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Review article

Efficacy of self-ligating versus conventional brackets in maxillary transverse development: A systematic review and meta-analysis

Eficacia de soportes ortodóncicos autoligantes versus convencionales en desarrollo transversal maxilar: una revisión sistemática y metaanálisis

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ABSTRACT

Introduction: Self-ligating brackets (SLB) have been promoted as superior to conventional brackets (CB) in maxillary arch development, though clinical evidence remains inconsistent. **Objective:** To evaluate the comparative efficacy of SLB versus CB systems in maxillary arch dimensional changes through systematic review and meta-analysis. **Method:** A systematic search was conducted in PubMed, Scopus, and ClinicalKey through December 2024. Randomized controlled trials and controlled clinical trials comparing SLB versus CB were included. Studies were assessed using Cochrane and JBI tools. A random-effects model was employed. **Results:** Six studies met criteria (353 participants). The meta-analysis revealed significant differences favoring SLB for maxillary intercanine width (MD = 0.83 mm, 95%CI 0.33-1.33, p=0.001), with no differences for mandibular intercanine width (MD = -0.38 mm, 95%CI -1.17-0.41, p=0.35). SLB d was associated with less incisor inclination (MD = -2.28°, 95%CI -4.56-0.00, p=0.05). **Conclusions:** SLB produced greater maxillary transverse expansion with less proclination. Longitudinal studies are needed to evaluate stability and cost-effectiveness.

Keywords: Orthodontic brackets; Dental arch; Maxilla; Systematic review.

RESUMEN

Introducción: los soportes ortodóncicos de autoligado (SLB) han sido promocionados como superiores a los soportes ortodóncicos convencionales (CB) en el desarrollo del arco maxilar, aunque la evidencia aún es inconsistente. **Objetivo:** evaluar la eficacia comparativa de los sistemas SLB y CB en los cambios dimensionales del arco maxilar mediante una revisión sistemática y un metaanálisis. **Método:** se realizó una búsqueda sistemática en PubMed, Scopus y ClinicalKey hasta diciembre de 2024. Se incluyeron ensayos controlados que compararon SLB con CB. Los estudios se evaluaron con las herramientas de Cochrane y JBI. Se empleó un modelo de efectos aleatorios. **Resultados**: seis estudios cumplieron los criterios (353 participantes). El metaanálisis mostró diferencias significativas a favor de SLB en el ancho intercanino maxilar (DM = 0,83 mm; IC del 95%: 0,33-1,33; p = 0,001), sin diferencias en el ancho intercanino mandibular (DM = -0,38 mm; IC del 95%: -1,17-0,41; p = 0,35). Los SLB demostraron una menor inclinación de los incisivos (DM = -2,28°; IC95% -4,56-0,00; p = 0,05). **Conclusiones:** los SLB producen una mayor expansión transversal maxilar con menor proclinación. Se requieren estudios longitudinales para evaluar la estabilidad y la costo-efectividad.

Palabras clave: soportes ortodóncicos; arco dental; maxilar; revisión sistemática.

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INTRODUCTION

Dental crowding represents the most prevalent malocclusion in contemporary orthodontic practice, affecting a substantial proportion of the global population and with a pronounced hereditary component that underscores its clinical significance.[1,2] This condition, characterized by insufficient arch space to accommodate proper dental alignment, presents multifaceted therapeutic challenges that require comprehensive treatment planning and sophisticated biomechanical approaches.[3] The etiology of crowding encompasses complex interactions among genetic predisposition, developmental jaw growth patterns, tooth size discrepancies, and environmental factors, making individualized treatment strategies essential for optimal clinical outcomes.[4,5]

Modern orthodontic management of crowding requires careful evaluation of patient-specific characteristics while considering functional requirements, aesthetic expectations, and long-term stability objectives.[6-9] Contemporary treatment approaches have evolved significantly, incorporating advanced biomechanical principles and innovative technologies that enable clinicians to address space deficiencies through multiple therapeutic modalities.[10,11] The selection of appropriate intervention strategies requires careful consideration of treatment complexity, patient compliance factors, and expected outcomes to achieve optimal dental positioning with minimal adverse effects.[12]

Space-acquisition methodologies in orthodontics have diversified considerably, offering clinicians a range of approaches to manage arch-length deficiencies effectively.[13-16] Interproximal reduction techniques provide minimally invasive options for creating a modest space between adjacent teeth through controlled enamel removal.[17-19] Distalization procedures offer alternative mechanisms for generating arch length by strategically repositioning posterior teeth distally.[20-22] Transverse arch expansion represents another fundamental approach, particularly beneficial for patients with constricted dental arches, where width augmentation can significantly increase available space. [23,24]

