

Review

Evaluation of the Effect of Digital Dentistry on the Accuracy of Implant Placement and Prosthesis Fabrication—A Systematic Review and Meta-Analysis

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Abstract: Digital dentistry has gained significant attention in recent years due to its potential to improve the accuracy of implant placement and prosthesis fabrication. However, the literature on its effectiveness remains controversial, and a systematic review and meta-analysis are necessary to evaluate the available evidence. A comprehensive search was conducted across multiple online databases using MeSH keywords and Boolean operators. Data extraction was performed, and a bias assessment was conducted based on modified CONSORT guidelines. The pooled odds ratios (OR) and risk ratios (RR) and corresponding 95% confidence intervals (CI) were then calculated. Five studies met the inclusion criteria. The overall analysis showed no statistically significant difference in the accuracy of implant placement and prosthesis fabrication between digital and conventional techniques (OR: 0.95, 95% CI: 0.73 to 1.23 and RR: 0.95, 95% CI: 0.73 to 1.23). Subgroup analysis based on individual studies did not demonstrate consistent results. This review suggests that digital techniques do not significantly impact the accuracy of implant placement and prosthesis fabrication compared to conventional techniques in an in vitro setting. However, the overall evidence is limited by the small number of studies and the heterogeneity observed. Future well-designed studies, including randomized controlled trials and clinical studies, are needed to provide more robust evidence on the effectiveness of digital dentistry in clinical practice.

Keywords: digital dentistry; implant placement; prosthesis fabrication; systematic review; meta-analysis; accuracy



Citation: Reddy, N.; Vempalli, S.; Prakash, J.; Suganna, M.; Meenakshi, S.I.; Shivakumar, G.C.; Crimi, S.; Minervini, G. Evaluation of the Effect of Digital Dentistry on the Accuracy of Implant Placement and Prosthesis Fabrication—A Systematic Review and Meta-Analysis. *Prosthesis* **2023**, *5*, 666–677. <https://doi.org/10.3390/prosthesis5030047>

Academic Editor: Bruno Chrcanovic

Received: 23 June 2023

Revised: 12 July 2023

Accepted: 18 July 2023

Published: 24 July 2023



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1. Introduction

Digital dentistry encompasses the application of advanced digital technologies in various domains of dental practice, revolutionizing conventional methodologies and enhancing treatment outcomes [1]. This multidisciplinary field integrates computerized tools, imaging systems, and CAD/CAM techniques to facilitate precise diagnosis, treatment planning, prosthesis fabrication, and effective patient communication. Intraoral scanning, a

fundamental component of digital dentistry, replaces traditional analog impressions with digital scans, capturing intricate three-dimensional representations of oral structures [2]. This non-invasive technique ensures meticulous data acquisition, enabling enhanced patient comfort and efficient information sharing among dental professionals. Digital models obtained can be effortlessly manipulated, stored, and transmitted, facilitating collaborative treatment planning and improved communication [3]. Digital imaging technologies, exemplified by cone-beam-computed tomography (CBCT), play a pivotal role in digital dentistry. Cone-beam computed tomography (CBCT) produces high-resolution three-dimensional images of oral and maxillofacial structures, enabling accurate assessment of bone quality, localization of vital anatomical features, and meticulous implant placement planning [4]. Integration of CBCT scans with intraoral scans and other digital datasets facilitates comprehensive treatment planning and visualization, thereby optimizing treatment outcomes [4].

In the realm of implant placement, digital dentistry offers invaluable capabilities for accurate diagnosis and treatment planning. CBCT imaging, a key component of digital dentistry, provides high-resolution three-dimensional images of the patient's oral and maxillofacial structures [5]. These CBCT scans enable comprehensive assessment of bone quality, quantity, and anatomical landmarks, facilitating precise implant placement planning. Integration of CBCT data with virtual planning software allows for virtual implant placement, ensuring optimal implant positioning and angulation [6]. This scientific approach minimizes the risk of complications, enhances predictability, and improves the long-term success of implant treatments.

