

## Artificial Intelligence Designing Tooth-Supported Fixed Prosthesis: a Systematic Review

*Desenho de Próteses Fixas Dentossuportadas por Inteligência Artificial: Revisão Sistemática*

*Diseño de Prótesis Fijas Dentosoportadas mediante Inteligencia Artificial: Revisión Sistemática*

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### Abstract

**Purpose:** To systematically evaluate the performance of artificial intelligence (AI)-driven software in the digital design of tooth-supported fixed prostheses compared with restorations produced by dental technicians, focusing on design efficiency, occlusal morphology, internal adaptation, and functional cuspal anatomy. **Materials and Methods:** Electronic searches were conducted in MEDLINE/PubMed, EMBASE, Web of Science, and Scopus, with manual reference screening, to identify relevant clinical and in vitro studies published until March 2024. Studies directly comparing AI-generated designs with technician-produced digital crowns were included. Two reviewers independently extracted data and assessed methodological quality using the QUIN tool for in vitro studies. When appropriate, outcomes were pooled using random-effects models, and heterogeneity was analyzed with the  $I^2$  statistic. **Results:** Of 1,417 records, four studies met the inclusion criteria. Quantitative analysis showed no significant differences between AI- and technician-based workflows in crown design time (MD -7.79; 95% CI -22.92 to 7.34;  $P = .31$ ), occlusal morphology (MD -1.02; 95% CI -4.57 to 2.52;  $P = .57$ ), or internal fit (MD -0.10; 95% CI -1.64 to 1.45;  $P = .90$ ). AI-generated crowns demonstrated a more consistent functional cuspal angle (MD 0.52; 95% CI 0.19 to 0.85;  $P = .002$ ). High heterogeneity ( $I^2 > 96\%$ ) was observed. **Conclusion:** AI-assisted crown design performs comparably to experienced technicians and may improve specific morphological features. However, the small number of studies and substantial heterogeneity highlight the need for standardized clinical research.

**Descriptors:** Artificial Intelligence; Computer-Aided Design; Dental Crown; Dental Prosthesis Design; Dental Internal Fit.

### Resumo

**Objetivo:** Avaliar sistematicamente o desempenho de softwares baseados em inteligência artificial (IA) no desenho digital de próteses fixas dentossuportadas em comparação com restaurações confeccionadas por técnicos em prótese dentária. **Materiais e Métodos:** Foram realizadas buscas nas bases MEDLINE/PubMed, EMBASE, Web of Science e Scopus até março de 2024, com busca manual nas referências. Incluíram-se estudos clínicos e in vitro que compararam diretamente coroas digitais geradas por IA e por técnicos. Dois revisores realizaram a extração dos dados e a avaliação da qualidade metodológica por meio da ferramenta QUIN. Quando apropriado, os desfechos foram agrupados em modelos de efeitos aleatórios e a heterogeneidade foi analisada pelo estatístico  $I^2$ . **Resultados:** Dos 1.417 registros, quatro estudos atenderam aos critérios de inclusão. Não houve diferenças significativas entre os fluxos de trabalho quanto ao tempo de desenho das coroas (DM -7,79; IC 95% -22,92 a 7,34;  $P = 0,31$ ), à morfologia oclusal (DM -1,02; IC 95% -4,57 a 2,52;  $P = 0,57$ ) e à adaptação interna (DM -0,10; IC 95% -1,64 a 1,45;  $P = 0,90$ ). As coroas geradas por IA apresentaram ângulo cuspidal funcional mais consistente (DM 0,52; IC 95% 0,19 a 0,85;  $P = 0,002$ ). Observou-se alta heterogeneidade ( $I^2 > 96\%$ ). **Conclusão:** O desenho de coroas assistido por IA apresenta desempenho comparável ao de técnicos experientes e possíveis vantagens morfológicas específicas; contudo, são necessários estudos clínicos padronizados.

**Descritores:** Inteligência Artificial; Desenho Assistido por Computador; Coroa Dentária; Desenho de Prótese Dentária; Adaptação Interna Dental.

