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SYSTEMATIC REVIEW

Clinical outcomes of digital scans versus conventional impressions for implant-supported fixed complete arch prostheses: A systematic review and meta-analysis

Isabella Neme Ribeiro dos Reis, DDS, PhD,[a] Camila Nogueira Chamma-Wedemann, DDS,[b] Ian Artoni de Oliveira Silva, DDS,[c] Rubens Spin-Neto, DDS, PhD,[d] Newton Sesma, DDS, PhD,[e] and Emily Vivianne Freitas da Silva, DDS, PhD[f]

ABSTRACT

Statement of problem. With the growing use of digital scanning, an evaluation of the clinical impact of digital scans versus conventional impressions in complete arch implant-supported prostheses is needed. However, systematic reviews on this subject are lacking.

Purpose. The purpose of this systematic review was to evaluate the scanning and impression times and the radiographic marginal bone loss over time associated with digital scans and conventional impressions for complete arch implant-supported fixed prostheses.

Material and methods. The search was performed in MEDLINE/PubMed, SCOPUS, EMBASE, and Web of Science. Only randomized clinical trials (RCTs) comparing digital scans and conventional impressions for complete arch prostheses were included in the review. The scan and impression times and marginal bone loss were analyzed through random effects meta-analysis.

Results. Six RCTs were included. The meta-analysis was conducted by using a standardized mean difference (MD) and indicated a statistically significant reduction in time for the digital scan group compared with the conventional group (MD 10.01 [7.46, 12.55], $P<.001$, $I^2=80\%$). The fact that digital scans were used did not lead to significant differences in radiographic marginal bone loss compared with conventional impressions after 6 months (MD −0.03 [−0.14, 0.08], $P=.58$, $I^2=0\%$), after 12 months (MD −0.06 [−0.24, 0.12], $P=.12$, $I^2=45\%$), and after 24 months (MD −0.12 [−0.32, 0.09], $P=.28$, $I^2=58\%$).

Conclusions. Digital scans significantly reduced the time required compared with conventional impressions for complete arch implant-supported prostheses. Nevertheless, additional studies with more consistent methodologies are needed for confirmation. No significant differences were found in radiographic marginal bone loss between treatments performed with digital scans and conventional impressions. (J Prosthet Dent xxxx;xxx:xxx-xxx)

The use of computer-aided design and computer-aided manufacturing (CAD-CAM) technologies in dentistry has become popular with conventional impression making being replaced with digital scanning in many practices.[1] Unlike conventional impressions, digital scanning does not require tray selection or impression materials, resulting in a cleaner process that is more comfortable for the patient and reduces resource waste.[2] If repetition is necessary, a straightforward computer command can be used to improve the specific part without redoing the entire scan.[2]

Implant-supported prostheses for patients with completely edentulous arches present challenges and require more clinical steps that are susceptible to error.[3] Intraoral scanners can capture images or videos of a restricted area, and the definitive casts are generated by stitching together these images. As a result, completely edentulous arches, long spans of mobile mucosa, and

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[a]Postgraduate student, Department of Stomatology, Division of Periodontics, School of Dentistry, University of São Paulo (USP), São Paulo, Brazil.
[b]Postgraduate student, Department of Prosthodontics, School of Dentistry, University of São Paulo (USP), São Paulo, Brazil.
[c]Graduate student, Department of Prosthodontics, School of Dentistry, University of São Paulo (USP), São Paulo, Brazil.
[d]Professor, Department of Dentistry and Oral Health, Section for Oral Radiology, School of Dentistry, Aarhus University, Aarhus, Denmark.
[e]Professor, Department of Prosthodontics, School of Dentistry, University of São Paulo (USP), São Paulo, Brazil.
[f]Professor, Department of Prosthodontics, School of Dentistry, University of São Paulo (USP), São Paulo, Brazil.

Clinical Implications

Reconstructions obtained from digital scans showed similar marginal bone level changes compared with those obtained from conventional impressions, indicating comparable clinical outcomes.

the use of multiple identical scan bodies can pose challenges, with the absence of landmarks resulting in image stitching errors.[4,5] These challenges may require additional time for accurate scanning. Moreover, a recent systematic review[3] mainly based on in vitro studies has suggested caution in relying solely on complete arch digital implant scans made using intraoral scanners, as the accuracy of such scans varied significantly based on interimplant distance, intraoral scanner type, scan body type, and operator experience.[3] These findings indicate that performing a digital scan for a complete arch implant-supported prosthesis may compromise accuracy and fit.