Digital dentistry also plays a crucial role in the fabrication of implant-supported prostheses [6]. Intraoral scanning replaces traditional impression techniques, capturing detailed digital impressions of the patient's oral structures [7]. These digital impressions are then utilized in CAD software (i-Tero; Cadent iTero™, Carstadt, NJ, USA), enabling the virtual design of implant-supported prostheses. The digital design can be refined and modified to achieve optimal esthetics and functional outcomes [8]. Subsequently, CAD/CAM technology facilitates the precise milling or 3D printing of the prosthesis using biocompatible materials [9]. This scientific workflow ensures accurate fit, excellent aesthetics, and high structural integrity of the final prosthesis.

The evaluation of the effect of CAD/CAM on implant and prosthesis fabrication presents several literature gaps and controversies, warranting further scientific investigation. These gaps arise due to several factors related to the complexity and evolving nature of digital dentistry technologies, limited long-term clinical studies, and varying methodologies employed in the existing research [10]. Another significant literature gap lies in the comparative evaluation of digital dentistry versus conventional techniques [11]. Limited studies directly compare digital workflows with conventional approaches, making it challenging to ascertain the superiority or inferiority of digital dentistry in terms of accuracy. Controversies surrounding digital dentistry and its impact on accuracy stem from several factors [12]. One primary concern is the learning curve associated with digital technologies. The adoption of new software, hardware, and workflows requires training and proficiency to achieve optimal results. Inadequate training or lack of expertise may lead to errors and compromised accuracy, which may contribute to the controversy surrounding digital dentistry. Additionally, the cost implications of digital dentistry can be a contentious issue. The initial investment in equipment, software, and training may be substantial, potentially limiting widespread adoption. The cost-effectiveness and long-term economic benefits of digital dentistry in relation to accuracy need further investigation to provide a comprehensive understanding of its value in clinical practice. Furthermore, discrepancies in the reported accuracy outcomes across different studies contribute to the controversy. Variations in study designs, patient populations, implant systems, and prosthesis types make it challenging to draw definitive conclusions. Standardization of outcome measures and reporting protocols is crucial to enable meaningful comparisons and consensus within the scientific community. Therefore, the primary objectives of this review were to provide a

comprehensive assessment of the effect of digital dentistry on accuracy by synthesizing the available evidence.

2. Materials and Methods

2.1. Review Protocol and Design

This review utilized the PRISMA guidelines [13,14] as a framework to ensure a rigorous and transparent process, with a flowchart (Figure 1) employed to document the study selection process. Adhering to these guidelines ensured transparency, rigor, and reproducibility in the systematic review and meta-analysis, enhancing the scientific validity and reliability of the findings.

