Pesquisa Brasileira em Odontopediatria e Clínica Integrada 2021; 21(supp1):e0027
https://doi.org/10.1590/pboci.2021.137
ISSN 1519-0501 / eISSN 1983-4632

SYSTEMATIC REVIEW

Direct and Indirect Bonding Techniques: A Systematic Review

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Academic Editor: Alessandro Leite Cavalcanti

Received: 29 January 2021 / **Review:** 01 April 2021 / **Accepted:** 05 May 2021

How to cite: Albertini P, Mele L, Palone M, Cremonini F. Direct and indirect bonding techniques: a systematic review. Pesqui Bras Odontopediatria Clín Integr. 2021; 21(supp1):e0027. https://doi.org/10.1590/pboci.2021.137

ABSTRACT

Objective: To assess the scientific evidence on direct and indirect bonding techniques to analyse the differences related to treatment time, number of appointments and number of bracket detachments. **Material and Methods:** The MEDLINE and Cochrane Library databases were searched through to March 2021. Reference lists from the retrieved publications were also examined. The following article types that described data on the different types of direct and indirect bonding techniques in orthodontics were included: prospective and retrospective cohort studies, case-control studies and randomized controlled clinical trials (RCCTs). Two review authors independently assessed eligibility, extracted data, and ascertained the quality of the studies. **Results:** The search strategy initially resulted in 824 articles, and after a careful selection comprising the inclusion criteria, 12 articles were picked for the final review, specifically 2 cohort studies, 4 case-control studies and 6 RCCTs. The methodological quality was low in 4 studies, medium in 2, and high in 6 articles. **Conclusion:** The evidence currently available suggests that the use of computer-aided bonding is related to a reduction in treatment time and the number of appointments compared to direct and manual indirect bonding. However, the total bonding time for computer-aided bonding technique, including digital bracket placement, was longer than for direct bonding. Further high-quality RCTs on the differences between direct and indirect bonding are necessary to determine more precise data, as well as additional advantages and disadvantages.

Keywords: Dental Materials; Dentin-Bonding Agents; Orthodontic Brackets.

Introduction

The direct bonding technique was first described in 1965 by Newman [1], while the first indirect bonding technique was introduced by Silverman et al. [2] in 1972. Numerous modifications and different techniques were derived from these two important starting points to make bonding the fastest and most accurate possible [3-7]. In fact, the positioning of brackets is one of the most important procedures in orthodontics regarding quality of the results, especially in complex cases [8], as misplaced brackets lead to errors of the first, second, and third-order [9-12].

The advent of the "digital age" first affected treatments involving crowns and fixed partial dentures [13-15], but orthodontics followed a few years later. The introduction of digital technologies was intended to reduce the adverse effects of orthodontic treatments [16-18], patient discomfort [12], and the need for compliance [19].

The use of CAD/CAM (computer-aided design/computer-aided manufacturing) technology in orthodontics, including digital tools for indirect bonding, is undoubtedly growing. However, clinical trials to supporting the growth of CAD/CAM technology in this area have not kept pace. The manufacturers of these software and custom-made devices claim that the total treatment time is reduced, and the results are better. Nowadays, it is possible to perform almost all of the steps digitally: from taking impressions, treatment planning, digital positioning of the brackets on the model, and their transfer to the teeth.

However, it is necessary to distinguish between two main methods of execution of computer-aided bonding. The first involves an initial setup, thanks to which it is possible to view the teeth in the desired final position and therefore to plan the precise position of the brackets, while the second provides only the option of positioning the brackets on the initial malocclusion model, thereby mimicking traditional indirect bonding, but in a digital way [20].

Improvements in computer-aided indirect bonding techniques have undoubtedly/purportedly optimized bracket positioning and reduced the number of manufacturing stages. However, manufacturers' claims that their CAD/CAM products for indirect bonding have several advantages over direct bonding techniques need to be confirmed by clinical trials.