Technological advancements have revolutionized orthodontic treatment protocols by introducing sophisticated bracket systems and innovative wire technologies that enhance treatment efficiency and patient comfort.[25,26] Conventional bracket systems, which have historically dominated orthodontic practice, utilize elastic ligatures or metal ties to secure archwires within bracket slots, providing reliable force transmission for tooth movement.[27,28] In contrast, self-ligating bracket (SLB) systems incorporate built-in mechanisms that eliminate the need for external ligatures, theoretically reducing friction and enhancing tooth movement efficiency through improved force delivery.[28,29]

The biomechanical advantages of self-ligating systems include reduced friction between archwires and bracket slots, which, theoretically, allow for more efficient tooth movement with lighter forces and potentially shorter treatment times.[29,30] Additionally, copper-nickel-titanium (Cu-NiTi) archwires have transformed initial alignment phases by providing consistent, gentle forces that facilitate predictable tooth movement while minimizing patient discomfort during early treatment stages.[30,31]

Comparative research investigating clinical performance differences between bracket systems has yielded varied results, with some studies suggesting modest advantages for self-ligating systems, while others report minimal clinically significant differences.[32-35] These investigations have revealed complex interactions among bracket design, archwire properties, and individual patient characteristics that influence treatment outcomes.[32] The evaluation of arch dimensional changes has become particularly important, as transverse development affects not only space availability but also facial aesthetics, airway dimensions, and long-term stability of orthodontic corrections.[33]

Despite extensive research, clinical evidence on the comparative efficacy of self-ligating versus conventional bracket systems in maxillary arch development remains inconsistent, with significant heterogeneity across study designs, outcome measures, and patient populations.[34,35] This variability necessitates a systematic evaluation of the available evidence to provide clinicians with reliable guidance for treatment planning.

The objective of this systematic review and meta-analysis was to evaluate the comparative effects of self-ligating brackets versus conventional bracket systems on maxillary arch dimensional changes and to provide evidence-based recommendations for clinical practice.

METHOD

Research question

This meta-analysis was prospectively registered in PROSPERO (CRD420251014188) and follows PRISMA 2020 guidelines[36] to compare self-ligating brackets (SLB) with conventional brackets (CB) in orthodontic patients with dental malocclusion. The study examined changes in maxillary and mandibular intercanine width and incisor inclination. The research question used the PICO format: Population (patients, including adolescents and young adults, with malocclusion), Intervention (SLB), Comparison (CB), and Outcomes (changes in intercanine width and incisor inclination). A systematic search was conducted across PubMed/MEDLINE, Scopus, and ClinicalKey databases through December 2024. The search was restricted to English- and Spanish-language publications based on the quality and relevance of the identified articles.

Search strategy

The following search strategies were used in each database:

PubMed/MEDLINE: *((self ligatable[All Fields] OR self ligate[All Fields] OR self ligated[All Fields] OR self ligating[All Fields] OR self ligation[All Fields] OR SLB[All Fields]) AND (conventional bracket*[All Fields] OR traditional bracket*[All Fields] OR CB[All Fields]) AND (buccal bone[All Fields] OR alveolar bone[MeSH Terms] OR dental arch[MeSH Terms] OR arch width[All Fields] OR transverse dimension*[All Fields] OR incisor inclination[All Fields] OR tooth inclination[All Fields]) AND adult[MeSH Terms] AND (Clinical Trial[ptyp] OR Controlled Clinical Trial[ptyp] OR Multicenter Study[ptyp])). Filter: free full text.*

Scopus*: TITLE-ABS-KEY (("self ligating bracket" OR "self ligating brackets" OR "self ligation" OR "SLB") AND ("conventional bracket" OR "conventional brackets" OR "traditional bracket" OR "edgewise bracket") AND ("buccal bone" OR "alveolar bone" OR "dental arch" OR "arch width" OR "transverse dimension" OR "transverse dimensions" OR "incisor inclination" OR "tooth inclination") AND "adult"). Filter: open access.*

ClinicalKey: *TITLE-ABS-KEY (("self ligating bracket" OR "self ligating brackets" OR "self ligation" OR "SLB") AND ("conventional bracket" OR "conventional brackets" OR "traditional bracket" OR "edgewise bracket") AND ("buccal bone" OR "alveolar bone" OR "dental arch" OR "arch width" OR "transverse dimension" OR "transverse dimensions" OR "incisor inclination" OR "tooth inclination") AND "adult"). Filters: full text, journal articles only.*

Inclusion and exclusion criteria

The inclusion criteria specified clinical studies directly comparing SLB with CB, including randomized controlled trials (RCTs) and controlled clinical trials (CCTs). Studies required at least 20 participants, a

minimum 6-month follow-up, and reported quantitative data on at least one primary outcome. Exclusion criteria encompassed in vitro studies, model studies, case reports, case series, narrative reviews, studies without quantitative data, studies including patients with craniofacial syndromes or orthognathic surgery, and studies without an adequate comparison group.