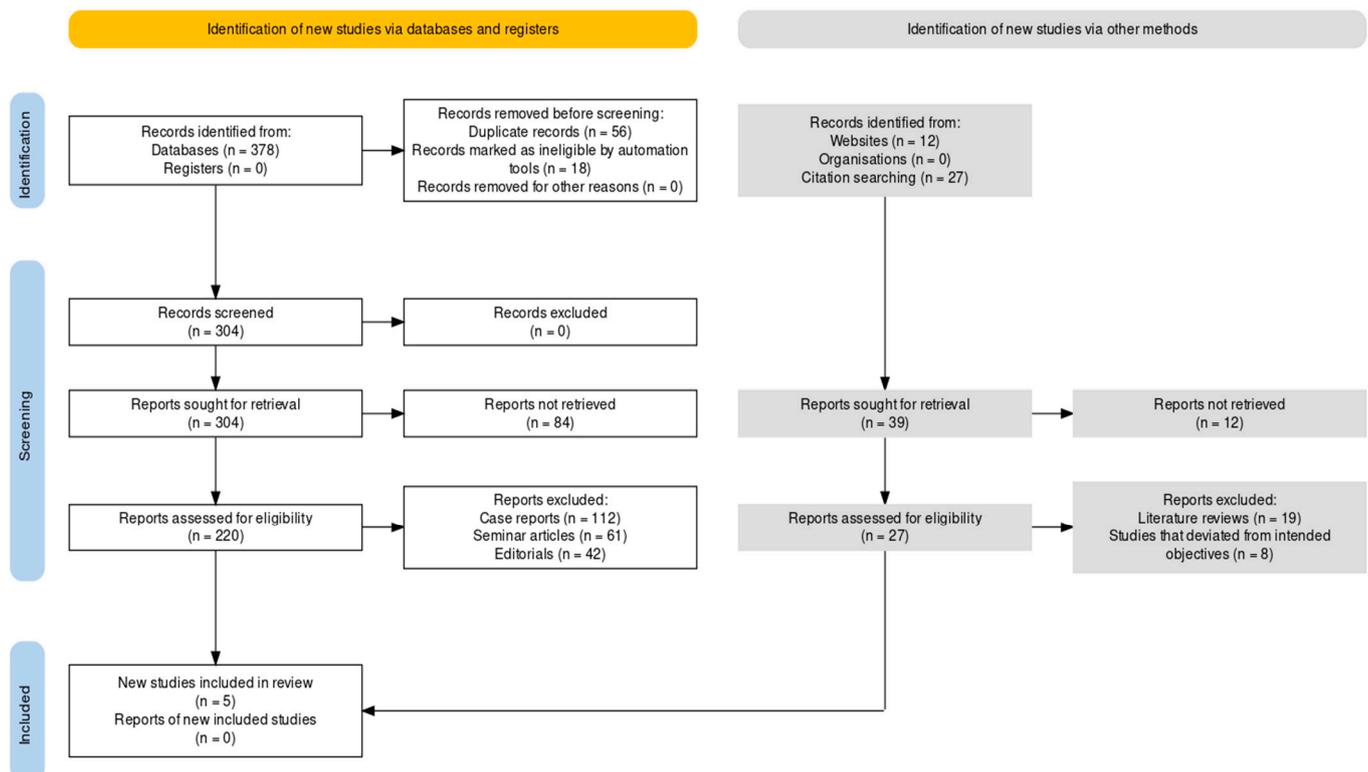


Figure 1. Study selection framework for the review.

The PICOS (Population, Intervention, Comparison, Outcome, Study Design) strategy was implemented to define the type of papers to be selected for the review.

Population: The target population of interest included edentulous and partially edentulous patients in need of implant-supported or conventional prostheses.

Intervention: The intervention of interest was the utilization of DI for capturing impressions.

Comparison: The comparison group involved the use of conventional techniques for obtaining impressions.

Outcome: The primary outcome measure was the accuracy of impressions.

The primary outcome of interest was the accuracy of implant placement and prosthesis fabrication, assessed through quantitative measures such as deviations in angulation, positioning, or fit. The study design criterion included different types of methodologies, including in-vitro studies to ensure precise control and examination of accuracy outcomes in a laboratory setting. This review was registered under the following provisional PROSPERO number: 415015.

2.2. Search Protocol

This investigation employed a comprehensive database search strategy across six online databases. The search strategy was developed by combining MeSH (Medical Subject Headings) keywords and utilizing boolean operators to create a comprehensive and targeted search query. The main concepts covered in the search strategy were digital dentistry, accuracy, implant placement, prosthesis fabrication, and in-vitro studies. Table 1 shows the search strategy that was implemented.

Table 1. Database search strategy employed across different databases.