### Resumen

**Objetivo:** Evaluar sistemáticamente el desempeño del software basado en inteligencia artificial (IA) en el diseño digital de prótesis fijas dentosoportadas en comparación con restauraciones realizadas por técnicos dentales. **Materiales y Métodos:** Se realizaron búsquedas en MEDLINE/PubMed, EMBASE, Web of Science y Scopus hasta marzo de 2024, con revisión manual de referencias. Se incluyeron estudios clínicos e in vitro que compararon directamente coronas digitales generadas por IA y por técnicos. Dos revisores extrajeron los datos y evaluaron la calidad mediante la herramienta QUIN. Cuando fue posible, los resultados se agruparon con modelos de efectos aleatorios y la heterogeneidad se analizó con el estadístico  $I^2$ . **Resultados:** De 1.417 registros, cuatro estudios cumplieron los criterios de inclusión. No se observaron diferencias significativas entre los flujos de trabajo en el tiempo de diseño de coronas (DM -7,79; IC 95% -22,92 a 7,34;  $P = 0,31$ ), la morfología oclusal (DM -1,02; IC 95% -4,57 a 2,52;  $P = 0,57$ ) ni la adaptación interna (DM -0,10; IC 95% -1,64 a 1,45;  $P = 0,90$ ). Las coronas generadas por IA mostraron un ángulo cuspidal funcional más consistente (DM 0,52; IC 95% 0,19 a 0,85;  $P = 0,002$ ). Se observó alta heterogeneidad ( $I^2 > 96\%$ ). **Conclusión:** El diseño asistido por IA presenta un desempeño comparable al de técnicos experimentados y posibles ventajas morfológicas específicas; sin embargo, se requieren estudios clínicos estandarizados.

**Descriptorios:** Inteligencia Artificial; Diseño Asistido por Computadora; Corona Dental; Diseño de Prótesis Dental; Adaptação Interna Dental.

### INTRODUCTION

Artificial intelligence (AI) refers to computational systems designed to replicate aspects of human cognitive activity, and its integration into dentistry has expanded rapidly, influencing areas from esthetic planning to

automated restoration design<sup>1</sup>. The increasing use of AI across healthcare, medicine, marketing, and education reflects its ability to process information through advanced algorithms that imitate human reasoning<sup>2</sup>. In dentistry, deep learning (DL) approaches, particularly Convolutional Neural

Networks (CNNs) and Generative Adversarial Networks (GANs), have enhanced predictive modeling and simulation capabilities, allowing practitioners to better visualize potential outcomes and streamline clinical workflows<sup>3,4</sup>.

Digital technologies such as intraoral scanning and computer-aided design/computer-aided manufacturing (CAD/CAM) have accelerated the shift toward virtual prosthodontic workflows, replacing traditional wax-ups with more efficient and standardized digital procedures<sup>5,6</sup>. However, these digital designs still depend heavily on the skills and experience of the operator. To minimize operator-driven variability, knowledge-based AI systems have been developed to support or automate parts of the CAD/CAM process. For example, platforms such as CEREC can automatically derive restoration proposals from occlusal patterns and morphological characteristics, potentially increasing reliability and reducing design time<sup>7-11</sup>.

Reconstructing accurate occlusal morphology remains a fundamental requirement for the functional and structural longevity of dental restorations. Deviations in occlusal anatomy, inadequate internal fit, or incorrect cusp inclination may negatively influence stress distribution and raise the risk of failure<sup>5,12</sup>. Although AI-generated restorations have demonstrated promising morphological resemblance to natural teeth, existing evidence is inconsistent because of methodological differences, variations in datasets, and heterogeneous evaluation protocols<sup>13</sup>. As a result, it is unclear whether AI-based design can consistently achieve outcomes equivalent to those created through conventional technician-guided CAD/CAM workflows.

Earlier systematic reviews have examined multiple potential applications of AI in prosthodontics, including automated shade selection, crown and fixed restoration design, identification of preparation finish lines, optimization of fabrication techniques, prediction of facial changes in removable prosthodontics, and the digital development of removable partial dentures<sup>14-16</sup>. Nonetheless, these reviews primarily addressed broader applications, and none directly compared tooth-supported fixed prosthesis designs generated by AI with those created by experienced dental technicians.