Selection and data extraction process

Two independent reviewers screened titles, abstracts, and full texts, with a third reviewer resolving discrepancies. The selection process was documented using a PRISMA flow diagram. Data extraction followed a standardized protocol capturing study characteristics, participant demographics, intervention details, treatment protocols, outcome measures, and measurement methods. Two independent reviewers performed data extraction, with discrepancies resolved through consensus.

Quality assessment

For RCTs, the Cochrane Collaboration risk of bias tool was applied, evaluating six domains: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, and selective reporting.[37] For CCTs, the Joanna Briggs Institute checklist [38] was used to assess participant selection, exposure measurement, confounding factors, outcomes, and statistical analysis. Two reviewers independently conducted these assessments.

Statistical analysis and heterogeneity assessment

The meta-analysis employed a random-effects model using the DerSimonian and Laird method 39, with calculations weighted by inverse variance. The primary effect measure was the mean difference in millimeters for dimensional changes and in degrees for inclination changes, with 95% confidence intervals. Heterogeneity was assessed through the I^2 statistic,[40] Cochran's Q test, visual inspection of forest plots, and calculation of the tau^2 statistic. Heterogeneity was categorized as low ($I^2 < 25\%$), moderate (I^2 25-75%), or high ($I^2 > 75\%$).

RESULTS

Study selection

The initial search identified 68 records (PubMed: 3, Scopus: 4, ClinicalKey: 61). After removing three duplicates, 65 articles were screened based on title and abstract. Of these, 56 were excluded for failing to meet the eligibility criteria. Nine full-text articles were assessed, of which three were excluded (two due to insufficient data for meta-analysis and one for not meeting the inclusion criteria). Finally, six studies met the eligibility criteria. They were included in the qualitative synthesis, with four studies providing sufficient data for each of the three primary outcomes of the meta-analysis. See Figure 1.