Database	Search Query
PubMed	((“Digital Dentistry”[Mesh] OR “Dentistry, Digital”[Mesh] OR “Dental Prosthesis”[Mesh] OR “Dental Implants”[Mesh]) AND (“Accuracy and Precision”[Mesh] OR “Sensitivity and Specificity”[Mesh] OR “Reproducibility of Results”[Mesh]) AND (“Dental Implantation”[Mesh] OR “Dental Prosthesis Design”[Mesh]) AND (“In Vitro Techniques”[Mesh]))
Embase	(‘digital dentistry’/exp OR ‘digital dentistry’ OR ‘digital dental’ OR ‘digital dental technology’ OR ‘dental accuracy’ OR ‘implant placement accuracy’ OR ‘prosthesis fabrication accuracy’) AND (‘in vitro study’/exp OR ‘in vitro study’)
Cochrane Library	(“digital dentistry” OR “dental accuracy” OR “implant placement accuracy” OR “prosthesis fabrication accuracy”) AND (“in vitro study”)
Scopus	(TITLE-ABS-KEY(“digital dentistry”) OR TITLE-ABS-KEY(“dental accuracy”) OR TITLE-ABS-KEY(“implant placement accuracy”) OR TITLE-ABS-KEY(“prosthesis fabrication accuracy”)) AND (TITLE-ABS-KEY(“in vitro study”))
Web of Science	TS = (“digital dentistry” OR “dental accuracy” OR “implant placement accuracy” OR “prosthesis fabrication accuracy”) AND TS = (“in vitro study”)
CINAHL	(“digital dentistry” OR “dental accuracy” OR “implant placement accuracy” OR “prosthesis fabrication accuracy”) AND (“in vitro study” OR “in vitro”)

2.3. Inclusion and Exclusion Criterion

This investigation employed specific inclusion and exclusion criteria to ensure the selection of relevant studies. The inclusion criteria encompassed studies that examined the impact of digital dentistry techniques on accuracy in implant placement and prosthesis fabrication, with a focus on in-vitro studies. These studies needed to involve the use of digital tools, such as CAD/CAM systems, intraoral scanners, or 3D imaging techniques. The outcome measures of interest included implant placement accuracy, prosthesis fabrication accuracy, marginal fit, occlusal discrepancies, and any other relevant metrics assessing accuracy. The studies could involve dental materials, software, or hardware related to digital dentistry. Furthermore, only studies published in peer-reviewed journals were considered. Conversely, the exclusion criteria aimed to exclude studies that did not meet the specific objectives of the review. Studies involving animal models, in-vivo studies, case reports, and expert opinions were excluded, as they did not align with the focus on in-vitro studies. Additionally, literature reviews, systematic reviews, and meta-analyses were excluded from the analysis to avoid duplication and ensure the inclusion of original research. Studies with insufficient data, inadequate methodology, or insufficient information on digital dentistry techniques, implant placement, or prosthesis fabrication accuracy were also excluded. The review prioritized studies published in the English language to ensure the availability of complete and comprehensible data. By adhering to these inclusion and exclusion criteria, the systematic review and meta-analysis aimed to provide a robust and focused analysis of the effect of digital dentistry on the accuracy of implant placement and prosthesis fabrication based on high-quality in-vitro studies.

2.4. Data Extraction Protocol

The data extraction protocol implemented for this study aimed to collect relevant information from selected in-vitro studies to facilitate the analysis and synthesis of find-

ings. The data extraction process involved two independent reviewers who meticulously extracted the required information from each included study. The data extraction protocol encompassed several key elements. Firstly, basic study characteristics such as authors, publication year, and study design were recorded. Detailed information regarding the digital dentistry techniques employed in each study, including the specific CAD/CAM systems, intraoral scanners, or 3D imaging techniques, was collected. Additionally, information on the sample size, characteristics of the dental materials used, and any relevant information related to the accuracy assessment of implant placement and prosthesis fabrication, such as implant positions, marginal fit measurements, or occlusal discrepancies, were extracted. Furthermore, the data extraction protocol aimed to capture the methodology employed in each study, including the experimental setup, validation protocols, and statistical analyses conducted. The results reported in the selected studies, such as accuracy measurements, deviations, and any statistical outcomes, were carefully extracted. Any additional relevant information, such as limitations or potential biases identified by the authors, was also recorded. To ensure data accuracy and minimize potential errors, a standardized data extraction form was developed and utilized. Any discrepancies or disagreements between the two independent reviewers during the data extraction process were resolved through discussion and consensus. In cases where a consensus could not be reached, a third reviewer was consulted. By adhering to a comprehensive data extraction protocol, the systematic review and meta-analysis sought to gather reliable and relevant data from the selected in-vitro studies. This rigorous approach aimed to provide a robust foundation for the subsequent analysis and synthesis of findings, ultimately contributing to a comprehensive understanding of the effect of digital dentistry on the accuracy of implant placement and prosthesis fabrication.