Accordingly, the objective of this systematic review was to evaluate dental crowns produced through AI-based software relative to those designed by dental technicians using digital systems. The comparison focused on key performance parameters such as occlusal morphology, internal fit, occlusion, and proximal contact. The working hypothesis was that AI-generated restorations would not differ significantly from technician-designed crowns in occlusal

morphology, internal fit, and cusp angle measurements, while potentially offering advantages in design efficiency.

## **MATERIAL AND METHOD**

### ○ *Search Strategy*

This systematic review followed the PRISMA recommendations and was registered in PROSPERO under the number CRD42021251847.<sup>17</sup> A comprehensive electronic search was carried out in the MEDLINE/PubMed, EMBASE, Web of Science, and Scopus databases. The search strategy combined terms related to artificial intelligence, machine learning, deep learning, CAD/CAM, dental crowns, and prosthesis design. To ensure completeness, additional manual screening of the reference lists of relevant publications was performed. All articles published up to March 31, 2024, were considered, and no language restrictions were applied.

### ○ *Inclusion and Exclusion Criteria*

Studies were eligible if they were clinical or in vitro investigations that compared AI-based systems for generating tooth-supported prostheses with digital designs produced by dental technicians. Research that did not include a direct comparison between these two types of digital workflows, studies focusing exclusively on removable prostheses, or studies lacking quantitative outcome measurements were excluded.

### ○ *Outcomes of Interest*

The primary variable of interest was design efficiency, evaluated as the time required to produce a crown design. Secondary measures included occlusal morphology, similarity of cusp angles to natural dentition, internal fit, and the assessment of proximal and occlusal contacts.

### ○ *Data Extraction*

Two reviewers (C.S.A.S.M. and G.G.O.V.) independently assessed titles, abstracts, and full texts, collecting data using a predefined form. Extracted information included study characteristics, details of AI models, comparator workflows, evaluation criteria, and findings. Any disagreements were settled through discussion with a third reviewer (G.L.F.).

### ○ *Risk of Bias Assessment*

The QUIN tool was used to evaluate the methodological quality of in vitro studies.<sup>18</sup> For clinical studies, the ROB-2 tool was applied to randomized trials, and the ROBINS-I tool was used for non-randomized investigations. Because of the limited number of included studies, formal evaluation of publication bias through funnel plot analysis was not feasible; instead, potential bias was considered qualitatively.

### ○ *Statistical Analysis*

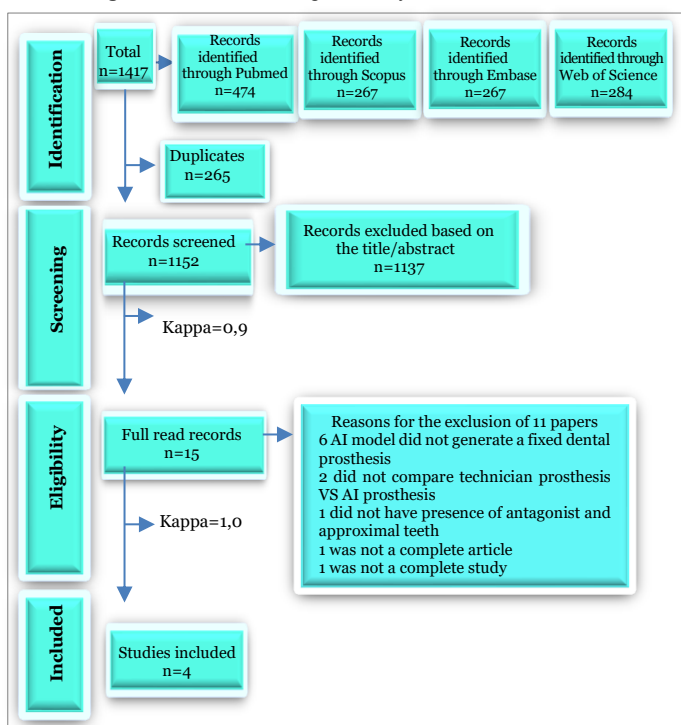
When applicable, data were synthesized using a random-effects model to account for variation across studies. Continuous outcomes were

expressed as mean differences (MDs) with corresponding 95% confidence intervals (CIs). Heterogeneity was quantified using the I<sup>2</sup> statistic, with values exceeding 75% interpreted as substantial inconsistency among studies. Planned sensitivity analyses were carried out when sufficient data were available (Table S1).