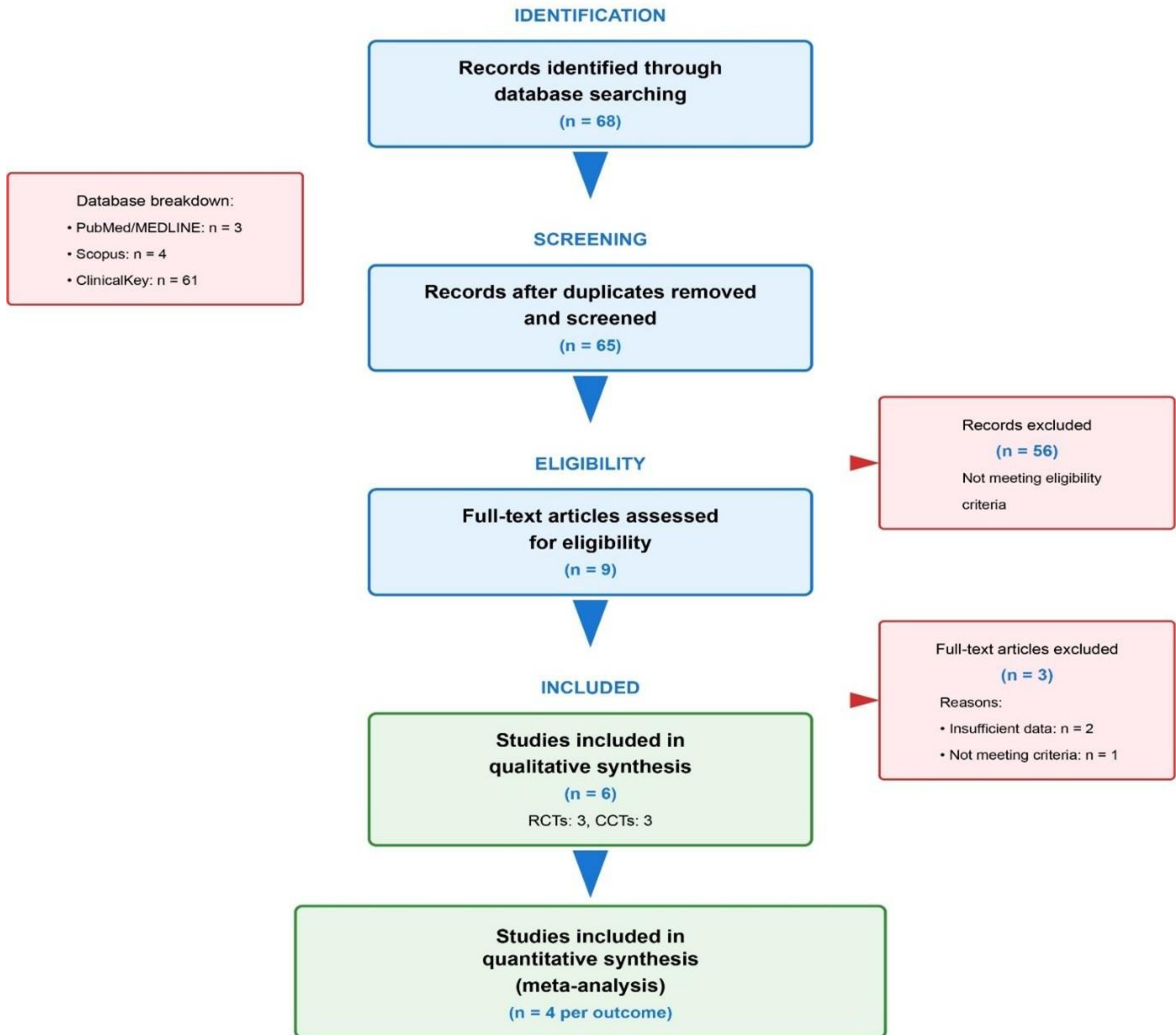

Figure 1. PRISMA 2020 flow diagram showing the study selection process for the systematic review and meta-analysis.

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The six included studies were published between 2007 and 2018, including both Randomized Clinical Trials (RCTs) and Controlled Clinical Trials (CCTs). Sample sizes ranged from 24 participants[43] to 108 participants.[56] Age demographics primarily included patients aged 13 to 36, encompassing both adolescents and young adults. See Table 1.

Table 1. Characteristics of included studies.

Authors	Design	Arch of interest	Sample size	Pretreatment mean age (years)	JBI Score
Fleming *et al*.[42]	RCT	Maxillary	96	19.7 ° (SD 5.90)	-
Almeida *et al*.[55]	RCT	Mandibular	25	SLB: 18.58 (5.43), CB: 21.61 (6.69)	-
Atik *et al*.[40]	CCT	Both	46	14.40±1.50 (ASL) 14.80±1.00 (PSL)	9/9

Mateu *et al.*[43]	RCT	Both	24	13-36	-
Anand *et al.*[56]	CCT	Both	108	13.50-13.80	9/9
Pandis *et al.*[45]	CCT	Mandibular	54	13.70	9/9

Methodological characteristics demonstrated considerable variation in bracket systems, archwire sequences, and treatment endpoints, reflecting clinical practice diversity. Self-ligating systems included active and passive designs from various manufacturers, including Damon Q, Damon 3MX, In-Ovation C, EasyClip, and Nexus. Conventional systems encompassed different prescriptions, including Roth, MBT, and standard edgewise designs. Archwire sequences varied significantly, with some following standardized protocols, such as the Damon sequence, while others employed institution-specific progressions. Treatment endpoints varied considerably, ranging from specific time points to achievement of clinical objectives. See Table 2.

Table 2. Summary of methodological data.

Trial	Bracket design	Archwires	End time-point	Outcomes
Fleming *et al.*[42]	SLB: Damon Q (0.022"); ASLB: In-Ovation C (0.022"); CB: Ovation (0.022")	0.013-0.019×0.025" Damon sequence	34 weeks minimum, 0.019×0.025" SS wire engaged passively	Maxillary intercanine width, interpremolar width, intermolar width, incisor inclination, molar inclination
Almeida *et al.*[55]	SLB: EasyClip (0.022×0.027"); CB: 3M Unitek (0.022×0.028")	0.013, 0.014, 0.016" NiTi sequence	7 months after treatment onset	Mandibular transverse dimensions, buccal bone thickness, and transverse width of buccal bone
Atik *et al.*[40]	Active SLB (0.022" Nexus) CB (0.022" Roth) Passive SLB (0.022" Damon 3MX)	Standard Damon sequence: 0.014" CuNiTi to 0.019×0.025" SS	Class I canine-molar relationship and ideal overjet/overbite achieved	Maxillary arch width changes, molar inclination changes, and maxillary and mandibular incisor inclinations
Mateu *et al.*[43]	SLB (Damon System) CB (Roth)	0.014 CuNiTi Damon, 0.014×0.025 CuNiTi Damon	Alignment completion	Intermolar development, transverse dimensions
Anand *et al.*[56]	SLB (Damon Q) CB (Mini Uni-twin, Victory series)	Not specified	Complete fixed appliance therapy over 14 months	Changes in arch dimensions, changes in mandibular incisor inclinations, final PAR scores, and treatment times
Pandis *et al.*[45]	SLB (Damon 2 0.022") CB (Microarch 0.022")	CB: 0.016" Cu-NiTi, 0.020" Sentalloy; SLB: 0.014" Cu-NiTi Damon, 0.014×0.025" Cu-NiTi Damon	Complete alleviation of crowding was judged clinically	Time to alignment, dental arch dimensions, and mandibular incisor inclination

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Methodological quality

The methodological quality of the included studies ranged from moderate to high. The RCT[42] presented a low risk of bias in random sequence generation and allocation concealment. Blinding of participants and operators was not possible due to the nature of the intervention. See Figure 2. The CCTs[40] showed excellent methodological quality according to the JBI critical appraisal checklist for comparable cohort studies, with all achieving a perfect score of 9/9. See Table 1.