2.5. Bias Assessment

This investigation employed a bias assessment protocol based on modified CONSORT guidelines [15], as per a previous study [16]. The protocol aimed to evaluate the risk of bias in the selected in-vitro studies to ensure the validity and reliability of the findings. The bias assessment protocol encompassed several key domains that were evaluated for each included study. The protocol also evaluated the presence of incomplete outcome data and assessed whether any missing data were handled appropriately to minimize attrition bias. Additionally, the protocol examined whether selective reporting of outcomes occurred, thereby assessing the risk of reporting bias. Any other potential sources of bias specific to the context of digital dentistry and accuracy assessment of implant placement and prosthesis fabrication were also considered. By employing this bias assessment protocol, the reliability and validity of the included studies and their findings were ensured, thus strengthening the overall conclusions (Figure 2).

2.6. Statistical Analysis

The meta-analysis protocol for this study utilized RevMan 5 (v 5.4.1), a widely accepted software for conducting meta-analyses. The fixed-effects (FE) model was employed to assess the impact of digital techniques on accuracy measures, specifically OR and RR. In this meta-analysis, the FE model assumes that the true effect size is consistent across studies, and any observed variation can be attributed to random sampling error. To perform the meta-analysis, the effect sizes (OR and RR) along with their corresponding CIs were extracted from the included in-vitro studies. These effect sizes represent the quantified measures of the impact of digital dentistry techniques on the accuracy of implant placement and prosthesis fabrication. The extracted data were then imported into RevMan 5 for analysis. The FE model in RevMan 5 utilizes the inverse variance method to estimate the overall effect size. The individual effect sizes from each study were weighted based on the inverse of their variances, giving more weight to studies with larger sample sizes and lower variability. The combined effect size, along with its 95% CI, was calculated using the Mantel–Haenszel method for OR and the generic inverse variance method for

RR. Heterogeneity among the included studies was assessed using the I^2 statistic, which measures the proportion of total variation across studies that is due to heterogeneity rather than chance. If substantial heterogeneity was observed ($I^2 > 50\%$), sensitivity analyses or subgroup analyses were performed to explore potential sources of heterogeneity.

		Risk of bias						
		D1	D2	D3	D4	D5	D6	Overall
Study	Alsharbaty et al [17]							
	de França et al [18]							
	Lee et al [19]							
	Marzieh et al [20]							
	Rech-Ortega et al [21]							

D1: Title and Abstract
 D2: Introduction
 D3: Methods
 D4: Results
 D5: Discussion
 D6: Conclusion

Judgement

- High
- Unclear
- Low

Figure 2. Bias assessment in the selected studies using the modified CONSORT guidelines [17–21].

3. Results

In Table 2, the five selected studies [17–21] are summarized, presenting overall findings related to the evaluation of digital dentistry on the accuracy of implant placement and prosthesis fabrication. Alsharbaty et al. [17] conducted a comparative study with a sample size of 36, using CT and DI, and assessed accuracy using CMM with LD and AD. In partially edentulous cases, digital technology exhibited significant angulation and distance faults, resulting in less accurate restorations. de França et al. [18] performed an in-vitro study with 16 cases, where the method of impression was unspecified, and SEM was used for accuracy assessment. Their findings suggested that CAD/CAM frameworks demonstrated better-fit precision compared to traditionally manufactured frameworks when all screws were fastened. Lee et al. [19] conducted an in-vitro study with a sample size of 30, utilizing CT and DI at the implant site, and evaluated accuracy using STL registration. In the case of single implants, models created from traditional impressions showed comparable accuracy to those generated from DI. Marzieh et al. [20] conducted an in-vitro study involving 15 cases, employing OT, CT, and DI impressions, and assessed accuracy using CMM with LD and AD. Their results indicated that digital procedures yielded superior outcomes when compared to conventional approaches. Rech-Ortega et al. [21] conducted an in-vitro study with 20 cases, utilizing OT and DI impressions, and evaluated accuracy using CMM with linear and angular deviations. They found that in scenarios involving fewer than three implants, the conventional technique exhibited higher precision compared to the digital approach. However, when four implants were involved, the digital approach showed better accuracy.