**RESULTS**

A total of 1,417 studies were initially identified through the electronic and manual search procedures. After removing 265 duplicates, 1,152 records were screened by title and abstract. Fifteen articles were reviewed in full, and four satisfied all inclusion criteria and were incorporated into the final analysis (Figure 1).

**Figure 1.** Flowchart diagram of systematic review.



Tables 1 and 2 summarize the characteristics of the included studies and the quantitative findings, respectively. The four eligible publications<sup>5,13,19,20</sup> were released between 2022 and 2024 and investigated different AI-based methods for designing fixed dental restorations. One investigation employed standardized dental models (Dental Study Model, Nissin Dental Product, Kyoto, Japan) to simulate maxillary and mandibular arch configurations<sup>20</sup>. Two studies used retrospective clinical datasets consisting of partial-arch scans from prepared posterior teeth originating from a single dental laboratory<sup>5,19</sup>. Another study generated its dataset from scanned resin models produced from impressions of twelve participants.<sup>13</sup>

Regarding the types of restorations evaluated, one study assessed multiple categories, including full crowns, mesial-occlusal-distal restorations, and inlays<sup>17</sup>, while the remaining three

focused exclusively on complete crowns<sup>5,13,19,20</sup>. Different AI approaches were compared across the studies. One compared artificial wax-up carving, AI-generated digital designs (PrintIn DentDesign, PrintIn, Taoyuan, Taiwan), and artificial digital carving<sup>20</sup>. Another contrasted a knowledge-based AI system (CEREC software v.4.6.1, biogeneric individual function; Charlotte, NC) with designs created by an experienced technician and trained dental students using CAD software<sup>13</sup>. A third compared two deep learning (DL) crown-design systems (Dentbird Crown, Imagoworks Inc., Gangnam-gu; and Automate, 3Shape Dental System, Copenhagen K, Denmark) with crowns produced manually by a trained technician using 3Shape software<sup>19</sup>.

**Table S1.** Search strategies adapted for each database.

MEDLINE/ PubMed	("Dental prosthesis design"[MeSH] OR Crown* OR Dental restoration* OR fixed prosthodontic* OR fixed dental prosth* OR fixed prosth* OR Dental prosth* OR Dental Abutment*) AND ("Artificial intelligence"[MeSH] OR "Computer Reasoning"[MeSH] OR "Machine learning"[MeSH] OR "Expert systems"[MeSH] OR "Fuzzy Logic"[MeSH] OR "Natural Language Processing" OR "Computer Neural Networks" OR "Computational Intelligence" OR "Machine Intelligence" OR "AI-based" OR "Computer Vision Systems" OR "Knowledge Acquisition" OR "Knowledge Representation" OR "Deep learning" OR "Supervised machine learning" OR "Unsupervised Machine Learning")
Embase	('tooth crown'/exp OR 'dental restoration'/exp OR 'fixed dental prosthesis'/exp OR 'tooth prosthesis'/exp OR 'dental prosthesis design' OR 'fixed prosthodontics') AND ('artificial intelligence'/exp OR 'computational intelligence'/exp OR 'artificial intelligence software'/exp OR 'machine learning'/exp OR 'deep learning'/exp OR 'supervised machine learning'/exp OR 'unsupervised machine learning'/exp OR 'expert systems'/exp OR 'fuzzy logic'/exp OR 'natural language processing'/exp OR 'artificial neural network'/exp OR 'machine intelligence' OR 'computer reasoning' OR 'computer vision systems' OR 'knowledge acquisition' OR 'knowledge representation')
Scopus	'crown' OR 'dental AND restoration' OR 'fixed AND dental AND prosthesis' OR 'dental AND prosthesis' AND 'artificial AND intelligence' OR 'computational AND intelligence' OR 'computer AND reasoning' OR 'ai-based' OR 'machine AND learning'
Web of Science	'dental prosthesis design' OR 'dental crown' OR 'dental prosthesis' OR 'fixed dental prosthesis' OR 'dental restoration' OR 'fixed prosthodontics' (All Fields) and 'artificial intelligence' OR 'machine learning' OR 'deep learning' OR 'computational intelligence' OR 'machine intelligence' OR 'AI-based' OR 'computer reasoning' (All Fields)

