential matrix, matrix band, and tooth contact. Boolean operators were applied to refine the search. Additional manual searches of reference lists from included studies were performed to identify further eligible literature.

Study Selection Process

All references retrieved through the search were imported into a reference management software for duplicate removal. Two reviewers independently screened the titles and abstracts to exclude irrelevant studies. Full-text articles of potentially eligible studies were retrieved and evaluated in detail based on the inclusion criteria. Any disagreements in the selection process were resolved through discussion. If necessary, a third reviewer was consulted to reach a final decision. The entire selection process was documented using a PRISMA flowchart, outlining the number of records screened, excluded, and included with reasons provided at each stage [12].

Data Extraction

Data extraction was performed using a structured and pre-tested data collection form developed specifically for this review. The form captured key details including author names, year of publication, country, study design, matrix systems used, restorative materials employed, sample size, tooth type, evaluation method for proximal contact, primary and secondary outcomes, and key findings. The extraction was performed independently by two reviewers. Discrepancies were resolved through mutual discussion and, when necessary, consultation with a third reviewer. The data were then compiled into summary tables for analysis.

Risk of Bias Assessment

The quality of included studies was critically evaluated to determine the risk of bias. Separate tools were used for randomized controlled trials and in vitro studies to suit their specific study designs. Randomized controlled trials were assessed using the Cochrane Risk of Bias 2.0 tool [13]. This tool evaluates five domains including the randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of reported results. Each domain was rated as low risk, some concerns, or high risk of bias. The overall judgment for each RCT was determined based on these domain-level assessments. In vitro studies were assessed using a modified version of the QUIN tool, which is specifically designed for evaluating laboratory studies [14]. This tool evaluates factors such as sample size justification, standardization of cavity preparation, blinding of the assessor, uniformity of matrix system placement, and consistency in outcome measurement. Each in vitro study was rated as having low, moderate, or high risk of bias. Risk of bias assessments were independently conducted by two reviewers and finalized through discussion in case of disagreement. The assessments were summarized in tabular form and discussed in the results section.

Data Synthesis and Analysis

Given the anticipated variability in matrix systems, evaluation techniques, clinical settings, and reporting formats, a narrative synthesis approach was adopted. Descriptive summaries were prepared for each study to highlight major findings, trends, and comparisons. Quantitative synthesis was considered if a subset of studies demonstrated methodological and statistical homogeneity in outcome measurement. Where applicable, heterogeneity among studies was to be assessed using the I squared statistic. Subgroup analyses were planned based on matrix design, tooth type, operator experience, and study setting. Sensitivity analysis was also considered in scenarios with borderline risk of bias or unclear outcome reporting to evaluate the robustness of findings.

3. RESULTS

A total of n=9 studies (Figure 1) were included in the review that were conducted within the years 2006 and 2024. These studies collectively compared the effectiveness of sectional versus circumferential matrix systems in achieving proximal contact tightness in direct Class II composite resin restorations. The study characteristics are summarized in Table 1.