Given the importance of this topic and the frequency of bonding in the orthodontic world, the purpose of this systematic review of the literature was to assess the scientific evidence on both traditional and digital direct and indirect bonding techniques. In particular, the main objective was to analyse the differences related to treatment time and the number of appointments required and the number of bracket detachments encountered.

Material and Methods

Search Strategy

The strategy for carrying out this systematic review was influenced mainly by the National Health Service (NHS) Centre for Reviews and Dissemination [21] and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statements [22,23].

A literature survey was done of the Medline database (www.ncbi.nim.nih.gov) to identify all the articles that examined the advantages and disadvantages of the different bonding techniques. The survey covered the period until March 2021 and used the following terms: "*Direct Bonding Orthodontics*", "*Indirect Bonding Orthodontics*", and "*Computer Aided Bonding Orthodontics*" to screen for relevant articles (Table 1). Additional research was conducted in the Cochrane Controlled Clinical Trials Register (www.cochrane.org/reviews).

Table 1. Search strategy results.

Terms	Search Strategy Results
((direct bonding orthodontics) OR indirect bonding orthodontic) OR computer aided bonding orthodontic*	824 articles

Study Selection Criteria

The inclusion and exclusion criteria are presented in detail in Table 2.

Table 2. Study selection criteria.

Inclusion Criteria	Exclusion Criteria
▪ Randomized and non-randomized controlled clinical trials (RCCTs; CCTs), case-control studies, cohort studies, prospective and retrospective studies. ▪ Articles written in the English or German language.	▪ Abstracts, case control studies, case series, case reports, descriptive studies, discussion or opinion articles, in vitro researches, systematic reviews and meta-analysis.

Data Collection

This systematic review of the literature analysed only studies containing certain aspects of bonding techniques, namely treatment time, number of appointments and number of bracket detachments. The "Population Intervention Comparison Outcome" (PICO) approach, modified according to the literature review needs, was adhered to, as detailed in Table 3.

Table 3. PICO Format.

PICO	Description
Population	Permanent dentition
Intervention	Fixed orthodontic therapy
Comparison	Direct bonding *vs.* indirect traditional bonding *vs.* computer aided bonding
Outcome	Treatment time, number of appointments and number of detachments

Methodological Quality Assessment and Level of Evidence

The methodological quality assessment was performed independently by two reviewers (PA, LM) using different scales. In particular, the Jadad scale was used to evaluate the methodological quality of RCTs [24]. On this scale, RCTs are scored by the presence of 3 specific characteristics: randomization, blindness and loss at follow-up. For each "Yes" answer, 1 point is assigned. The overall score ranges from 0–5. An RCT with a score greater than or equal to 3 is considered of good quality. Articles on other studies were scored on the Newcastle–Ottawa Scale (NOS), the result of collaboration between the universities of Newcastle, Australia, Ottawa and Canada [25,26]. This scale was developed to evaluate the quality of non-randomized trials in meta-analyses, cohort studies, and case-control studies. It consists of a "star" system, whose scores are divided into various sections; a maximum of 4 points are awarded for the selection of study groups, 2 points for the "comparability" of the groups, and 3 points for the outcome for cohort studies or "execution" for case-control studies. The overall score obtained with this scale ranges from 0–9 points.

Levels of evidence were assigned to the studies taken into consideration according to the classification by the Oxford Centre for Evidence-Based Medicine Levels of Evidence [27,28]. Any doubt about relevant studies was clarified by contacting the authors by e-mail. To minimize methodological errors, each article was reviewed by a statistician.

Results

The potential items to be included in the review were carefully selected according to the research strategy illustrated in Figure 1. The search strategy resulted in 824 articles, but after careful selection according to the inclusion/exclusion criteria, only 12 articles were deemed suitable for inclusion in the final review [20,29-39]. Specifically, two cohort studies, four case-control studies and six RCCTs were analysed for quality and level of evidence (Table 4). Data from these articles on the reduction in treatment time, the number of detachments, and the score before and after the orthodontic treatments are shown in Table 5.