**Table 1.** Study characteristics of included studies.

Chen et al, 2022	
Study type	In vitro
Number of participants or dental typodonts	12 participants
Type of fixed dental prosthesis	Crown
Desktop or intraoral scanner	Intraoral scanner (CEREC AC OmniCam, Sirona Dental Systems)
AI algorithm	GANs
AI dental software design	CEREC software (v.4.6.1, Sirona Dental Systems) Biogeneric individual function
Dental technician digital software	CEREC software (v.4.6.1, Sirona Dental Systems)
Prerequisite parameters for anatomical contour crown	1) minimal occlusal thickness of 1.5 mm; 2) cement layer thickness of 50 µm.
Cho et al, 2023	
Study type	In vitro
Number of participants or dental typodonts	30 participants
Type of fixed dental prosthesis	Crown
Desktop or intraoral scanner	Intraoral scanner
AI algorithm	CNNs and GANs
AI dental software design	Dentbird Crown (Imagoworks Inc, Gangnam-gu)
Dental technician digital software	3Shape Dental System (3Shape) Auto Crown and Auto Placement functions
Prerequisite parameters for anatomical contour crown	1) minimal occlusal thickness of 1.0 mm; 2) cementation space: no internal gap at the margin extending, with 40 µm gap for inner surface; 3) margin line adaptation: 0.1 mm, 50°; 4) emergence profile: straight or slightly concave; 5) occlusal contact: 10 µm, at least one on each functional cusp and central fossa area; 6) proximal contact: -20 µm, buccolingual area, located in occlusal third

CNN: convolutional neural networks; GAN: Generative adversarial networks.

**Table 1 (continued).** Study characteristics of included studies.

Cho et al, 2024	
Study type	In vitro
Number of participants or dental typodonts	30 participants
Type of fixed dental prosthesis	Crown
Desktop or intraoral scanner	Intraoral scanner
AI algorithm	AI-1: - AI-2: CNNs and GANs
AI dental software design	AI-1: Automate (3Shape, Copenhagen K, Denmark) AI-2: Dentbird Crown (Imagoworks Inc, Gangnam-gu)
Dental technician digital software	3Shape Dental System (3Shape)
Prerequisite parameters for anatomical contour crown	1) minimal occlusal thickness of 1.0 mm; 2) cementation space: no internal gap at the margin extending, with 40 µm gap for inner surface and an additional 50 µm gap. 3) margin line adaptation: 80 µm, 50°; 4) emergence profile: straight or slightly concave; 5) occlusal contact: 0 µm on each contact point, at least one contact on every functional cusp and the central fossa area; 6) proximal contact: -20 µm, buccolingual area, located in the occlusal third.
Liu et al, 2024	
Study type	In vitro
Number of participants or dental typodonts	10 dental standard model of teeth (Dental study model, Nissin Dental Product)
Type of fixed dental prosthesis	10 dental standard model of teeth (Dental study model, Nissin Dental Product)
Desktop or intraoral scanner	15 crowns 15 mesial-occlusal-distal 15 inlays
AI algorithm	Desktop scanner (Medit T510, Medit)
AI dental software design	GANs
Dental technician digital software	PrintIn DentDesign (Printin)
Prerequisite parameters for anatomical contour crown	PrintIn DentDesign (Printin, Printin, Taoyuan Taiwan)

CNN: convolutional neural networks; GAN: Generative adversarial networks.