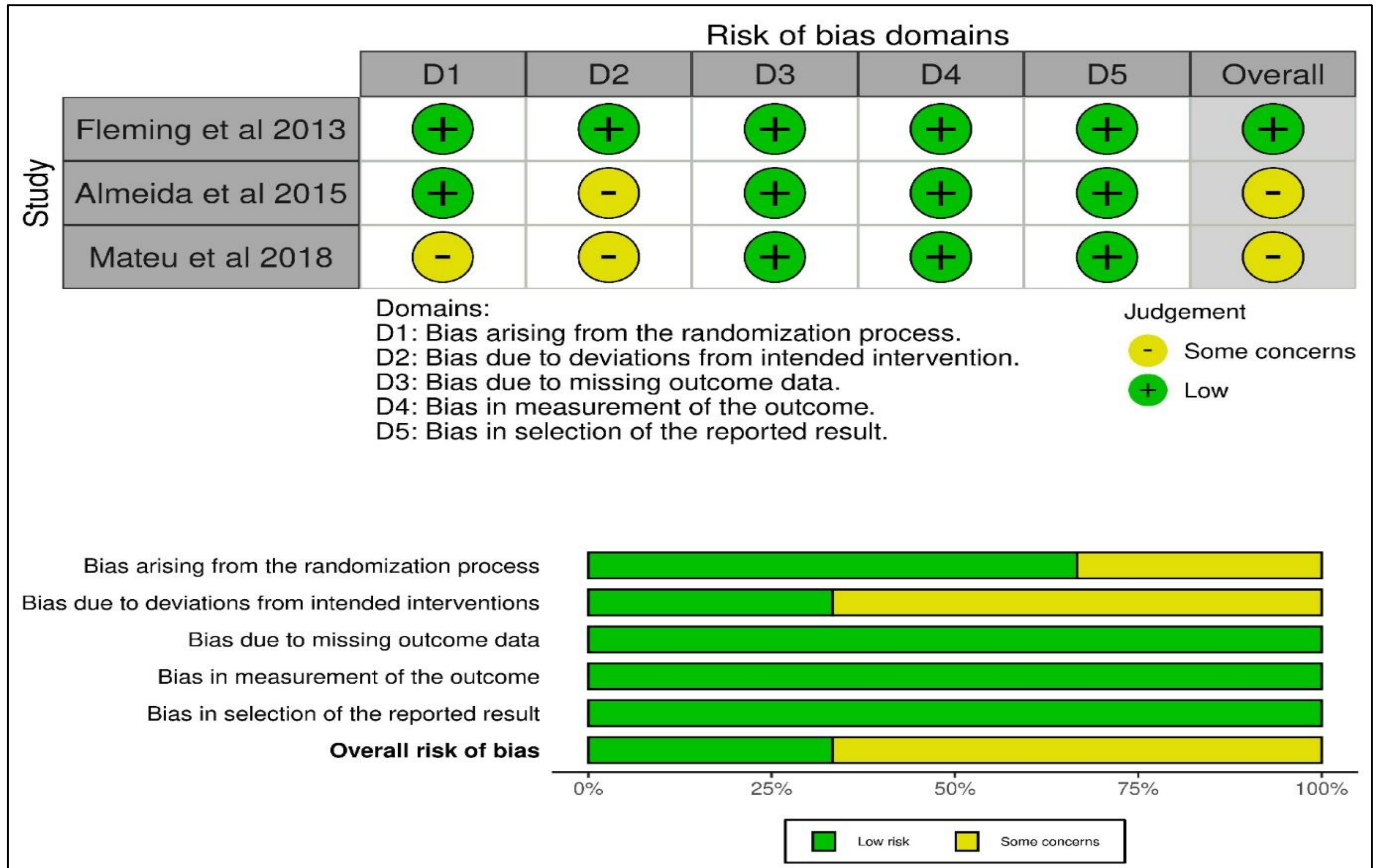
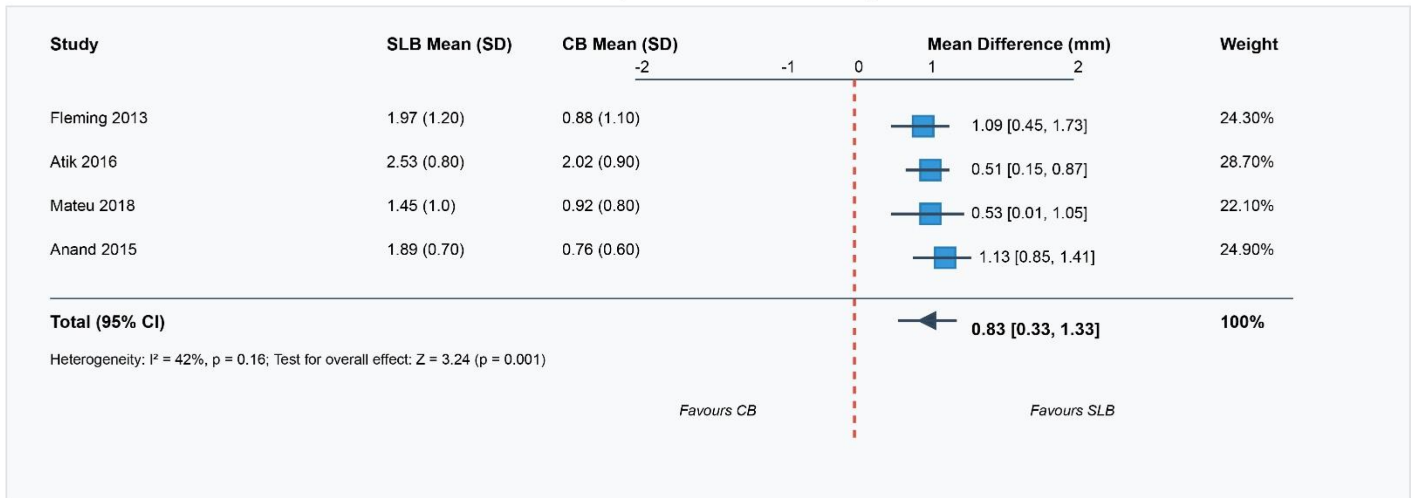