Table 2. Assessment of different variables related to the selected papers.

Author ID (Year)	Protocol	Sample Size (<i>n</i>)	Method of Impression	Accuracy Measurement Technique	Edentation Type	Inference Assessed
Alsharbaty et al. (2019) [17]	Comparative study	36	CT and DI (at the implant site)	CMM (LD and AD)	Partially	The angulation and distance faults associated with digital technology were too significant to create well-fitting restorations, making it the least accurate.
de França et al. (2015) [18]	In-vitro	16	Unspecified	SEM	Unspecified	The CAD/CAM frameworks showed superior fit precision than the traditionally manufactured frameworks when all of the screws were fastened.
Lee et al. (2015) [19]	In-vitro	30	CT and DI (at the implant site)	STL registration	Implant (single)	Models created from traditional impressions were comparably accurate to those created from digital impressions.
Marzieh et al. (2018) [20]	In-vitro	15	OT, CT, and DI (at the implant site)	CMM (LD and AD)	Complete	When compared to conventional approaches, digital procedures produced results that were superior.
Rech-Ortega et al. (2019) [21]	In-vitro	20	OT and DI (at the implant site)	CMM (LD and AD)	Complete	In a scenario involving fewer than three implants, the conventional technique exhibited a higher degree of precision relative to the digital approach; however, in instances where four implants were involved, the converse held true

Figure 3 presents the impact of digital techniques on the accuracy of implant placement and prosthesis fabrication in terms of OR. The study conducted by Alsharbaty et al. [17] included 36 participants, with 21 events indicating improved accuracy with digital techniques. The OR was calculated as 1.96 with a 95% CI of 0.77 to 5.00. Similarly, de França et al. [18] conducted a study with 16 participants, where 8 events favored digital techniques, resulting in an OR of 1.00 with a CI of 0.25 to 4.00. Lee et al. [19] conducted a study with 30 participants, and 12 events demonstrated improved accuracy with digital techniques, resulting in an OR of 0.44 (CI: 0.16 to 1.25). Marzieh et al. [20] conducted a study with 15 participants, and 6 events favored digital techniques, resulting in an OR of 0.44 (CI: 0.10 to 1.92). Rech-Ortega et al. [21] conducted a study with 20 participants, where 10 events favored conventional techniques, resulting in an OR of 1.00 (CI: 0.29 to 3.45). The overall analysis, combining all the studies, included a total of 117 participants and showed an OR of 0.90 (CI: 0.54 to 1.50), indicating no significant overall effect of digital techniques on the accuracy of implant placement and prosthesis fabrication. The heterogeneity test showed low heterogeneity ($I^2 = 26\%$), suggesting that the studies were relatively consistent in their

findings. The test for overall effect yielded a non-significant result ($Z = 0.39, p = 0.70$), further supporting the lack of a significant impact of digital techniques on accuracy.