**Table 2.** Mean and standard deviation of outcome data characteristics about dental crowns of included studies.

Chen et al, 2022	
Number of teeth and position on arch	12 right mandibular second premolar
Number of crown samples	12
Time spent (s): recorded for crown design process	AI - Dental Technician -
3D trueness (RMS, µm): overall surface difference	AI - Dental Technician -
Occlusal surface morphology (RMS, µm)	AI 469.7 ± 51.8 Dental Technician 418.8 ± 71.3
Internal fit (RMS, µm)	AI - Dental Technician -
Finish line differences: Average distances (µm)	AI - Dental Technician -
Cusp angle (°)	AI 70.84 ± 4.31 Dental Technician 67.45 ± 5.30
Cho et al, 2023	
Number of teeth and position on arch	18 mandibular posterior teeth; 12 maxillary posterior teeth
Number of crown samples	30
Time spent (s): recorded for crown design process	AI 284.5 ± 90.5 Dental Technician 314.4 ± 91.7
3D trueness (RMS, µm): overall surface difference	AI - Dental Technician -
Occlusal surface morphology (RMS, µm)	AI 54.1 ± 25.5 Dental Technician 241.3 ± 88.9
Internal fit (RMS, µm)	AI 55.4 ± 17.1 Dental Technician 85.6 ± 29.6
Finish line differences: Average distances (µm)	AI 239.1 ± 133.3 Dental Technician 301.7 ± 216.3
Cusp angle (°)	AI - Dental Technician -
Cho et al, 2024	
Number of teeth and position on arch	14 mandibular posterior teeth; 16 maxillary posterior teeth
Number of crown samples	30
Time spent (s): recorded for crown design process	AI 284.5 ± 90.5 Dental Technician 314.4 ± 91.7
3D trueness (RMS, µm): overall surface difference	AI - Dental Technician -
Occlusal surface morphology (RMS, µm)	AI 54.1 ± 25.5 Dental Technician 241.3 ± 88.9
Internal fit (RMS, µm)	AI 55.4 ± 17.1 Dental Technician 85.6 ± 29.6
Finish line differences: Average distances (µm)	AI 239.1 ± 133.3 Dental Technician 301.7 ± 216.3
Cusp angle (°)	AI - Dental Technician -

s: seconds; RMS: root mean squared error.

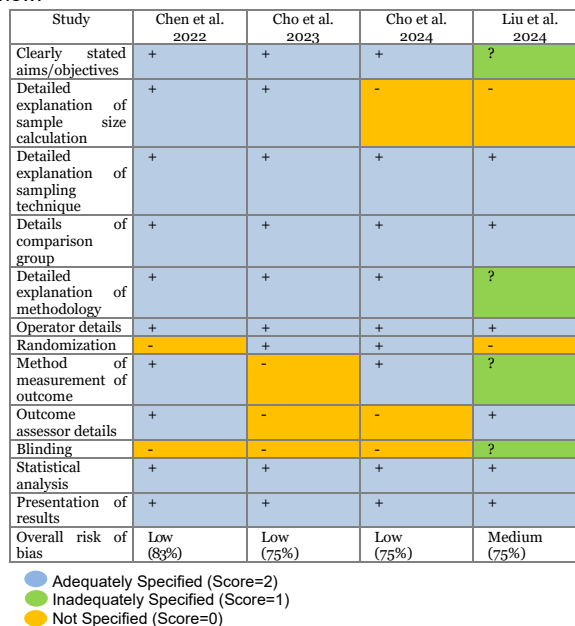
**Table 2 (continued).** Mean and standard deviation of outcome data characteristics about dental crowns of included studies.

Liu et al, 2024		
Number of teeth and position on arch	5 right maxillary first molar	
Number of crown samples	10	
Time spent (s): recorded for crown design process	AI	60s ± 5
	Dental Technician	300s ± 20
3D trueness (RMS, µm): overall surface difference	AI	68.4
	Dental Technician	51.0
Occlusal surface morphology (RMS, µm)	AI	-
	Dental Technician	-
Internal fit (RMS, µm)	AI	-
	Dental Technician	-
Finish line differences: Average distances (µm)	AI	-
	Dental Technician	-
Cusp angle (°)	AI	-
	Dental Technician	-

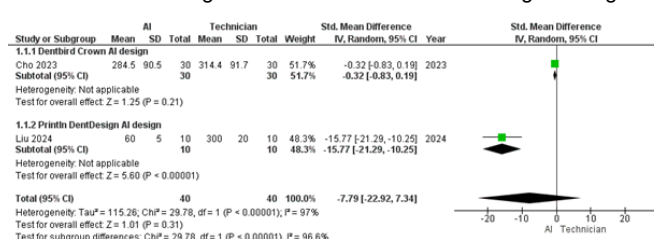
s: seconds; RMS: root mean squared error.

The fourth study evaluated a GAN-based software system (Dentbird Crown, Imagoworks Inc.) against a conventional CAD system from the same manufacturer<sup>20</sup>. The risk-of-bias assessment (Figure 2) indicated that three studies<sup>5,19,20</sup> demonstrated moderate risk of bias, while one<sup>13</sup> was considered to have high overall risk. All four studies contributed data to the assessment of occlusal contacts, internal fit and marginal adaptation, and design time.