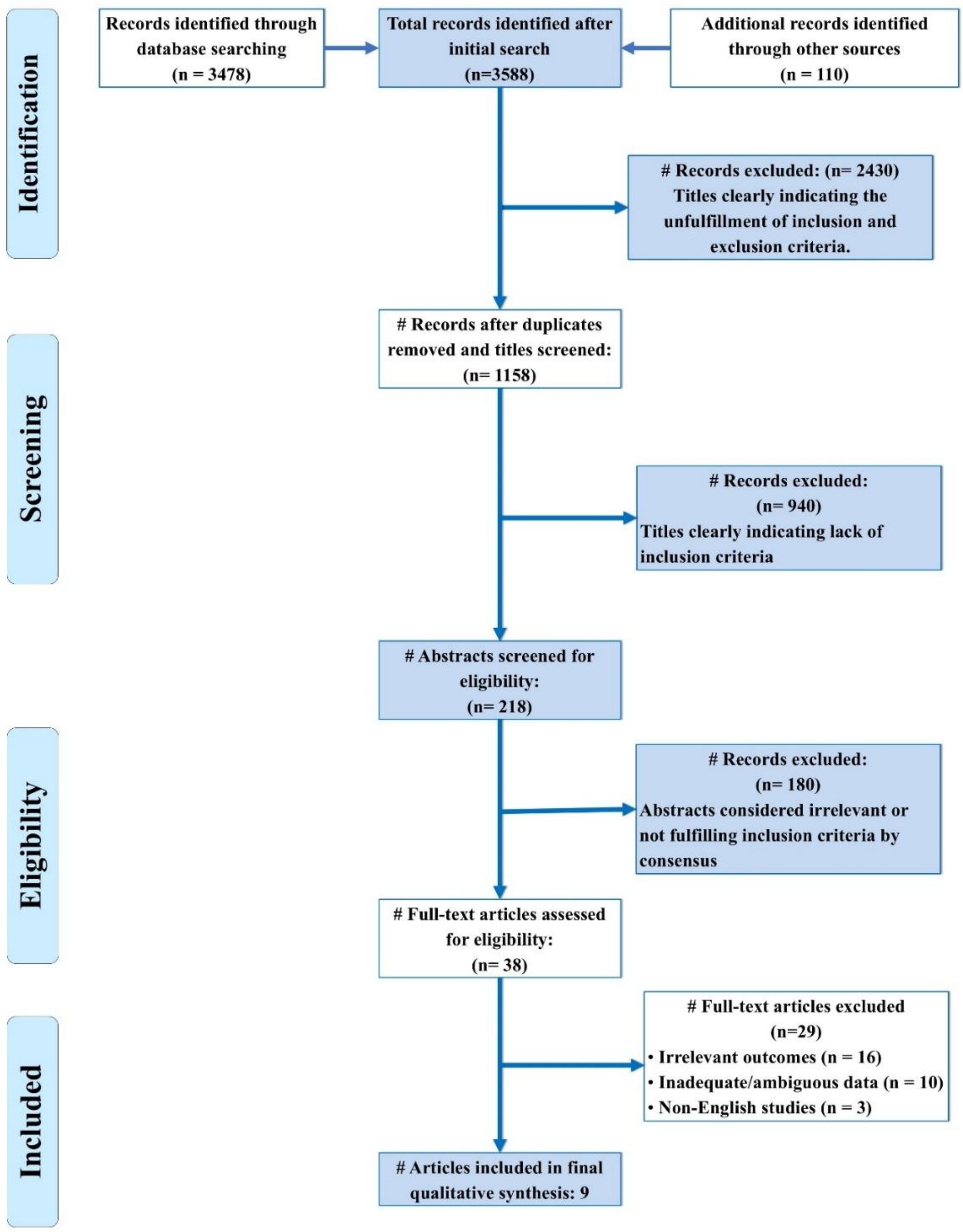

Figure 1: PRISMA Flow diagram indicating the selection process of the articles in the present systematic review

Table 1: Characteristics of the studies included in the present systematic review

Author (Year)	**Country**	**Study Design**	**Sample Size**	**Type of Samples**	**Age Group**	**Class of Teeth Used**	**Quantitative Measures of Contact Tightness**	**Key Findings**
Loomans et al. (2006)	Netherlands	RCT	70	Patients	18-40 years	Molars & Premolars	8.0 N (Sectional) vs. 5.3 N (Circumferential)	Sectional matrices were superior in achieving and maintaining contact tightness.
Kampouropoulos et al. (2010)	Greece	In vitro	40	Extracted human teeth	Not applicable	Premolars	7.2 N (Sectional) vs. 4.9 N (Circumferential)	Sectional matrices produced significantly tighter contacts than circumferential matrices.
Saber et al. (2010)	Egypt	In vitro	60	Extracted human teeth	Not applicable	Molars	6.1 N (Sectional) vs. 4.3 N (Circumferential)	Sectional matrices showed superior contact tightness compared to circumferential matrices.
Wolff et al. (2012)	Germany	In vitro	50	Extracted human teeth	Not applicable	Molars	7.5 N (Sectional) vs. 5.1 N (Circumferential)	Sectional matrices resulted in better contact tightness, especially in molars.