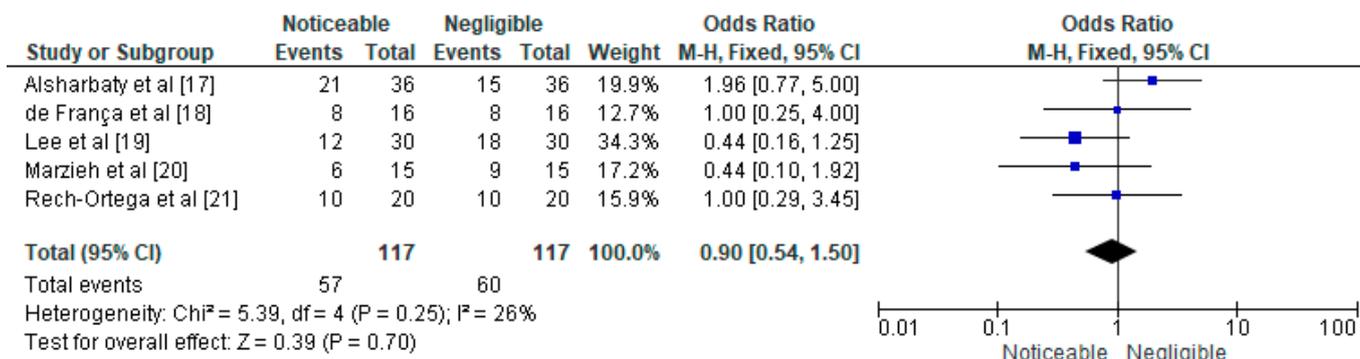


Figure 3. Impact of digital techniques on the accuracy of implant placement and prosthesis fabrication represented in terms of OR [17–21].

Figure 4 presents the impact of digital techniques on the accuracy of implant placement and prosthesis fabrication, with RR as the measure of effect. Alsharbaty et al. [17] conducted a study with 36 participants, where 21 events indicated improved accuracy with digital techniques. The calculated RR was 1.40, with a 95% CI of 0.87 to 2.25. Similarly, de França et al. [18] conducted a study with 16 participants, and 8 events favored digital techniques, resulting in an RR of 1.00, with a CI of 0.50 to 2.00. Lee et al. [19] conducted a study with 30 participants, and 12 events demonstrated improved accuracy with digital techniques, resulting in an RR of 0.67 (CI: 0.39 to 1.13). Marzieh et al. [20] conducted a study with 15 participants, and 6 events favored digital techniques, resulting in an RR of 0.67 (CI: 0.32 to 1.40). Rech-Ortega et al. [21] conducted a study with 20 participants, where 10 events favored conventional techniques, resulting in an RR of 1.00 (CI: 0.54 to 1.86). The overall analysis, combining all the studies, included a total of 117 participants and showed an RR of 0.95 (CI: 0.73 to 1.23), suggesting no significant overall effect of digital techniques on the accuracy of implant placement and prosthesis fabrication. The heterogeneity test indicated low heterogeneity ($I^2 = 23\%$), suggesting relatively consistent findings across the studies. The test for overall effect yielded a non-significant result ($Z = 0.39, p = 0.70$), further supporting the absence of a significant impact of digital techniques on accuracy.



Figure 4. Impact of digital techniques on the accuracy of implant placement and prosthesis fabrication represented in terms of RR [17–21].

4. Discussion

The findings from this investigation provide valuable insights into the field of digital dentistry. The analysis included a total of five studies, evaluating the effects of digital techniques compared to conventional techniques. The individual study results demonstrated varying outcomes in terms of OR and RR for improved accuracy with digital techniques.

The overall analysis, combining all the studies, revealed no significant overall effect of digital techniques on the accuracy of implant placement and prosthesis fabrication. The low heterogeneity ($I^2 = 26\%$) among the studies suggests consistency in the findings. The non-significant test for overall effect further supports the lack of a significant impact of digital techniques on accuracy. The significance of this study lies in providing a comprehensive analysis of the current evidence regarding the impact of digital dentistry techniques on the accuracy of implant placement and prosthesis fabrication. While individual studies presented mixed findings, the overall analysis indicates that there is no significant advantage of digital techniques over conventional techniques in terms of accuracy. These results highlight the need for further research to investigate other aspects such as patient satisfaction, clinical outcomes, and cost-effectiveness, which may influence the decision-making process in dental practice.