Figure 2. Risk of bias assessment for randomized controlled trials using the RoB 2.0 tool.

Changes in maxillary intercanine width

The meta-analysis of four studies (242 participants) showed a mean difference of 0.83 mm (95%CI 0.33 - 1.33, p=0.001) in favor of self-ligating brackets, indicating that SLB produced greater transverse expansion of the maxillary arch in the canine region compared with conventional brackets. See Figure 3A. Heterogeneity was moderate (I^2 = 42.30%, p = 0.16), suggesting reasonable consistency across studies and lending credibility to the pooled estimate.



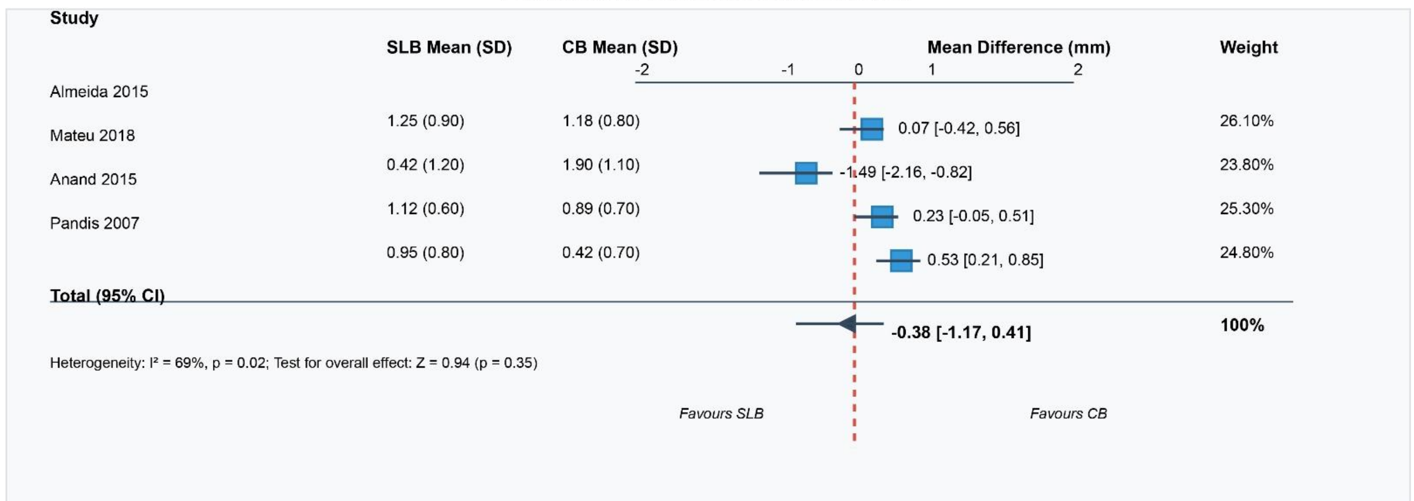


Figure 3. Forest plots for arch dimensional changes comparing self-ligating vs conventional brackets.