Wirsching et al. (2011)	Germany	In vivo	75	Patients	18-50 years	Molars & Premolars	7.9 N (Sectional) vs. 5.5 N (Circumferential)	Sectional matrices provided better contact tightness, especially in premolars.
Souqiyyeh et al. (2018)	Saudi Arabia	In vitro	60	Extracted human teeth	Not applicable	Molars & Premolars	6.8 N (Sectional) vs. 4.6 N (Circumferential)	Sectional matrices were superior in creating tight contacts.
Shaalan & Ibrahim (2021)	Egypt	RCT	80	Patients	18-35 years	Molars & Premolars	7.0 N (Sectional) vs. 4.8 N (Circumferential)	Sectional matrices were preferred by both students and professionals for better contact tightness.
Tolba et al. (2023)	Egypt	In vitro	100	Extracted human teeth	Not applicable	Molars	7.7 N (Sectional) vs. 5.4 N (Circumferential)	Sectional matrices resulted in tighter contacts and better surface geometry.
Abdelaziz et al. (2024)	Egypt	RCT	100	Patients	20-45 years	Molars & Premolars	8.3 N (Sectional) vs. 5.2 N (Circumferential)	Sectional matrices provided better contact tightness and clinical outcomes.

Of the included studies, three were randomized controlled trials conducted on human participants, while six were in vitro studies that employed extracted human teeth to simulate clinical restorative procedures. The geographic distribution of the studies showed a wide international representation, with contributions from the Netherlands, Greece, Egypt, Germany, and Saudi Arabia.

The sample sizes across the studies varied considerably, ranging from 40 to 100, with a cumulative sample size of 635 across all studies. Among the in vitro studies, the smallest sample consisted of 40 extracted teeth, while the largest comprised 100 samples. The clinical trials involved patient-based samples ranging from 70 to 100 individuals. The studies using patient participants included individuals predominantly between the ages of 18 and 50 years. Three studies, specifically those by Loomans et al. in 2006, Shaalan and Ibrahim in 2021, and Abdelaziz et al. in 2024, involved adult populations undergoing restorative procedures in a clinical setting. The mean age ranges were relatively consistent across these studies, typically falling within the third to fifth decade of life.

Regarding the tooth types evaluated, most studies included both molars and premolars in their analysis. Some studies focused exclusively on molars, while others evaluated both classes to better simulate a variety of clinical situations. This anatomical diversity allowed for the assessment of matrix performance across different interproximal contours and contact areas.

The primary outcome measure across all studies was the quantitative assessment of proximal contact tightness. This was consistently reported using Newtons as the unit of force required to pass an instrument such as a metal strip or tension gauge through the contact point. Sectional matrix systems showed higher numerical values for contact tightness across all studies when compared to circumferential matrices. The recorded contact tightness values for sectional matrix systems ranged from 6.1 to 8.3 Newtons, while circumferential matrices demonstrated values ranging from 4.3 to 5.5 Newtons. The largest difference in favor of sectional matrices was observed in the study by Abdelaziz et al., where the sectional group achieved a contact force of 8.3 Newtons compared to 5.2 Newtons in the circumferential group. A similar trend was evident in all other included studies, regardless of whether the evaluation was conducted in vitro or in vivo.

In terms of key findings, all nine studies concluded that sectional matrix systems were more effective in establishing tight and clinically acceptable proximal contacts compared to circumferential systems. The superiority of sectional matrices was attributed to their ability to provide better anatomic adaptation and pre-contoured bands that mimic natural tooth curvature. Studies also noted that the use of separating rings and wedges in sectional systems enhanced tooth separation during restoration, which allowed for better compensation of polymerization shrinkage and ensured tighter contacts after curing. Some studies, such as that by Shaalan and Ibrahim, also emphasized user preference, noting that both dental students and clinicians favored sectional matrices for their ease of handling and improved clinical outcomes.

