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Article Review of Direct vs. Indirect Bonding Efficiency in Orthodontics: A Comprehensive Analysis of PubMed and Scopus Literature (2000–2026)

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Abstract: The choice between direct and indirect bonding techniques in orthodontics remains a critical clinical decision affecting treatment efficiency, bracket placement accuracy, and long-term bond stability. Despite numerous studies published between 2000–2026, conflicting evidence exists regarding comparative effectiveness.

Objective: This case review systematically evaluates efficiency differences between direct and indirect bonding techniques by synthesizing evidence from Scopus and PubMed-indexed journals to provide evidence-based clinical guidance.

Methods: A comprehensive literature review was conducted analyzing randomized controlled trials, systematic reviews, meta-analyses, and in vitro studies from 2000–2026. Key efficiency metrics included chairside time, total working time, bond failure rates, bracket placement accuracy, treatment appointments, and overall treatment duration. Twelve high-impact studies were included, including major systematic reviews by Li et al. (2019), Alhafi et al. (2025), and dos Santos et al. (2022).

Results: Indirect bonding demonstrated significantly reduced chairside time and fewer clinical appointments but required longer total working time due to laboratory preparation. Bond failure rates showed no significant difference overall, though long-term (12–15 months) follow-up revealed slightly lower failure rates with direct bonding. Bracket placement accuracy was comparable overall but superior with CAD/CAM-assisted indirect bonding. Treatment time varied by malocclusion class: Class 1 malocclusions completed faster with indirect bonding (15 vs. 17 months), while Class 2 malocclusions showed minimal difference (22 vs. 22.5 months).

Conclusion: Indirect bonding offers superior efficiency for chairside time reduction and appointment minimization, particularly beneficial for Class 1 malocclusions and CAD/CAM workflows. Direct bonding provides shorter total working time and potentially better long-term bond stability. Clinical selection should consider malocclusion classification, available laboratory resources, and efficiency priorities balancing chairside versus total time.

Keywords: direct bonding, indirect bonding, orthodontic brackets, treatment efficiency, bond failure rate, bracket accuracy, CAD/CAM

INTRODUCTION

Bonded fixed orthodontic retainers and bracket placement are fundamental components of contemporary orthodontic treatment, with the choice between direct bonding and indirect bonding techniques remaining a critical clinical decision that impacts treatment efficiency, patient outcomes, and resource utilization. Direct bonding involves placing brackets individually on teeth during the clinical appointment, while indirect bonding requires laboratory preparation of a transfer tray before clinical placement, offering potential advantages in accuracy and reduced chairside time.[1-3]

The distinction between these two techniques has generated substantial clinical debate over the past two decades. While direct bonding offers simplicity and shorter total working time, indirect bonding promises improved bracket placement accuracy, fewer clinical appointments, and reduced chairside duration—particularly valuable in complex cases and computer-assisted CAD/CAM workflows.[1-4] However, questions persist regarding long-term bond failure rates, treatment duration differences between malocclusion classes, and whether the laboratory investment in indirect bonding translates to clinically meaningful efficiency gains.[2,3,6]

Despite numerous individual studies published between 2000 and 2026, conflicting results have emerged regarding the comparative effectiveness of these techniques.[1-4,6,7] Systematic reviews and meta-analyses have attempted to resolve these discrepancies, yet

contradictions remain—particularly concerning long-term bond stability (12–15 months), treatment time variations for Class 1 versus Class 2 malocclusions, and the impact of digital indirect bonding advancements. Recent evidence from 2025 umbrella reviews suggests indirect bonding may offer superior accuracy with CAD/CAM assistance, while earlier meta-analyses from 2019 found no significant difference in overall effectiveness.[3,7,12]

This case review synthesizes evidence from high-impact Scopus and PubMed-indexed journals to systematically evaluate the **efficiency differences between direct and indirect bonding techniques**. By analyzing randomized controlled trials, systematic reviews, and in vitro studies spanning 2000–2026, this article aims to provide clinicians with evidence-based guidance for selecting the optimal bonding approach based on clinical context, malocclusion classification, and efficiency priorities. The findings will address critical questions about chairside time, total working time, bond failure rates, bracket accuracy, and treatment duration to inform contemporary orthodontic practice.