In implant dentistry, a passive fit between the superstructure and the implants has been used to determine the clinical validity of digital scans.[6] According to Jemt and Lie,[7] a passive fit can be described as an accuracy standard that does not cause long-term complications. Clinical scenarios with misfits between the implant and overlying prosthesis have been linked to higher plaque accumulation,[8] which can subsequently cause biological complications (for example, peri-implant inflammation and marginal bone loss). Moreover, misfits also increase stress at the bone-implant-prosthetic interfaces, leading to technical complications, including screw loosening and prosthesis fracture, and biologic consequences, including marginal bone loss.[8,9] While other factors can impact peri-implant bone loss, a randomized clinical trial (RCT) should provide the ideal study design to isolate confounding factors and determine the effects of a single intervention, such as comparing digital scans versus conventional impressions on this outcome.

Recent RCTs have investigated the clinical efficiency and marginal bone loss associated with conventional impressions for complete arch implant-supported prostheses. Given the increasing clinical use of digital scans, a thorough and comprehensive review of the existing evidence on this subject is essential.

The authors are unaware of a previous systematic review that compared digital scans and conventional impressions for rehabilitating completely edentulous arches with implant-supported prostheses. The present systematic review included only RCTs aiming to evaluate the scan and impression times, which refers to the time required for making the scan or impression, and radiographic marginal bone loss associated with using digital scans or conventional impressions for complete-arch implant-supported fixed prostheses. The null hypotheses were that no differences would be found between the groups regarding clinical outcomes, specifically scan and impression times and radiographic marginal bone loss.

MATERIAL AND METHODS

The protocol of the present systematic review was registered in the international prospective register of systematic reviews (PROSPERO) ID: CRD42022354274. The protocol was conducted according to the preferred reporting items for the systematic review and meta-analyses (PRISMA) statement.[10]

The focused question was: How is time efficiency and marginal bone loss affected when using digital scans and conventional impressions for complete arch implant-supported prostheses? In order to identify the studies for this review, the population, intervention, comparison, outcome, and study (PICOS) question was defined as patients requiring a complete arch implant-supported prosthesis (P), digital workflow (I), conventional workflow (C), efficiency (O) (primary outcome: scan and impression times; secondary outcome: marginal bone loss), and RCTs (S).

The inclusion criteria were RCTs reporting scan and impression times and radiographic marginal bone loss in digital scans and conventional impressions for complete arch implant-supported prosthesis fabrication. Exclusion criteria included cross-sectional, retrospective, cohort studies, case reports, case series, zygomatic or pterygoid implant studies, duplicates, literature or systematic reviews, interviews, commentaries, animal, cadaver, or in vitro studies, and studies lacking comparative assessments of digital and conventional workflows for complete arch implant-supported prosthesis fabrication related to clinical efficiency, effectiveness, and marginal bone loss or those with insufficient information.

The literature search was conducted electronically, without any limitations for language or date, in MEDLINE/Pubmed, Embase, Scopus, and Web of Science databases last searched in December 2022. The search strategy for each database is presented in Supplemental Table 1 (available online). A hand search of the reference and citation lists of all eligible full-text articles was also performed.

Two authors (C.N.C.W., I.A.O.S.) independently assessed the studies, and the Cohen kappa coefficient for inter-reviewer agreement was calculated. In cases of disagreement, a third reviewer (I.N.R.R.) was consulted. Articles of interest were then analyzed based on preestablished inclusion and exclusion criteria after title and summary reading.

The following data were extracted: study reference, articles' original country, number of patients, mean age (in years), number of implants, number of prostheses, open flap or flapless surgery, guided or conventional surgery, loading protocol, temporary prosthesis, digital system and technique, splinted scan bodies, conventional impression material and technique, splinted transfers, definitive prosthesis material, outcomes analyzed, prosthesis location, tilting of implants, implant and prosthesis survival and success, scan and impression times, and radiographic marginal bone loss.

Random-effects meta-analyses were conducted using a software program (RevMan, version 5.4; The Cochrane Collaboration). The analyzed outcomes comprised scan and impression times and radiographic marginal bone level changes. Outcomes were expressed using means, and the summary estimate was derived through mean differences. The groups compared were digital scans versus conventional impressions, and significant differences between pooled effect estimates for each group were determined. Statistical heterogeneity among studies was explored using the I^2 index and the Cochrane Q statistic, with confidence intervals (CIs) set to 95% (95% CI). To investigate the contribution of each study to the overall evidence and the robustness of the synthesized results, a sensitivity analysis was conducted by omitting one study at a time.

