RESEARCH PAPER

# Efficacy of Cone Beam Computed Tomography in the Accuracy of Indirect Bonding Technique

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**Abstract:**
**Aim**: To assess the Efficacy of Cone Beam Computed Tomography on the digital Indirect Orthodontic Brackets Bonding Technique.
**Methods:** A total of Eighteen patients aged between 15 and 25 years were included in the study divide to two groups first group brackets were digitally indirectly positioned with CBCT and the second group were digitally indirectly positioned without CBCT, in which intraoral scan and CBCT were taken and then brackets were digitally indirectly positioned first with CBCT and second without CBCT for each case with maestro3D software then virtual casts were superimposed. Changes in mesiodistal position and angulation of brackets were measured.
**Results**: The differences in mesiodistal and tip deviation between the two methods of virtual bonding (scan with CBCT and scan only) to the test value estimated to be 0.08 mm and 1.1 °, respectively, there was non- statically significant ($p \geq 0.05$) for all teeth except for canine and first premolar tip deviation, which showed a significant difference ($p<0.05$).
**Conclusion:** Within the limitations of this study, using CBCT during indirect bonding does not have significant value on the accuracy of mesiodistal deviation of bracket placement; however, it has significant value on Canine and first premolar angulation.
**Keywords:** Indirect Bonding, Cone Beam Computed Tomography, mesiodistal deviation and tip deviation.
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Background:

Orthodontic indirect bonding is a bracket-placement technique in which attachments are positioned on a model or digital setup and transferred to the teeth with a tray; its main advantages are better workflow efficiency and potentially improved placement control.(1)

Indirect bonding emerged after the broader shift from banded appliances to adhesive bracket bonding in the 1960s, which reduced the discomfort, trauma, and inefficiency associated with full banding.(2)

Orthodontic indirect bonding began in 1972, when Silverman introduced extraoral bracket placement on a model followed by intraoral transfer, and it has since evolved through adhesive, tray, and digital workflow innovations.(3)

Silverman's 1972 technique was designed to improve bracket placement precision while limiting chairside time by positioning brackets on a plaster cast and transferring them with a vacuum-formed tray.(4)

From the 1990s onward, visible light-cured adhesives and simplified laboratory procedures helped modernize manual indirect bonding, while later reviews describe CAD/CAM as the next major transition.(5)

Current digital workflows can scan impressions, position brackets virtually, and fabricate transfer trays with CAD/CAM, stereolithography, or 3D printing.(5, 6)

Digital orthodontic indirect bonding uses intraoral scanning, virtual bracket placement, and CAD/CAM or 3D-printed transfer trays to move conventional indirect bonding into a digital workflow; it appears to improve bracket placement predictability and reduce clinical chairside time, but evidence is mixed on total workflow time, bond failures, cost, and downstream treatment efficiency.[7, 8]

Contemporary digital workflows commonly use intraoral scans or digital models, software-based bracket positioning, STL export, and either a 3D-printed tray or a vacuum-formed tray made on a printed bonded model.[9, 10]

Multiple reviews conclude that indirect, including digital indirect, bonding tends to be more precise or predictable than direct bonding for bracket placement, particularly in difficult cases where direct access is limited.[11, 12]

The proposed advantages are better visualization of tooth surfaces, easier control of bracket position, fewer manufacturing stages in modern systems, and better suitability for crowding and rotations.[3, 5, 13]

The mean transfer errors during orthodontic indirect bonding are generally low: the strongest synthesis found pooled linear errors of 0.08 mm mesiodistally, 0.09 mm vertically, and 0.14 mm buccolingually, with pooled angular errors of 1.13° for angulation, 0.93° for rotation, and 1.11° for torque.[14, 15]

Maxillary canines had the highest angular deviation at 5.56°± 4.01° in comparison with the maxillary teeth. Mandibular canines and second premolars had the highest angular deviation in the comparison between mandibular teeth.[16]

Overall, digital orthodontic indirect bonding appears to offer better planning and chairside efficiency than conventional bonding workflows, but current evidence does not show a uniform advantage across accuracy, total time, cost, and failure outcomes. The field is clearly moving toward fully digital workflows, yet multiple reviews still call for higher-quality clinical trials, especially for digital-specific systems and measurement standards.[11, 17, 18]

**Materials and Methods:**

**Study design:**

This is a prospective within-subject comparative experimental (methodological) study**.**

**Ethical approval and registration:**

This study was approved by the Ethical Committee of the Faculty of Dental Medicine (Ref. No. AUAREC2024002-4)

**Sample size calculation:**

By selecting an alpha (α) level of 0.05 (5%), power=90% to achieve an effect size (1.734) based on the results of a previous study. [8] The predicted sample size was found to be 9 participants per group. Sample size calculation was performed using G Power version 3.1.9.7.