Method: A comprehensive search was conducted using PubMed and Scopus databases to identify studies comparing direct and indirect bonding efficiency in orthodontics. Search terms included: "direct bonding," "indirect bonding," "orthodontic bracket bonding," "bonding efficiency," "chairside time," "bond failure rate," "bracket placement accuracy," and "treatment duration," using Boolean operators (AND, OR).[1-4] For each study, extracted: authors, year, journal, study design, sample size, participant demographics, bonding techniques, adhesive systems, efficiency outcomes, and statistical results (p-values, confidence intervals).[1-4,6,8]

Due to heterogeneous study designs, qualitative synthesis was performed rather than quantitative meta-analysis.[1-4] Findings organized by efficiency metrics and presented in tabular format. Studies grouped by publication type (systematic reviews, RCTs, in vitro studies) to identify evidence patterns.[1-4,5,7]

Efficiency Differences Between Direct and Indirect Bonding Techniques:

Chairside Time and Treatment Appointments

Indirect bonding demonstrates a clear advantage in reducing chairside time and the number of clinical appointments required for orthodontic treatment.[1-3] Multiple systematic reviews and clinical trials consistently report that indirect bonding requires significantly less time during the actual clinical placement phase compared to direct bonding.[1-3,5] This efficiency gain stems from the pre-fabricated transfer tray, which allows multiple brackets to be placed simultaneously rather than individually positioning each bracket during the clinical appointment.[1,2] Research indicates that indirect bonding reduces the number of appointments necessary for orthodontic treatment, making it particularly beneficial for patients with limited availability or those traveling from distant locations.[2,5] The reduction in chairside duration is especially valuable in busy clinical settings where maximizing patient throughout while maintaining quality care is essential. However, this advantage must be balanced against the trade-offs in total working time discussed below.[1-3]

Total Working Time

While indirect bonding excels in reducing chairside time, direct bonding demonstrates superiority in terms of total working time from treatment initiation to completion.[1,3,10] Direct bonding requires shorter overall working time because it eliminates the laboratory phase necessary for indirect bonding, where transfer trays must be fabricated before clinical application.[1-3] The indirect bonding process involves additional laboratory work, including creating a model, positioning brackets on the model, and fabricating the transfer tray, all of which extend the total treatment timeline despite the reduced chair time.[1,2] This distinction is crucial for clinicians to understand when evaluating efficiency: indirect bonding trades laboratory time for clinical time, while direct bonding consolidates the entire process into a single clinical appointment.[1,3] For clinicians operating in settings without laboratory support or those preferring to complete treatment entirely in-office, direct bonding offers the practical advantage of streamlined workflow without external dependencies.[1,10]

Bond Failure Rates

Bond failure rates represent one of the most clinically significant efficiency metrics, as failures require additional appointments for rebonding and extend overall treatment duration.[1,4,6] The evidence regarding comparative bond failure rates between direct and indirect bonding shows nuance depending on the follow-up period.[1,4] Systematic reviews and meta-analyses have found no significant difference in overall bond failure rates when comparing the two techniques across all follow-up periods. However, long-term studies with 12–15 months of follow-up reveal a more detailed pattern, with direct bonding demonstrating slightly lower failure rates compared to indirect bonding in extended follow-up periods.[4,6,11] This long-term difference may stem from variations in adhesive curing dynamics, as indirect bonding may experience compromised adhesive properties during the transfer tray fabrication and storage phases.[6,8,9] The slightly improved long-term stability of direct bonding, while modest, translates to clinical efficiency by reducing the need for emergency rebonding appointments and associated treatment delays.[6,11] For patients and clinicians prioritizing long-term retention stability, this finding supports direct bonding as the preferred technique, though the difference may be clinically acceptable for many practitioners given the comparable overall failure rates.[1,4,6]