Changes in mandibular intercanine width

The meta-analysis of four studies (212 participants) showed a mean difference of -0.38 mm (95%CI -1.17 - 0.41, p = 0.35), with no statistically significant difference between SLB and CB (Figure 3B). This result must be interpreted with considerable caution due to substantial heterogeneity (I^2 = 68.70%, p = 0.02). The primary sources of this heterogeneity include differences in archwire protocols across studies (standardized Damon sequences vs. institution-specific progressions), the inclusion of both adolescent and adult patients (introducing biological differences in mandibular bone density and growth potential), and heterogeneous treatment endpoints. The wide confidence interval crossing zero indicates that no meaningful clinical conclusion regarding mandibular transverse change can be drawn from the current evidence.

Changes in incisor inclination

The meta-analysis of four studies (272 participants) revealed a mean difference of -2.28° (95% CI: -4.56 to 0.00, p = 0.05), with a borderline trend favoring self-ligating brackets, indicating less incisor proclination with SLB than with CB (Figure 4A). Heterogeneity was high (I^2 = 76.10%, p = 0.006), substantially limiting the reliability of this pooled estimate. The main sources of variability include differences in SLB design (active vs.

passive), archwire sequences, patient age range, and treatment duration. This finding should be considered exploratory rather than conclusive evidence of a clinical advantage.

A. Incisor Inclination Changes (Degrees)

Study	SLB Mean (SD)	CB Mean (SD)	Mean Difference (°)	Weight
Fleming 2013	3.20 (2.10)	4.80 (2.30)	-1.60 [-2.85, -0.35]	26.30%
Atik 2016	2.80 (1.90)	5.90 (2.20)	-3.10 [-4.45, -1.75]	24.70%
Mateu 2018	4.10 (2.50)	5.20 (2.80)	-1.10 [-3.25, 1.05]	22.10%
Anand 2015	3.50 (1.80)	6.20 (2.10)	-2.70 [-3.85, -1.55]	26.90%
Total (95% CI)			**-2.28 [-4.56, 0]**	**100%**

Heterogeneity: I² = 76%, p = 0.006; Test for overall effect: Z = 1.96 (p = 0.050)

Favours SLB *Favours CB*

B. Funnel Plots for Publication Bias Assessment

Maxillary Intercanine Width
Anand 2015
Fleming 2013
Atik 2016
Mateu 2018
Standard Error
Mean Difference (mm)

Mandibular Intercanine Width
Anand 2015
Pandis 2007
Almeida 2015
Mateu 2018
Standard Error
Mean Difference (mm)

Incisor Inclination
Anand 2015
Atik 2016
Fleming 2013
Mateu 2018
Standard Error
Mean Difference (°)

Individual studies
Funnel plot boundaries

Figure 4. Meta-analysis of incisor inclination and publication bias assessment.

Publication bias assessment

The publication bias assessment using funnel plots showed a relatively symmetrical distribution for maxillary intercanine width, suggesting no significant publication bias for this outcome (Figure 4B). Egger's test was not significant ($p > 0.05$), increasing confidence in the completeness of the analyzed data.

DISCUSSION

The comparative analysis reveals complex clinical outcomes that challenge simplistic assumptions of bracket superiority and highlight the importance of evidence-based selection. The statistically significant 0.83 mm advantage of self-ligating brackets in maxillary intercanine width expansion represents a clinically meaningful finding that may influence treatment planning for patients requiring transverse arch development. This finding is consistent with theoretical biomechanical advantages, including reduced friction and improved force distribution, which facilitate efficient transverse tooth movement.[41,42] The moderate heterogeneity

suggests reasonable consistency across studies, populations, and protocols, lending credibility to the pooled estimates. However, clinical significance must be evaluated within individual treatment contexts, as 0.83 mm of additional expansion may be highly relevant for some patients while minimally impactful for others, depending on the severity of transverse deficiency.[43]

The absence of significant differences in mandibular intercanine width underscores the complexity of orthodontic biomechanics and the influence of anatomical factors. The mandibular arch traditionally demonstrates less transverse expansion responsiveness compared to the maxillary arch due to early symphyseal suture fusion and denser cortical bone.[44,45] This anatomical reality may explain why bracket differences that manifest in maxillary expansion do not translate into mandibular advantages. Substantial heterogeneity suggests that factors beyond bracket design play prominent roles in lower arch outcomes, including individual anatomical variation, age-related differences in bone density, and varying clinician treatment mechanics.[46,47] The wide confidence interval that crosses zero indicates considerable uncertainty, suggesting that clinical decision-making should not rely primarily on expectations of mandibular transverse change.