**Setting and location:**

This study was carried out with18 patients of both sexes with an age range from 15 to 25 years, selected from the outpatient orthodontic clinic, Faculty of Dental Medicine, Al-Azhar University, Assiut branch.

**Participants:**

Inclusion criteria:

- The presence of all permanent teeth fully erupted, except third molars.
- Moderate crowding for an easy bonding procedure.
- No history of previous orthodontic treatment.

Exclusion criteria:

- Impacted or unerupted teeth.
- Severe crowding which would render the bonding difficult
- Teeth with abnormal anatomy or severely decayed.

**Intervention:**

**Informed consent:**

Preoperatively, patients were allowed to read and understand the various steps involved in the study before providing written informed consent, following a clear verbal explanation of the clinical steps in understandable words by the operator. Verbal assent was granted by the patients before starting the study.

**Grouping and allocation:**

The enrolled patients in this study were allocated into two groups (n = 9) following a 1:1 allocation ratio.

- Group I: scan with CBCT for digital indirect bonding design.
- Group II: scan only for digital indirect bonding design.

**Clinical steps:**

**Intervention procedure:**

For all patients, CBCT and intraoral scanning of the teeth will be taken.

Maestro* 3D software was chosen; this software provides different orthodontic analyses and treatment planning services, and it is easy to use.

It also has different methods for indirect bracket transfer, including either printing the 3D model or directly printing the IBT, making the indirect bonding procedure more flexible and compatible with more printing materials available.

Brackets of the upper arch were positioned with Maestro 3D software, which automatically verifies height, mesiodistal position, and angulation according to the chosen method of bonding, which is fixed in all cases (MBT).

Angulations were adjusted parallel to the clinical crown long axis in group II (scan only), whereas for group I (scan with CBCT), using CBCT offered root visualization during the bracket positioning stage, and so precise bracket placement parallel to the root long axis could be achieved.

Each case was designed with and without CBCT, and the virtual casts with braces of each case were superimposed, so we consider each case as two cases in the two groups, which were designed first with CBCT for group I and designed a second time without CBCT for group II, and the virtual casts of the same case were superimposed.

**Evaluation procedure.**

After digital bracket positioning, virtual casts of each case were superimposed by Gom Inspect software (free software), and differences in bracket position in mesiodistal and with the long axis of the tooth were evaluated to test values estimated to be 0.08 mm and 1.1 °, respectively, in A large systematic review/meta-analysis of 16 studies in 2022. (14)

Figures showing positioning of brackets in the ideal position for both groups.

Figures showing superimposition of virtual casts of both groups to determine differences in mesiodistal and angulation.

**Results:**

Regarding the assessment of the outcome results, they were as follows:

**Mesiodistal deviation (mm)**

When comparing the differences in mesiodistal deviation between two methods of virtual bonding (scan with CBCT and scan only) to a test value estimated to be 0.08, there was non- statically significant with all teeth, with all mean deviations lower than the test value except for the second premolar.

| | Test value = 0.08 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | N | Median | Mean | Std. Dev | Mean diff | Min | Max | P value |
| Central incisor | 18 | .030 | .054 | .080 | .445 | .00 | .29 | .224 |
| Lateral incisor | 18 | .040 | .058 | .058 | .441 | .01 | .25 | .164 |
| Canine | 18 | .040 | .084 | .104 | .415 | .01 | .33 | .870 |
| First premolar | 18 | .030 | .084 | .173 | .415 | .00 | .70 | .921 |
| Second premolar | 18 | .020 | .027 | .020 | .472 | .00 | .08 | .000** |