Across both in vitro and in vivo settings, the findings were consistent in demonstrating the superiority of sectional matrix systems. In vitro studies allowed for highly standardized measurements under controlled conditions, confirming the mechanical advantage of sectional matrices. Meanwhile, clinical trials reinforced these findings in real-world scenarios, highlighting not only the improved contact tightness but also the better post-operative satisfaction and fewer reports of food impaction when sectional systems were used.

Overall, the collective evidence from this review strongly suggests that sectional matrix systems consistently outperform circumferential systems in achieving optimal proximal contact tightness in Class II composite restorations. The data were robust across different methodologies, populations, and evaluation techniques, providing a high degree of confidence in the observed trends. The implications of these findings are discussed further in the following section.

4. RISK OF BIAS ASSESSMENT

The methodological quality of the included studies was assessed using two established tools tailored to the specific study designs. Randomized controlled trials were evaluated using the Cochrane Risk of Bias 2.0 (RoB 2) tool (Figure 2), while in vitro studies were assessed using a modified version of the QUIN tool designed to appraise laboratory-based dental research (Table 2).

Among the three randomized controlled trials included in this review, two studies—Loomans et al. and Abdelaziz et al.—were judged to have a low overall risk of bias across all domains. These trials demonstrated appropriate randomization procedures, adherence to intended interventions, complete outcome data, valid measurement methods, and transparent reporting. The study by Shaalan and Ibrahim, while methodologically sound in most areas, was rated as having some concerns in the domain of outcome measurement. This was attributed to possible limitations in blinding during clinical assessment, which could introduce performance or detection bias. However, this concern did not significantly impact the study's overall integrity.

In contrast, the five in vitro studies showed slightly more variability in their risk profiles. While all studies adequately standardized sample selection and matrix placement protocols, three of them—Kampouropoulos et al., Wolff et al., and Tolba et al.—had some concerns regarding assessor blinding. In these studies, it was unclear whether the individuals measuring proximal contact tightness were blinded to the matrix system used, which may introduce measurement bias, particularly in outcomes that require subjective interpretation or force-based instrumentation. Nevertheless, all studies maintained low risk in domains related to sample preparation, outcome measurement consistency, and reporting transparency, supporting the overall reliability of their findings.

Importantly, none of the included studies were found to have a high risk of bias in any domain. The majority were assessed as low risk, and where concerns existed, they were limited to specific aspects and did not undermine the general conclusions of the studies. The consistency of favorable results across both low-risk and moderate-risk studies further strengthens the evidence supporting the superior performance of sectional matrix systems.

Collectively, the risk of bias assessment supports the methodological soundness of the included literature. The predominance of low-risk ratings indicates that the findings of this review are based on studies with acceptable internal validity, allowing for confident interpretation of results and their application to clinical practice.