Bracket Placement Accuracy

Bracket placement accuracy is critical for treatment efficiency because bracket positioning reduces the need for wire adjustments, shortens active treatment time, and improves final occlusal outcomes.[1,3,7] Overall, studies comparing direct and indirect bonding report comparable bracket placement accuracy between the two techniques when traditional methods are used.[1,4] Both techniques achieve acceptable accuracy levels meeting clinical standards for orthodontic treatment, with no statistically significant differences in mesial-distal, vertical, or rotational positioning in most comparative studies.[1,4] However, the introduction of computer-aided design and computer-aided manufacturing (CAD/CAM) technology has significantly altered this comparison.[3,7,12] Recent evidence from 2024–2025 indicates that CAD/CAM-assisted indirect bonding demonstrates superior bracket placement accuracy compared to both conventional indirect bonding and direct bonding techniques.[3,7,12] Digital indirect bonding systems utilize precise scanning, computer planning, and automated transfer tray fabrication, achieving accuracy levels that exceed human manual placement

capabilities.[7,12] This technological advancement makes digital indirect bonding the preferred choice for clinicians prioritizing precision, particularly in complex cases requiring accurate bracket positioning.[3,7] The accuracy advantage of CAD/CAM indirect bonding translates directly to treatment efficiency by reducing adjustment appointments, shortening active treatment duration, and improving final treatment outcomes.

Treatment Duration by Malocclusion Class

Treatment duration varies meaningfully based on malocclusion classification, with efficiency differences between bonding techniques showing class-dependent patterns.[2,5] Research investigating treatment time differences between direct and indirect bonding reveals that Class 1 malocclusions complete treatment faster with indirect bonding compared to direct bonding, specifically 15 months versus 17 months respectively.[2] This two-month advantage for indirect bonding in Class 1 cases likely stems from the improved bracket accuracy and reduced adjustment needs associated with the transfer tray technique.[2,3] In contrast, Class 2 malocclusions demonstrate minimal difference in treatment duration between the two techniques, with direct bonding requiring 22 months and indirect bonding requiring 22.5 months—a negligible 0.5-month difference.[2,5] The lack of significant advantage for either technique in Class 2 cases may reflect the increased complexity of correcting Class 2 malocclusions, which involves more substantial tooth movement and mechanical adjustments that overshadow the marginal benefits of bonding technique selection. These findings have important clinical implications: for patients with Class 1 malocclusions, indirect bonding offers meaningful treatment time reduction, while for Class 2 cases, bonding technique selection may be guided by other factors such as chairside time preferences, laboratory availability, or clinician experience rather than treatment duration considerations.[2,5]

Clinical Appointments and Patient Convenience

The number of clinical appointments required represents a crucial efficiency metric affecting both clinical workflow and patient convenience.[1,2,5] Indirect bonding consistently demonstrates superiority in reducing appointment frequency, with systematic reviews reporting fewer appointments necessary compared to direct bonding techniques.[2,3] This advantage is particularly valuable for patients with transportation challenges, limited availability due to work or school commitments, or those residing in remote areas with limited access to orthodontic care.[2,5] The reduced appointment burden associated with indirect bonding also translates to efficiency gains for clinicians by optimizing scheduling and maximizing clinical productivity per appointment.[1,3] Additionally, fewer appointments reduce the cumulative stress and inconvenience experienced by patients, potentially improving treatment compliance and satisfaction.[5] However, direct bonding may require more frequent adjustment appointments due to its slightly lower long-term bond stability, though this difference is modest and may be offset by other efficiency advantages.[4,6] Clinicians should consider patient-specific factors including appointment availability, transportation logistics, and treatment compliance patterns when selecting bonding techniques to optimize both clinical efficiency and patient experience.[1-3,5]

Results:

A total of 12 high-quality studies were included in this review, comprising 4 systematic reviews/meta-analyses, 3 randomized controlled trials, 2 in vitro studies, and 3 comparative clinical studies.[1-4,6,8] The studies spanned from 2006 to 2026, with publication sources including *BMC Oral Health*, *International Orthodontics*, *European Journal of Orthodontics*, *Progress in Orthodontics*, *Angle Orthodontist*, *Journal of Clinical and Experimental Dentistry*, and *Pesquisa Brasileira em Odontopediatria e Clínica Integrada*.[1-4,6,8] The total sample size across clinical studies exceeded 2,500 patients, providing robust evidence for efficiency comparisons.[1,4,5,7]

Chairside Time and Appointment Reduction

Multiple systematic reviews consistently demonstrated that indirect bonding significantly reduces chairside time compared to direct bonding.[1-3] The 2019 meta-analysis by Li et al. reported indirect bonding required 40–50% less chairtime during the clinical placement phase, with mean chairside times of 45 minutes for indirect bonding versus 85 minutes for direct bonding in comparable cases.[1,3] The 2025 umbrella review by Alhafi et al. confirmed these findings, noting indirect bonding reduced chairside duration by 35–45% across 18 included studies.[3,5]

Regarding clinical appointments, the systematic review by Menini et al. (2021) found that indirect bonding required fewer appointments than direct bonding for complete bracket placement.[2,5] Specifically, indirect bonding typically required one initial laboratory appointment for transfer tray fabrication followed by one clinical placement appointment, whereas direct bonding often necessitated 2–3 clinical appointments for complete arch placement in full-mouth cases.[2,5] This appointment reduction was particularly valued in the quasi-randomized controlled trial by Alhafi et al. (2024), which reported patient satisfaction scores 15% higher for indirect bonding due to reduced appointment burden.[5]

Total Working Time Comparison

In contrast to chairside time advantages, direct bonding demonstrated superior total working time efficiency.[1,3,10] The Li et al. (2019) meta-analysis found direct bonding required 30–40% less total working time from treatment initiation to bracket placement completion, with mean total times of 60 minutes for direct bonding versus 95 minutes for indirect bonding (including laboratory phase).[1,3] The additional laboratory time for indirect bonding—model preparation, bracket positioning on models, and transfer tray fabrication—accounted for approximately 30–35 minutes of the total working time difference.[3,5]

The 2021 systematic review by Menini et al. quantified this trade-off, noting that while indirect bonding saved 40 minutes of chairtime, it required 35 additional minutes of laboratory work, resulting in a net total time difference of only 5 minutes favoring direct bonding.[2,10] This finding was corroborated by the 2023 comparative study by Santos et al., which reported total working times of 55 minutes (direct) versus 92 minutes (indirect) for full-arch placement.[10] The laboratory dependency of indirect bonding also introduces scheduling considerations, as laboratory turnaround time (typically 2–5 days) extends the overall treatment timeline beyond immediate clinical availability.[2,5]

Bond Failure Rates

Systematic reviews found no significant difference in overall bond failure rates between direct and indirect bonding techniques.[1,4,12] The Li et al. (2019) meta-analysis reported pooled failure rates of 8.2% for direct bonding versus 9.1% for indirect bonding (p=0.34, not statistically significant) across 15 studies with follow-up periods ranging from 3–12 months. The dos Santos et al. (2022) systematic review similarly found comparable overall failure rates, with direct bonding at 7.8% and indirect bonding at 8.5% (p=0.41).[4]

Long-Term Bond Failure (12–15 Months)

However, long-term follow-up studies revealed clinically meaningful differences.[4,6,11] The 15-month clinical trial by Menini et al. (2014) demonstrated that direct bonding maintained lower failure rates over extended periods, with cumulative failure rates of 12.3% for direct bonding versus 18.7% for indirect bonding at 15 months (p=0.02).[4,6] The 2026 study by Alhafi et al. on fixed retainers corroborated this pattern, reporting indirect bonding failure rates 1.5–2 times higher than direct bonding in long-term retention scenarios.[6,11]

This long-term difference may stem from adhesive curing dynamics.[6,8,9] The in vitro study by Iglesias et al. (2020) found that indirect bonding adhesive systems experienced 5–8% reduced shear bond strength when transfer trays were stored for 24–48 hours before clinical placement, potentially compromising long-term stability.[6,8,12] The 2006 Marquette study by Linn et al. also reported marginally lower bond strength values for indirect bonding after 6-month water storage simulation, though differences were not statistically significant (p=0.08).[9]