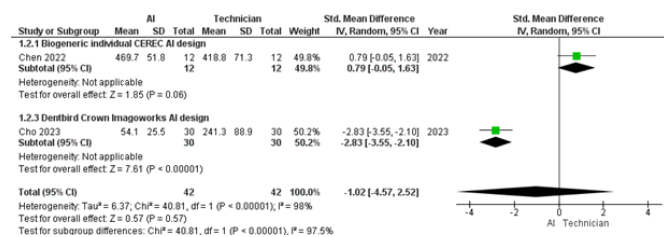
**Figure 2.** Risk of bias assessment of studies included on systematic review.



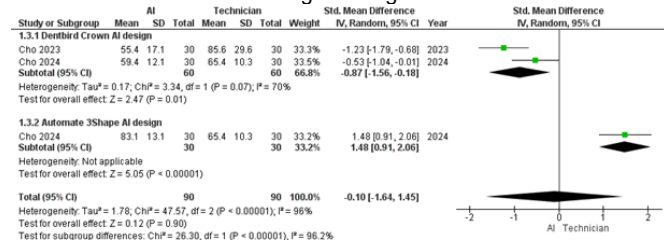
**Figure 3.** Meta-analysis and forest plot of time spent in seconds recorded for designing crown process on digital design program of crown AI-based design and dental technician-based digital design.



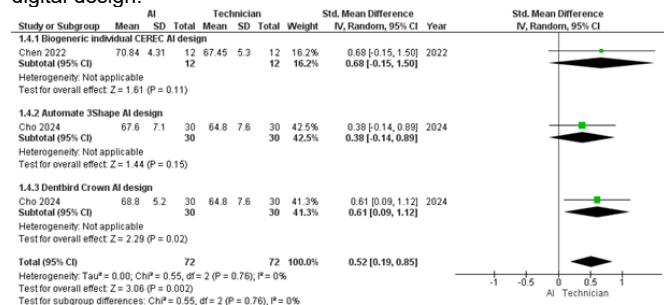
**Figure 4.** Meta-analysis and forest plot of occlusal morphology of virtual crowns in root mean square error, comparing AI-based design and dental technician-based digital design.



**Figure 5.** Meta-analysis and forest plot of internal fit of finalized digital crown in root mean square error, of crown AI-based design and dental technician-based digital design.



**Figure 6.** Meta-analysis and forest plot of functional cuspal angle formed between the cusp plane and longitudinal axis of the tooth in degrees, of crown AI-based design and dental technician-based digital design.



The meta-analysis revealed substantial heterogeneity across most evaluated outcomes ( $I^2 > 96\%$ ) (Figures 3-6). No significant differences were detected between AI-based and technician-based digital designs in terms of design time (standardized mean difference [SMD]  $-7.79$ ; 95% CI  $-22.92$  to  $7.34$ ;  $P = .31$ ), occlusal morphology (SMD  $-1.02$ ; 95% CI  $-4.57$  to  $2.52$ ;  $P = .57$ ), or internal fit of the final restorations (SMD  $-0.10$ ; 95% CI  $-1.64$  to  $1.45$ ;  $P = .90$ ). However, AI-generated crowns demonstrated a statistically significant difference in functional cuspal angle (SMD  $0.52$ ; 95% CI  $0.19$  to  $0.85$ ;  $P = .002$ ), suggesting greater consistency in this specific morphological parameter.

Overall, the findings highlight the feasibility of AI-driven crown design but also underscore the limited number of available studies and the methodological variability that limits generalizability of the pooled results.

## DISCUSSION

This systematic review provides an updated synthesis of the available evidence comparing crown designs generated by AI-based systems with those produced by dental technicians using digital

software. Overall, the results indicate that the performance of AI-assisted workflows is largely comparable to technician-led designs, and the null hypothesis, that no significant differences would be observed in occlusal morphology or internal fit, was not rejected. Although AI demonstrated a significant difference in functional cuspal angle, this finding was not consistently reflected across other evaluated parameters.