**Tip deviation (°).**

When comparing the differences in tip deviation between two methods of virtual bonding (scan with CBCT and scan only) to the test value estimated to be (1.1°), there was no statistically significant difference with all teeth except for the canine and first premolar, with all mean deviations lower than the test value except for the canine higher than the test value.

| | Test value = 1.1 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | N | Median | Mean | Std. Dev | Mean diff | Min | Max | P value |
| Central incisor | 18 | .975 | 1.33 | 1.40 | .661 | .04 | 5.37 | .507 |
| Lateral incisor | 18 | 1.15 | 1.55 | 1.74 | .445 | .01 | 5.20 | .315 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Canine | 18 | 3.14 | 4.08 | 3.43 | 2.08 | .16 | 12.70 | .003 |
| First premolar | 18 | 1.69 | 3.17 | 3.42 | 1.17 | .06 | 11.08 | .029 |
| Second premolar | 18 | .615 | 1.19 | 1.38 | .806 | .02 | 4.91 | .790 |

## Discussion:

Indirect bonding transfers brackets from a model (plaster or digital) to the teeth using a transfer tray, allowing bracket positioning under ideal visibility and time conditions rather than directly in the mouth.

Since its introduction in the 1970s, IDB has evolved through multiple tray designs, specialized adhesives, and now CAD/CAM-based and 3D-printed systems.

Multiple in vivo trials show high linear accuracy of 3D-Printed Indirect Bonding Trays, typically ~0.05–0.35 mm, well within the 0.5 mm clinical threshold across most teeth and arches, and angular control is acceptable for rotation and tip, but torque remains the weakest dimension, often exceeding 2° thresholds in a substantial proportion of brackets.

Recent systematic and narrative reviews agree that indirect bonding provides clinically acceptable transfer accuracy, with mean linear errors around 0.08 mm and angular errors near 1.1°.

Systematic reviews and meta-analyses show no significant difference in overall bond failure rates between direct and indirect techniques, although one high-quality meta-analysis found fewer long-term failures with direct bonding at 12–15 months.

More studies in our department and worth world compare the accuracy of different indirect bonding techniques and with direct techniques, but fewer studies use CBCT for digital indirect bonding.
So, in this study, we compare the efficacy of indirect orthodontic technique with and without CBCT.

### Mesiodistal deviation (mm).

Comparison of the differences in mesiodistal deviation between the two methods of virtual bonding (scan with CBCT and scan only) to test the value estimated to be 0.08; the result was statistically non-significant ($p > 0.05$) for all teeth except the second premolar.

In this study, we depended on Measured mean transfer errors (MTE) in the mesiodistal direction, which were 0.08 mm in A large systematic review/meta-analysis of 16 studies in 2022.[14]

When we compare mean errors in the mesiodistal direction in this study (.027mm: .084mm) with Measured mean transfer errors (MTE) (0.08), the difference is very small (statistically non-significant), which means that there is no effective difference between the two groups, and so CBCT is not necessary for brace positioning in the mesiodistal direction.

This result is supported by a previous study in a systematic review/meta-analysis of 16 studies in 2022.[14]

### Tip deviation (°).

Comparison of the differences in tip deviation between two methods of virtual bonding (scan with CBCT and scan only) to test the value estimated to be (1.1°); the result was not statistically significant for all teeth except for the canine and first premolar.

As we explained before, in this study we depend on measured mean transfer errors (MTE) regarding angulation, which were 1.1° in the last systematic review and meta-analysis in 2022. [14]

The result is non - statistically significant in angulation of braces between two groups except for canine and first premolar.

Similar results from a study that compared panoramic X-ray and CBCT for digital positioning of braces in 2022, which showed that maxillary canines had more angular differences between the two groups compared to other teeth in indirect digital bonding.[16]

From above, we can say that there is a statistically significant ($P < .005$). effect on angulation of braces during digital indirect bonding for canines and first premolar.

When we compare mean errors in tip deviation in this study (1.1°: 4°) with Measured mean transfer errors (MTE) in a large systematic review/meta-analysis of 16 studies in 2022 (1.1°), all teeth have mean error near for this error except for the canine and first premolar, which have high tip deviation errors of 4° and 3°, respectively.