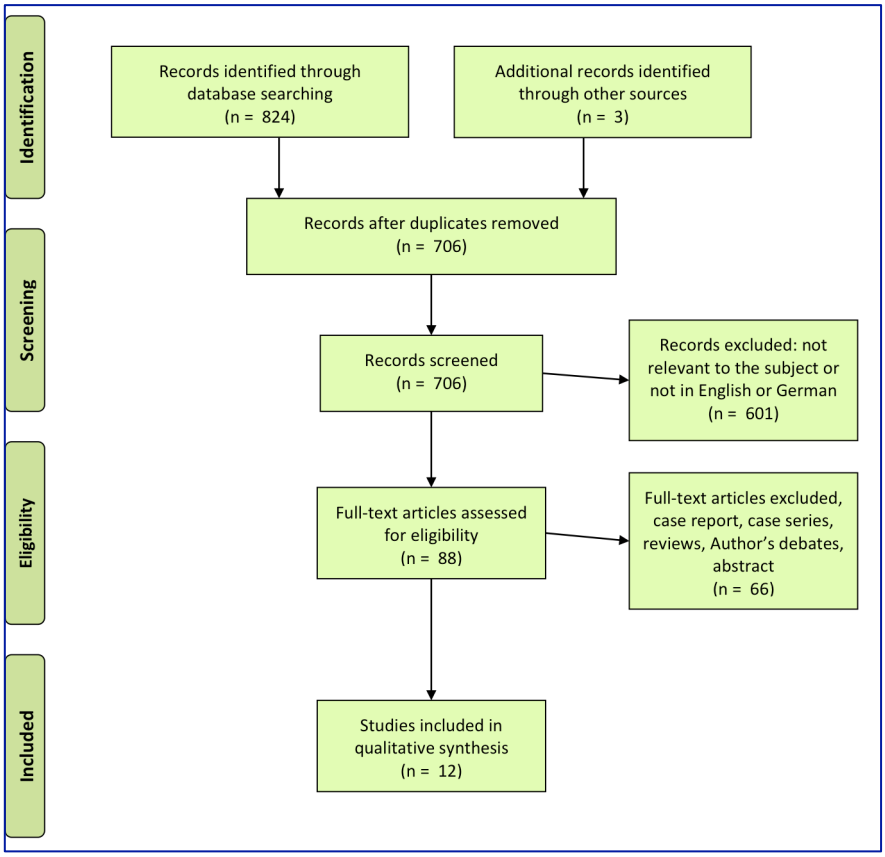

Figure 1. PRISMA flow diagram. Flow chart illustrating the selection of relevant articles.

Table 4. Quality evaluation and level of evidence of the studies included in the qualitative synthesis.

Study	Design	Evaluation Scale	Quality Evaluation	Level of Evidence
Czolgosz et al. [20]	RCCT	JADAD[1]	4	1b
Thiyagarajah et al. [29]	RCCT	JADAD[1]	3	1b
Saxe et al. [30]	RCCT	JADAD[1]	3	1b
Miles [31]	RCCT	JADAD[1]	3	1b
Murakami et al. [38]	RCCT	JADAD[1]	3	1b
Penning et al. [39]	RCCT	JADAD[1]	4	1b
Alford et al. [32]	Case-Control Study	NOS[2]	7	3
Weber et al. [33]	Case-Control Study	NOS[2]	3	3
Bozelli et al. [34]	Cohort Study	NOS[2]	6	2b
Menini et al. [35]	Cohort Study	NOS[2]	8	2a
Haeger [36]	Case-Control Study	NOS[2]	7	3
Brown et al. [37]	Case-Control Study	NOS[2]	6	3

[1]JADAD: Jadad Scale; [2]NOS: Newcastle-Ottawa Scale.

Table 5. Parameters analyzed in the included articles.