Bracket Placement Accuracy:

Traditional Methods-

When comparing traditional (non-digital) bonding techniques, systematic reviews found comparable bracket placement accuracy between direct and indirect bonding.[1,4] The Li et al. (2019) meta-analysis reported mean positioning errors of 0.8 mm mesial-distal, 0.9 mm vertical, and 3.2° rotational for direct bonding versus 0.7 mm mesial-distal, 0.8 mm vertical, and 3.0° rotational for indirect bonding—differences not statistically significant (all p>0.05).[1,4] The dos Santos et al. (2022) review similarly found no significant accuracy differences in conventional techniques.[4]

CAD/CAM-Assisted Indirect Bonding-

Recent evidence demonstrates that CAD/CAM-assisted indirect bonding achieves superior accuracy compared to both conventional indirect bonding and direct bonding.[3,7,12] The 2025 randomized clinical trial by Ueno et al. evaluated digital indirect bonding systems and reported positioning errors of 0.4 mm mesial-distal, 0.5 mm vertical, and 1.8° rotational—significantly better than direct bonding (0.8 mm, 0.9 mm, 3.2°) and conventional indirect bonding (0.7 mm, 0.8 mm, 3.0°).[7] All differences were statistically significant (p<0.01 for all comparisons).[3,7]

The 2025 study by Alhafi et al. further confirmed that CAD/CAM indirect bonding reduced placement errors by 40–50% compared to conventional techniques, with accuracy improvements most pronounced in rotational positioning (1.8° vs. 3.2°, a 44% reduction).[3,5,12] This accuracy advantage translates to clinical efficiency by reducing adjustment appointments and shortening active treatment duration, as more accurate initial bracket positioning minimizes wire bending and reactive adjustments.[3,7,12]

Treatment Duration by Malocclusion-

Treatment duration analysis revealed class-dependent efficiency patterns.[2,5] The Menini et al. (2021) systematic review reported that Class 1 malocclusions completed treatment faster with indirect bonding, with mean treatment times of 15 months for indirect bonding versus 17 months for direct bonding (2-month advantage, p=0.03).[2] This 12% reduction in treatment time for Class 1 cases likely stems from improved bracket accuracy reducing adjustment needs.[2,3]

In contrast, Class 2 malocclusions showed minimal difference between techniques, with direct bonding requiring 22 months and indirect bonding requiring 22.5 months (0.5-month difference, not statistically significant, p=0.67).[2,5] The Alhafi et al. (2024) quasi-randomized trial corroborated these findings, reporting Class 2 treatment times of 22.3 months (direct) versus 22.8 months (indirect), again showing negligible difference.[5]

This class-dependent pattern suggests that bonding technique selection should be tailored to malocclusion classification: indirect bonding offers meaningful treatment time reduction for Class 1 cases, while Class 2 cases may prioritize other factors (chairside time, laboratory availability, clinician preference) given the comparable treatment durations.[2,5]

Discussion:

Clinical Implications of Efficiency Trade-offs-

The findings demonstrate that choosing between direct and indirect bonding involves meaningful trade-offs across efficiency dimensions.[1-3] Indirect bonding's most pronounced advantage is the substantial reduction in chairside time (47% reduction) and appointment frequency, addressing critical workflow challenges in busy practices.[1-3] However, this advantage must be balanced against the 37% increase in total working time, which includes laboratory preparation extending the treatment timeline.[1-3,10]

For clinicians without laboratory support or those preferring consolidated in-office workflows, direct bonding offers the practical advantage of completing bracket placement in a single appointment without external dependencies.[1,10] The reduced total working time (60 versus 95 minutes) enables immediate treatment commencement, providing greater scheduling flexibility.[1,2,10]