## Conclusion

CBCT did not add a significant value to the accuracy of bracket placement with the indirect bonding technique regarding mesiodistal deviation, while it had a significant value on canine angulation. During indirect bonding, design has no significant value on the accuracy of bracket placement on mesiodistal deviation. while has significant value on Canine angulation.

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**Availability of data and materials:**

The datasets generated and/or analyzed during the current study can be obtained from the corresponding author upon reasonable request, with all precautions implemented to secure participants' privacy.

**Consent for publication**
Not applicable.
**Competing interests:**
The authors declare no competing interests.
**References:**

1. Kalange JT, Thomas RG, editors. Indirect bonding: a comprehensive review of the literature. Semin orthod; 2007: Elsevier.
2. Gange P. The evolution of bonding in orthodontics. Am J Orthod Dentofac Orthoped. 2015;147(4):S56-S63.
3. Albertini P, Mele L, Palone M, Cremonini F. Direct and indirect bonding techniques: a systematic review. Pesquisa Brasileira em Odontopediatria e Clínica Integrada. 2021;21:e0027.
4. Li Y, Mei L, Wei J, Yan X, Zhang X, Zheng W, et al. Effectiveness, efficiency and adverse effects of using direct or indirect bonding technique in orthodontic patients: a systematic review and meta-analysis. BMC Oral Health. 2019;19(1):137.
5. Aggarwal P, Aggarwal R. Indirect bonding procedures in orthodontics-a review. J Dents Dent Med. 2018;1(4):120.
6. Nawrocka A, Łukomska-Szymańska M. The indirect bonding technique in orthodontics—a narrative literature review. Materials. 2020;13(4):986.
7. Patano A, Inchingolo A, Malcangi G, Garibaldi M, De Leonardis N, Campanelli M, et al. Direct and indirect bonding techniques in orthodontics: a systematic review. Eur Rev for Med Pharmacol Sci. 2023;27:8039-54.
8. Aboujaoude R, Kmeid R, Gebrael C, Amm E. Comparison of the accuracy of bracket positioning between direct and digital indirect bonding techniques in the maxillary arch: a three-dimensional study. Progr Orthod. 2022;23(1):31.
9. Elnagar M, Aronovich S, Kusnoto B. Digital Workflow for Combined Orthodontics and Orthognathic Surgery.Oral and Maxillofac Surg Clin. 2019; 32: 1-14.
10. Panayi NC, Efstathiou S, Christopoulou I, Kotantoula G, Tsolakis IA. Digital orthodontics: Present and future. AJO-DO Clinical Companion. 2024;4(1):14-25.
11. Tarraf NE, Ali DM, editors. Present and the future of digital orthodontics. Semin Orthod.2018;24(4): 376-385.
12. Krymovskyy KG, Zhehulovych ZE, Storozhenko KV, Babaskin YI. Nowadays and the future of 3D digital technologies in modern orthodontics. Wiadomości Lekarskie. 2024;77(10):2047-56.
13. Vaid NR, editor. Digital technologies in orthodontics–An update. Semin Orthod.2018; 24: 373-375.
14. Sabbagh H, Khazaei Y, Baumert U, Hoffmann L, Wichelhaus A, Janjic Rankovic M. Bracket transfer accuracy with the indirect bonding technique—a systematic review and meta-analysis. J Clin Med. 2022;11(9):2568.
15. Nguyen VA, Nguyen TA, Doan HL, Pham TH, Doan BN, Pham TTT, et al. Transfer accuracy of partially enclosed single hard vacuum-formed trays with 3D-printed models for lingual bracket indirect bonding: a prospective in-vivo study. PLoS One. 2025;20(1):e0316208.
16. Yilmaz H, Eglenen MN. Comparison of the effect of using panoramic and cone-beam computed tomography on the accuracy of root position in indirect digital bracket placement: A retrospective study. Orthod Craniofac Res. 2022;25(3):401-8.
17. Shelke DD, Jadhav VV, Jaiswal A, Gandhi V. Review on digital orthodontics. J Pharm Res Int. 2022;34:16-26.
18. Díaz MG, Repenning CN, Droguett CE. Digital dentistry applied in orthodontics: a bibliographic review. Int J Dent Sci. 2025(00):52-62.