Article	Type of Treatment	Sample Size	Total Treatment Time (Mean, Month)	Number of Appointment	Number of Bracket Detachment
Czolgosz et al. [20]	Computer Aided Bonding	15	-	-	5.1%
	Direct Bonding	12	-	-	0%
Thiyagaraj ah et al. [29	Indirect Bonding	273 Brackets	-	-	2.2%
	Direct Bonding	266 Brackets	-	-	2.9%
Saxe et al. [30]	Suresmile Indirect Bonding	38	14.7	-	-
	Direct Bonding	24	20	-	-
Miles [31]	Brackets Conditioned with MIM	17	-	-	1.4%
	Brackets Not Conditioned with MIM	19	-	-	1.2%
Penning et al. [39]	Customized Brackets	85	15.5 p<0.01	8.91 p≤0.01	5.47 p=0.09
	Conventional Brackets	89	14.9	8.98	3.58 p=0.09
Murakami et al. [38]	Indirect Bonding	35	14.23 p=0.05	-	-
	Direct Bonding	11	22.91	-	-
Brown et al. [37]	Computer-Aided Bonding	32	13.8 p<0.05	14.1 p<0.05	-
	Indirect Bonding	33	16.9	14.9	-
	Direct Bonding	-	21.9	-	-
Weber et al. [33]	Insignia Indirect Bonding	35	14.23 p<0.0001	14	-
	Conventional Direct Bonding	11	22.91	22.5	-
Haeger [36]	Indirect Class 1 Child Patient	225	15.2	-	-
	Indirect Class 2 Child Patient	66	22.7	-	-
	Direct Class 1 Child Patient	161	17.2	-	-
	Direct Class 2 Child Patient	127	22.2	-	-
Bozelli et al. [34]	Indirect Bonding	17	-	11	-
	Direct Bonding	17	-	7	-
Menini et al. [35]	Indirect Bonding	19	-	-	-
	Direct Bonding	33	-	-	-
Alford et al. [32]	Suresmile Indirect Bonding	69	15.8		
	Direct Bonding	63	23		

Discussion

Given the importance and frequency of bonding in orthodontics, it is important to obtain precise information regarding the biomechanical requirements of orthodontists [40] and the biological parameters of the patients [41], as this will have daily clinical application. In literature, the advantages and disadvantages of indirect bonding techniques have been discussed in several articles [20,29,42,34-36,38]. Furthermore, due to the progress made in the field of digital orthodontics, it is important to evaluate these new techniques and compare them with traditional indirect and direct bonding.

Direct vs. Indirect Bonding

The article by Haeger [36] regarding orthodontic treatment time in traditional indirect bonding reported that fewer appointments are necessary than with the direct method. However, the distinction is made between class 1 and class 2 malocclusions. In the case of class 1 malocclusions, traditional indirect bonding required less time on average (15 months) than direct bonding (17 months), while in class 2 malocclusions, direct bonding took less time (22 months) than indirect bonding (22.5 months).

Murakami et al. [38] and Brown et al. [37] agree that traditional indirect methods require less time than direct bonding, respectively 14.23 months and 22.91 months on average according to the former, and 16.9 months versus 21.9 months according to the latter. The second study also described the number of appointments required on average, specifically 16.5 for direct bonding and 14.9 for indirect bonding.

As regards bracket detachment, Bozelli et al. [34] observed no statistically significant difference between the two techniques. However, they noted that more bracket detachments were encountered in the lower than in the upper arch. In most cases, bracket detachments are probably due to the orthodontist's ability to keep the tooth dry, and to respect the adhesive criteria and obtain proper occlusion.

A study performed by Menini et al. [35] demonstrated no difference in bracket detachment between traditional indirect and direct bonding. These results are also in agreement with the study by Thiyagarajah et al. [29]

One article described traditional indirect bonding without comparing it with other categories—a study by Miles [31] compared the failure rate over six months between indirect bonding with or without the use of methyl methacrylate monomer (MMM) on custom bracket bases. This revealed that the bracket detachment was 1.4% for brackets conditioned by MMM and 1.2% for unconditioned brackets. Therefore, the bracket detachment rate is low and appears to be unaffected by conditioning with MMM.

Direct *vs.* Computer-Aided Indirect Bonding

A study by Penning et al. [39] comparing non-customized with customized systems found that the latter yielded no statistically significant reduction in either total treatment time or the number of appointments necessary for orthodontic treatment. The total treatment time was influenced by both the operator and the severity of the malocclusion rather than the orthodontic system used. In this case, however, the customized method was associated with a greater number of bracket detachments than the non-customized one, mainly due to inaccuracies in the digital setup.