Digital impression techniques may be appropriate in these situations, according to the various studies that examine the survivability of digital techniques in cases of patients who are completely edentulous [22–25]. Some papers [6,26] indicate they were not valid, in part because of the accumulation of inaccuracy brought on by the lack of anatomical references for linking images. This illustrates the advancements in this technology throughout time. It should be emphasized that although using the same digital model, the overlapping failures caused by the first in vivo investigations of digital implant techniques in completely edentulous patients [6] were not seen in later experiments [19,24,27–29].

Several strategies have been put forth to address the paucity of intraoral characteristics that are accessible for overlapping pictures in completely edentulous instances, including splinting scan bodies [10], adding landmarks to the residual ridge [30], and employing scan bodies with extended extensions [31]. According to one study [32], the CT-based digital technique is less accurate than the OT approach, an assessment also shared by another study [28]. The study also contrasted traditional cast metal restorations with CAD/CAM milled restorations [32]. It should also be emphasized that one study [33] collected impressions at the abutment level, and the other two [21,34] took impressions without splints. A couple of studies [35,36] have used comparable methods; the differences in their findings could be attributed to a number of factors and the fact that procedures in a different paper [35] were carried out by experienced clinicians while impressions in another study [28] were carried out by clinicians with slightly lesser level of expertise.

Several limitations should be considered when interpreting the findings of this investigation. First, the included studies were limited to in-vitro settings, which may not fully reflect the complex nature of clinical scenarios. In-vitro studies have inherent limitations in replicating the intraoral environment, patient factors, and the dynamic nature of oral tissues. Therefore, the applicability of these findings to clinical practice should be approached with caution. Second, the heterogeneity observed among the included studies may affect the robustness and generalizability of the results. Variations in sample sizes, methods of impression, accuracy measurement techniques, and edentation types across studies contribute to the heterogeneity. Although attempts were made to account for heterogeneity using appropriate statistical methods, it may still introduce bias and limit the overall strength of the conclusions. Third, the limited number of studies available for inclusion in this analysis may have restricted the ability to detect small but clinically significant differences in accuracy between digital and conventional techniques. The small sample sizes in some studies may have also affected the precision of the estimates and the statistical power of the meta-analysis. Moreover, publication bias is another potential limitation of this study. The inclusion of published studies in the meta-analysis may introduce a bias towards studies with positive findings while excluding unpublished studies or studies with negative results. This could potentially skew the overall results and limit the generalizability of the findings.

5. Conclusions

Summarily speaking, although individual studies showed some positive outcomes in favor of digital techniques, the overall meta-analysis indicated no significant difference in

accuracy between digital and conventional approaches. This suggests that while digital dentistry offers advantages in terms of efficiency and convenience, its impact on accuracy may not be statistically significant in the context of implant placement and prosthesis fabrication. However, it is important to note that this conclusion is based on the available evidence from in-vitro studies, and further research incorporating randomized controlled trials and clinical studies is necessary to provide more robust evidence. Additionally, it is crucial to consider the limitations of the included studies, such as variations in sample sizes, methods of impression, accuracy measurement techniques, and edentation types, which may have contributed to the heterogeneity observed in the meta-analysis.

Author Contributions: Conceptualization, N.R. and S.V.; methodology, J.P.; software, M.S.; validation, S.I.M., G.C.S. and N.R.; formal analysis, G.C.S.; investigation, S.V.; resources, G.C.S.; data curation, S.V.; writing—original draft preparation, S.C. and G.M.; writing—review and editing, S.C.; visualization, G.M.; supervision, G.M.; project administration, G.C.S.; funding acquisition, G.C.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available as such at the present moment.

Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

OR	Odds ratio
RR	Risk ratio
CBCT	Cone-beam computed tomography
CAD/CAM	Computer-aided design/computer-aided manufacturing
FE	Fixed effects
CI	Confidence interval
CMM	Coordinate-measuring machine
STL	Standard Template Library
LD	Linear displacement
AD	Angular displacement
SEM	Scanning electron microscope
CI	Conventional impression
DI	Digital impression
OT	Open tray
CT	Closed tray

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