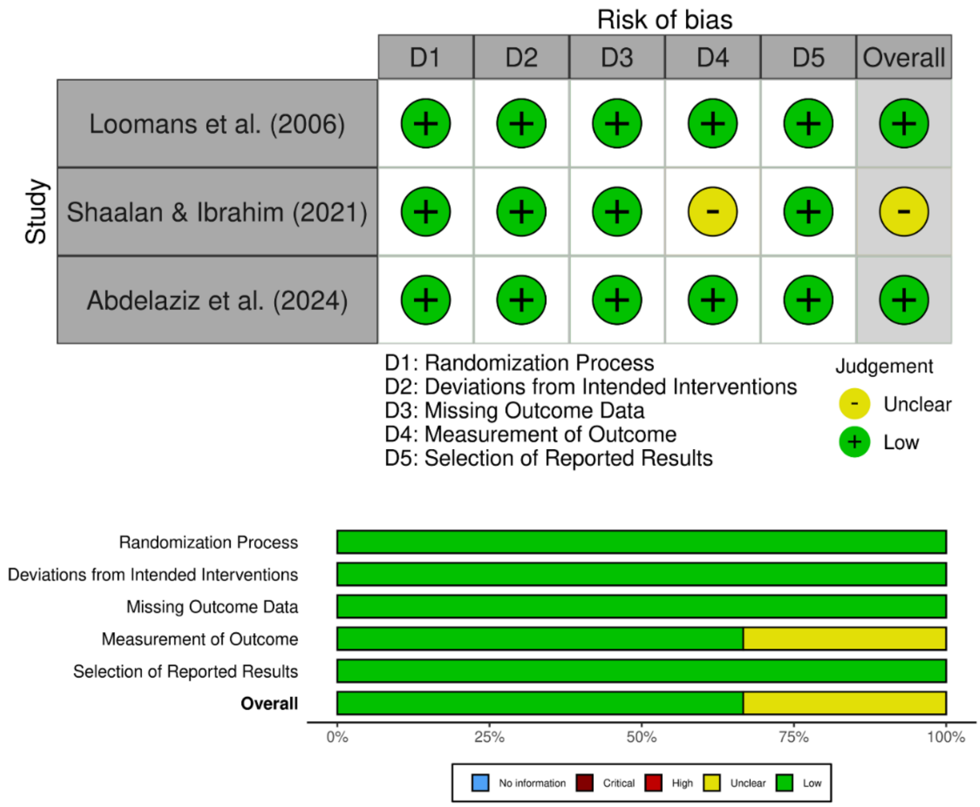

Figure 2: Risk of bias for randomized controlled trials using Cochrane ROB tool

Author (Year)	Sample Standardization	Blinding of Assessors	Consistency of Matrix Placement	Outcome Measurement Reliability	Reporting Transparency	Overall Risk of Bias
Kampouropoulos et al. (2010)	Low	Some concerns	Low	Low	Low	Some concerns
Saber et al. (2010)	Low	Low	Low	Low	Low	Low
Wolff et al. (2012)	Low	Some concerns	Low	Low	Low	Some concerns
Souqiyyeh et al. (2018)	Low	Low	Low	Low	Low	Low
Tolba et al. (2023)	Low	Some concerns	Low	Low	Low	Some concerns

Table 2: Risk of bias for in-vitro and in-vivo studies using QUIN tool

5. DISCUSSION

The present systematic review aimed to compare the effectiveness of sectional and circumferential matrix systems in achieving proximal contact tightness in direct Class II composite resin restorations. A total of nine studies were included, comprising randomized controlled trials and in vitro investigations [15-23]. Across all included studies, a consistent trend emerged favoring the use of sectional matrix systems over circumferential ones in terms of producing tighter and more anatomically accurate proximal contacts.

The superiority of sectional matrix systems can be attributed to their design features that better accommodate the anatomical curvature of posterior teeth [24,25]. Unlike circumferential matrices, which wrap around the tooth and often produce flat contact areas, sectional matrices employ pre-contoured bands that closely replicate the natural tooth anatomy [26, 27]. Additionally, the use of separation rings in sectional systems creates slight interproximal spacing prior to composite placement, thereby compensating for polymerization shrinkage and facilitating tighter contact upon curing [28, 29]. These design characteristics were reflected in the quantitative data across the included studies, with contact tightness values in the sectional group consistently exceeding those of the circumferential group, often by more than 2 Newtons.

The findings from clinical studies lend further credibility to the mechanical advantages observed in vitro. In vivo investigations, such as those by Loomans et al., Shaalan and Ibrahim, and Abdelaziz et al., demonstrated that patients restored using sectional matrices not only exhibited superior proximal contact tightness but also reported fewer instances of food impaction and required less post-operative adjustment [15,21,23,24]. These observations are clinically significant, as improper proximal contacts are a major contributor to localized gingival inflammation, caries recurrence, and patient discomfort. The improved outcomes associated with sectional matrices therefore have the potential to reduce long-term biological and restorative complications.