In contrast, Czolgosz et al. [20] reported that chairside time is shorter for computer-aided indirect bonding than for direct bonding, but that total treatment time (including digital bracket placement) was longer for computer-aided indirect bonding than for traditional direct bonding. Furthermore, there were significantly

more immediate bracket bonding failures with computer-aided indirect bonding than with traditional direct bonding.

Brown et al. [37], on the other hand, reported that 8 months less total treatment time was required for CAD-CAM bonding compared to direct bonding, and 3 months less than indirect bonding. Nevertheless, the number of appointments required was quite similar in the three groups. The only statistically significant difference was observed in the comparison between the CAD-CAM group and the directly bonded group, with 2.5 appointments less on average being necessary for the former.

Weber et al. [33] also demonstrated a significant reduction in treatment time in cases treated via a digital method (Insignia) compared to a conventional one, requiring 14.23 months and 22.91 months on average, respectively. There are several explanations for this reduction in treatment time, and one of these is the fact that with the Insignia system, the position of each tooth is established via a virtual setup, and it is plausible that each alignment error is, therefore, less severe. The resolution of orthodontic cases in a shorter time, therefore, probably correlates with the precision of the positioning of the brackets because less rebracketing and fewer bends are necessary. In addition, even less time is required thanks to the creation of a setup, which allows customization of the brackets based on the tooth positions.

An article by Alford et al. [32] discussed the Suresmile system. On average, this system reduced treatment time by 7 months with respect to conventional equipment. However, these results must be interpreted with caution because neither the patient selection method nor the distribution of cases among the three orthodontists is clearly reported, although the cases were handled by the same operators.

That being said, another article on Suresmile by Saxe et al. [39] agreed that the total treatment time is reduced by using the digital system instead of the conventional one. Similarly, in a study by Alford et al. [32], the total treatment time was reduced in cases treated with the Suresmile digital system compared to those treated with manual indirect bonding. On average, there was a reduction of about 7 months. However, since that was not a randomized clinical trial, many uncontrollable variables may have affected the results. Moreover, only non-extraction cases were taken into account; it would be interesting to ascertain whether the findings extend to extraction cases, considering the increase in problems related to root movement and parallelism. Nevertheless, it should be noted that the article by Saxe et al. [30] reported a reduction in treatment time of about 25% using the digital system as compared to conventional one. However, these results need to be interpreted with caution because neither the method of selection nor the distribution of clinical cases among orthodontists is known.

Indirect *vs.* Computer-Aided Indirect Bonding

Only one article by Brown et al. [37], compared traditional indirect bonding with computer-aided bonding. They reported that the total treatment time was 16.9 months and 13.8 months on average, respectively. As for the number of appointments using digital bonding, they were reduced compared to the indirect manual method.

Conclusion

There was a decrease in the number of appointments and treatment time required for indirect bonding compared to direct bonding; the number of bracket detachments does not seem to be influenced by the method. Treatment time and the number of appointments were further reduced through the use of computer-aided indirect bonding associated with the use of setup. However, the total bonding time required for computer-aided

bonding, including digital bracket placement, was longer than for direct bonding. More qualified RCTs are required to make reliable recommendations about direct and indirect bonding, particularly computer-aided indirect bonding.

Authors' Contributions

PA	https://orcid.org/0000-0002-4020-5065	Formal Analysis, Investigation, Data Curation, Writing - Original Draft, Writing - Review and Editing.
LM	---	Data Curation and Writing - Review and Editing.
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FC	https://orcid.org/0000-0002-4641-2196	Conceptualization, Methodology and Writing - Review and Editing.

All authors declare that they contributed to critical review of intellectual content and approval of the final version to be published.

Financial Support

None.

Conflict of Interest

The authors declare no conflicts of interest.

Data Availability

The data used to support the findings of this study can be made available upon request to the corresponding author.

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