The borderline significant incisor inclination finding offers notable insights into biomechanical differences extending beyond simple expansion effects. Self-ligating brackets demonstrated less incisor proclination, with a mean difference of -2.28° compared to conventional systems. This finding has important clinical implications, as excessive proclination represents a common treatment side effect that compromises facial aesthetics, lip support, and long-term stability.[48,49] Reduced proclination may reflect improved force distribution characteristics, minimizing unwanted tooth movements while achieving alignment objectives. However, the high heterogeneity (I^2 = 76.10%) substantially limits the generalizability of this finding. Given the borderline significance and elevated heterogeneity, this result should be considered hypothesis-generating rather than conclusive. Actual effects may vary considerably depending on specific bracket designs, archwire sequences, and individual patient characteristics. [50,51]

Theoretical biomechanical advantages extend the friction-reduction paradigms that dominate marketing literature. Observed differences may reflect complex interactions among bracket design, archwire characteristics, force distribution patterns, and individual patient responses that are not captured by simple friction measurements.[28,29] Self-ligating mechanisms may provide consistent force delivery, maintain optimal archwire-bracket relationships, and reduce ligature placement variability. Additionally, purported chair time reductions and simplified procedures may indirectly influence outcomes through improved patient compliance and consistent appointment intervals.[52,53]

Clinical implications suggest individualized bracket selection based on specific treatment objectives rather than on assumptions of universal superiority. For patients requiring significant maxillary transverse expansion, self-ligating brackets may offer measurable advantages that influence treatment planning and outcome predictions.[40] The additional 0.83 mm expansion capability might reduce the need for adjunctive expansion procedures or allow more conservative approaches in borderline cases. Conversely, for treatments focused primarily on alignment with minimal expansion requirements, bracket system choice may have less impact, allowing cost, operator preference, and patient comfort to guide decisions.[54]

Substantial heterogeneity underscores the complexity of orthodontic treatment and the multiple factors influencing outcomes beyond bracket design. Archwire protocols, treatment mechanics, operator experience, patient compliance, and individual anatomical variations contribute to outcomes, potentially overshadowing differences in brackets.[32,33] These findings suggest that standardized protocols and systematic case management approaches may more profoundly influence treatment success than bracket selection alone. Economic considerations cannot be ignored, as self-ligating systems require a higher initial investment

but may offer reduced chair time. Cost-effectiveness analyses should incorporate material costs, time savings, treatment efficiency, patient satisfaction, and long-term stability outcomes.

Limitations

The following limitations must be considered when interpreting these findings: (1) The search was restricted to English-language publications based on the quality and relevance of articles identified, which may nonetheless have excluded relevant studies in other languages. (2) Only six studies met the inclusion criteria (four per outcome), limiting statistical power. (3) The included studies enrolled patients from 13 to 36 years of age, introducing biological variability in bone density and growth potential that may have differentially influenced outcomes. (4) The studies span 2007–2018, encompassing multiple generations of SLB and CB designs, representing a clinically important source of heterogeneity. (5) An I^2 of 76.10% in the incisor inclination outcome exceeds the high-heterogeneity threshold, substantially limiting the interpretability of the pooled estimate; meta-regression was not feasible with four studies per outcome. (6) The nature of orthodontic interventions precludes blinding of patients and operators, introducing potential performance bias across all included studies.

CONCLUSIONS

Self-ligating brackets demonstrated superior maxillary transverse expansion, with a clinically meaningful 0.83 mm advantage in intercanine width development, which could significantly influence treatment planning for patients requiring arch expansion. This finding suggests that theoretical biomechanical advantages translate into measurable clinical benefits in specific treatment scenarios, supporting the use of self-ligating systems when maxillary transverse development is a primary treatment objective.

The absence of significant differences in mandibular intercanine width changes and the tendency toward reduced incisor inclination with self-ligating systems indicate that bracket selection effects are location-specific and multifactorial. These findings emphasize that treatment outcomes depend on complex interactions among bracket design, anatomical considerations, and individual patient characteristics, rather than on mechanical advantages alone.

Future research should prioritize large-scale randomized controlled trials with standardized protocols, long-term stability assessments, and comprehensive cost-effectiveness analyses incorporating both clinical outcomes and economic considerations. Meta-regression analyses should be incorporated when a sufficient number of studies are available to explore sources of heterogeneity formally. Evidence-based bracket selection should be individualized to specific treatment goals, with self-ligating systems considered for maxillary expansion, while recognizing that conventional brackets remain a viable option for many orthodontic treatment scenarios.

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CONFLICTS OF INTEREST DECLARATION

The authors declare no conflicts of interest.

AUTHOR CONTRIBUTIONS

JPR participated in the conceptualization and study design, literature search, statistical analysis, writing, and final approval of the manuscript.
OMB participated in the literature search, data extraction, statistical analysis, writing, and final approval of the manuscript.
MLP participated in data extraction, quality assessment, writing, and final approval of the manuscript.
AHH participated in methodological validation, supervised the statistical analysis, and provided final approval.
LBP participated in study design validation, supervision of epidemiological analysis, writing, and final approval of the manuscript.
ADC participated in study conceptualization, general supervision, writing, and final approval of the manuscript.

STATEMENT ON THE USE OF ARTIFICIAL INTELLIGENCE

The authors declare that they do not use artificial intelligence to generate this manuscript.

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