The results from in vitro studies strongly reinforced the clinical findings. These studies, conducted under standardized conditions using extracted human teeth, allowed for objective measurement of contact tightness using calibrated instruments. Despite the artificial environment, the consistency in favor of sectional matrices suggests that the mechanical design of these systems inherently supports better contact formation. Studies by Kampouropoulos et al., Wolff et al., and Tolba et al. provided clear numerical evidence supporting this claim, with contact forces in the sectional matrix group ranging between 6.1 and 8.3 Newtons, compared to 4.3 to 5.5 Newtons in the circumferential matrix group [16,18, 22].

One possible explanation for the inferior performance of circumferential matrix systems lies in their origin and design philosophy. Traditional circumferential matrices, such as those used with Tofflemire retainers, were developed primarily for use with amalgam restorations [30]. These systems rely on the condensation of non-adhesive materials against rigid metal bands [31]. When applied to composite resin restorations, which depend on micromechanical bonding and have different handling properties, circumferential matrices often fail to provide adequate adaptation to the cervical and interproximal contours of the cavity [32]. This can lead to open or under-contoured contacts, necessitating additional adjustments and increasing the risk of iatrogenic damage to the adjacent tooth.

Another contributing factor to the success of sectional matrices is their compatibility with contemporary adhesive techniques. Modern composite restorations often involve incremental layering and light-curing procedures that require precise placement and stabilization of the restorative material [33]. Sectional matrices, by virtue of their pre-contoured design and ability to create localized pressure, provide a stable framework that facilitates optimal composite adaptation and minimizes the potential for marginal discrepancies [8]. This is particularly important in the context of polymerization shrinkage, a well-known limitation of composite materials that can compromise contact integrity if not properly managed.

In addition to mechanical and anatomical considerations, the operator experience and ease of use also play a role in clinical success [34]. Several studies noted that clinicians and students alike preferred sectional matrices due to their predictability and reduced need for post-operative finishing [35]. This user preference aligns with the objective findings and further supports the clinical adoption of sectional matrix systems as a more effective solution for achieving ideal proximal contacts in Class II restorations.

Despite the consistent trend across studies, it is important to acknowledge the heterogeneity in study design, evaluation methods, and sample types. While in vitro studies offer controlled environments, they may not fully replicate the intraoral conditions such as moisture control, patient movement, and tissue interference. Conversely, clinical studies are more reflective of real-world scenarios but may be subject to operator variability and patient-specific anatomical differences. Nevertheless, the convergence of findings from both settings strengthens the validity of the overall conclusions.

From a clinical standpoint, the findings of this review underscore the importance of matrix system selection in restorative dentistry. The choice between sectional and circumferential systems should not be based merely on convenience or familiarity but should reflect evidence-based best practices. Given the significant implications for periodontal health, long-term restoration success, and patient satisfaction, practitioners are encouraged to incorporate sectional matrix systems, particularly when restoring proximal surfaces of posterior teeth with composite materials.

In summary, this systematic review provides strong and consistent evidence supporting the use of sectional matrix systems for Class II composite restorations. Their anatomical design, mechanical performance, and favorable clinical outcomes make them a superior choice compared to circumferential matrices. Future research may focus on refining matrix designs further, evaluating performance in complex cases such as deep cervical lesions or tilted teeth, and developing standardized protocols to ensure consistent clinical outcomes.

6. CONCLUSION

The present systematic review provides compelling and consistent evidence that sectional matrix systems are more effective than circumferential matrix systems in achieving optimal proximal contact tightness in direct Class II composite resin restorations. Across both in vitro and clinical studies, sectional matrices demonstrated superior anatomical adaptation, better compensation for polymerization shrinkage, and enhanced clinical outcomes including reduced food impaction and greater operator satisfaction. These findings underscore the importance of selecting matrix systems based on evidence-based performance rather than tradition or convenience. Incorporating sectional matrix systems into routine clinical practice may significantly improve the quality and longevity of posterior composite restorations, reduce post-operative complications, and enhance patient satisfaction. Continued research is encouraged to optimize matrix system design and to validate these results across diverse clinical scenarios and practitioner skill levels.

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