The meta-analysis showed no statistically significant differences between the two design approaches for design time (MD  $-7.79$ ; 95% CI  $-22.92$  to  $7.34$ ;  $P = .31$ ), occlusal morphology (MD  $-1.02$ ; 95% CI  $-4.57$  to  $2.52$ ;  $P = .57$ ), or internal fit (MD  $-0.10$ ; 95% CI  $-1.64$  to  $1.45$ ;  $P = .90$ ). Heterogeneity levels were very high ( $I^2 > 96\%$ ) for most outcomes, suggesting substantial methodological variability among the included studies. The only consistent statistically significant result was observed for functional cuspal angle (MD  $0.52$ ; 95% CI  $0.19-0.85$ ;  $P = .002$ ;  $I^2 = 0\%$ ), indicating that AI may generate cusp inclinations with more uniformity than human designers.

These findings illustrate the developing capabilities and current limitations of AI in prosthodontic design. AI-driven systems appear able to replicate many anatomical features of natural teeth with accuracy like that achieved by trained technicians. This suggests that AI may serve as a support tool within digital workflows, particularly in situations where standardized morphology or reduced manual workload is desired. For example, AI-assisted CAD/CAM procedures have been associated with reductions in time-consuming manual adjustments and may help alleviate the cognitive burden placed on technicians by complex virtual design tasks<sup>5,7,12</sup>.

When contextualized with prior literature, the results of this review highlight the variability observed across studies examining AI in prosthodontics. Cho et al.<sup>5</sup> reported improved design efficiency with an AI-assisted approach, noting that automation in margin identification and occlusal adjustment contributed to reductions in overall working time. Conversely, Chen et al.<sup>13</sup> found that crowns generated by experienced technicians exhibited closer resemblance to original tooth morphology than those produced by knowledge-based AI, underscoring the influence of operator expertise and the limitations of training datasets. Liu et al.<sup>20</sup> demonstrated favorable reproducibility and satisfactory internal adaptation for AI-generated crowns but acknowledged that these advantages may vary depending on case complexity and software architecture. Together, these findings reflect a mixed but promising landscape, with AI showing the ability to enhance precision and efficiency without consistently surpassing technician-driven methods<sup>8,14</sup>.

Several factors may explain the inconsistency of outcomes among the included studies. Differences in AI algorithms (knowledge-based, deep learning, GAN-driven), variations in CAD/CAM software, and the diverse nature of the evaluation protocols contribute to the observed heterogeneity. Additionally, the studies included small sample sizes and often relied on in vitro designs, which limits the robustness and generalizability of their conclusions. Methodological discrepancies, including differences in tooth type, preparation design, scan quality, and reference datasets, further complicate cross-study comparisons and interpretation of pooled results.

Despite these limitations, the integration of AI into prosthodontic workflows remains a promising development. Automated crown design has the potential to support dental technicians by improving standardization, reducing manual labor, and enhancing efficiency. As AI tools continue to evolve, they may also facilitate more personalized and data-driven design processes, enabling improved accuracy and reproducibility. Importantly, these technologies are likely to function as complementary aids rather than replacements for skilled professionals, who remain essential for supervising, validating, and adjusting AI-generated proposals.

In summary, the findings of this systematic review suggest that AI-based crown design can produce outcomes comparable to traditional technician-guided digital methods, with possible benefits in specific morphological parameters such as functional cuspal angle. However, the limited number of available studies and the substantial variability highlight the need for additional high-quality clinical research. Future investigations should employ standardized methodologies, larger and more diverse datasets, and clear reporting protocols to more definitively determine the role and reliability of AI in fixed prosthodontic design.

## CONCLUSION

Within the limits of the available evidence, AI-based crown design demonstrated performance comparable to that of restorations digitally created by trained dental technicians. No significant differences were observed between the two approaches for design time, occlusal morphology, or internal adaptation. AI-generated crowns showed greater consistency in functional cuspal angles, although this finding was not uniform across all evaluated parameters.

While the current results support the feasibility of integrating AI into digital prosthodontic workflows, the small number of studies and substantial methodological variability limit the strength of the conclusions. Additional well-designed clinical investigations are needed to clarify the reliability, accuracy, and clinical relevance of AI-assisted fixed prosthesis design.

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## CONFLICT OF INTERESTS

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The authors declare no conflict of interest.

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