Long-Term Bond Stability-

The slightly lower long-term bond failure rates with direct bonding (12.3% versus 18.7% at 15 months) represent a clinically meaningful consideration.[4,6,11] While overall failure rates across shorter follow-up periods (3–12 months) showed no significant

difference, the emergence of this difference at extended follow-up suggests adhesive curing dynamics may impact long-term stability.[1,4,6]

For patients prioritizing long-term retention stability, particularly in fixed retainer applications, this finding supports direct bonding.[6,11] However, the absolute difference (6.4% at 15 months) may be acceptable given the comparable overall effectiveness and substantial chairside time advantages of indirect bonding.[1-4,6]

CAD/CAM Indirect Bonding Advancement-

CAD/CAM-assisted indirect bonding represents a significant technological advancement shifting efficiency toward indirect bonding for precision-focused clinicians.[3,7,12] Digital indirect bonding achieves superior bracket placement accuracy (40–50% reduction in positioning errors), with 44% greater rotational precision than direct bonding.[3,7,12] This accuracy advantage reduces wire bending and reactive adjustments, directly shortening active treatment duration.[3,7] However, CAD/CAM indirect bonding requires substantial digital infrastructure investment, limiting practical applicability despite superior accuracy.[3]

Malocclusion Class-Dependent Treatment Duration-

The class-dependent treatment duration patterns have important implications.[2,5] Indirect bonding reduces treatment time by 2 months (12%) for Class 1 malocclusions, likely from improved bracket accuracy.[2,3] In contrast, Class 2 cases show negligible difference (22 versus 22.5 months), suggesting bonding technique selection for Class 2 should prioritize chairside time or laboratory availability over treatment duration.[2,5]

Limitations and Future Research-

Limitations include English-only publication restriction, database limitation to PubMed and Scopus, and study heterogeneity limiting quantitative comparisons.[1-4,6] Future research should address long-term follow-up beyond 15 months, cost-effectiveness of CAD/CAM indirect bonding, and technique selection in specific patient populations.[1-4,6,7]

Conclusion:

This comprehensive review of 12 studies published between 2000–2026 demonstrates that direct and indirect bonding techniques offer distinct efficiency profiles that should guide clinical selection based on specific practice priorities and patient characteristics.[1-4]

Key Conclusions-

1. Indirect bonding is superior for chairside time reduction (47% reduction) and appointment minimization, making it the preferred choice for clinicians managing high patient volumes or patients with limited appointment availability.[1-3,5]
2. Direct bonding offers superior total working time efficiency (37% reduction) by eliminating laboratory dependencies, making it preferable for clinics without laboratory support or for patients requiring immediate treatment commencement.[1-3,10]
3. Long-term bond stability is slightly better with direct bonding (12.3% versus 18.7% failure at 15 months), supporting direct bonding for fixed retainer applications where relapse prevention is critical.[3,7,12]
4. CAD/CAM-assisted indirect bonding achieves superior bracket placement accuracy (40–50% reduction in positioning errors), representing a significant technological advancement for precision-focused clinicians with existing digital infrastructure.[2,5]
5. Treatment duration advantages are malocclusion-class dependent: indirect bonding reduces treatment time by 2 months (12%) for Class 1 malocclusions but shows no significant difference for Class 2 cases.[2,5]

Clinical Recommendations-

Clinicians should select bonding techniques based on individualized efficiency priorities:

- Choose indirect bonding when chairside time reduction, appointment minimization, or CAD/CAM precision are priorities, particularly for Class 1 malocclusions.
- Choose direct bonding when total working time efficiency, immediate treatment commencement, or long-term bond stability are priorities, particularly for Class 2 malocclusions or fixed retainer applications.
- Consider digital indirect bonding for clinics with existing digital infrastructure prioritizing maximum bracket placement accuracy.

Both techniques demonstrate comparable overall effectiveness with no significant differences in overall bond failure rates or bracket accuracy (conventional methods), supporting either technique as clinically appropriate based on efficiency preferences rather than effectiveness concerns. The optimal choice depends on balancing chairside time against total working time, considering malocclusion classification, evaluating laboratory resources, and prioritizing long-term stability versus appointment convenience for individual patients.

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