The methodological quality of each included study was independently assessed by 2 reviewers (C.N.C.W., I.A.O.S.) using the Cochrane Risk of Bias Tool for RCTs (RoB 2).[11] The certainty of the evidence was determined for each meta-analysis using the grading of recommendations assessment, development, and evaluation (GRADE) approach.[12]

RESULTS

The flow chart of the literature search is presented in Figure 1. Initially, 2487 publications were identified. After removing duplicates, 2338 studies were screened, with 2330 excluded based on title and abstract review (kappa score: 0.94). Eight studies were assessed in full-text, and 2 were ineligible as they did not compare conventional impressions and digital scans (kappa score: 1.00). Therefore, 6 studies remained eligible for inclusion in this review.[13–18]

All included studies were RCTs published between 2016 and 2022 evaluating digital scans and conventional impressions for complete arch implant-supported fixed prostheses. Tables 1 and 2 detail the characteristics, patient demographics, and surgical and prosthetic procedures of the included studies. Three studies were conducted in Italy,[13,15,16] 2 in Spain,[14,17] and 1 in Egypt.[18] All studies were carried out solely in university settings. The number of study participants ranged from 12[17] to 56.[18] Five studies reported their patients' mean age ranged from 57.2[13,18] to 65.5 years.[16] The number of

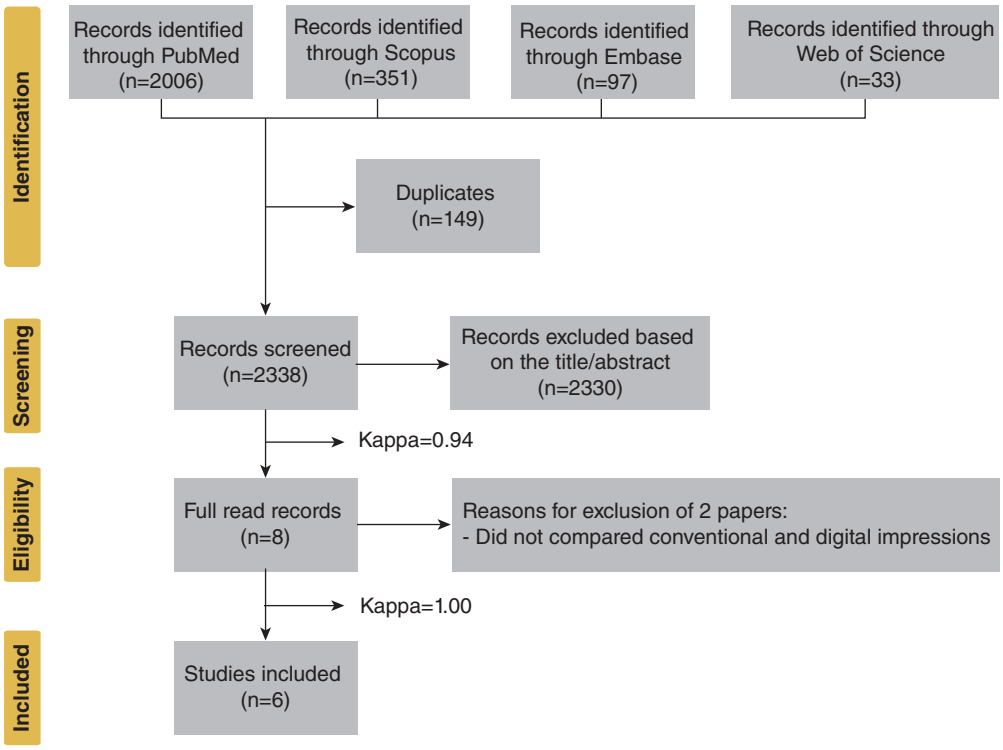

Figure 1. Flowchart of selection process.

Table 1. Summary of study characteristics and patient demographics

Study Reference	Country	Follow-up After Implant Placement	Number of Patients/ Implants	Mean Age	Sex Ratio (Female/Male)	Number of Prostheses
Cappare et al, 2019	Italy	3, 6, 12 and 24 months	50/300	64.4	Not reported	50
Cattoni et al, 2021	Italy	12, 24, 36 and 48 months	50/200	65.5	Not reported	50
Elawady et al, 2022	Egypt	6, 12 and 24 months	56/224	57.2	19/37	56
Gherlone et al, 2016	Italy	3, 6 and 12 months	25/120	57.2	15/10	30
Peñarrocha-Diago et al, 2017	Spain	12 and 24 months	18/131	59.25	9/9	21
Roig et al, 2021	Spain	Not reported	12/78	-	Not reported	24. Two prostheses for each patient. one prosthesis made from digital scan, and other through conventional impression

Table 2. Summary of surgical and prosthetic procedures

Study Reference	Surgical Technique	Loading	Temporary Prosthesis	Digital System	Conventional Material and Technique	Definitive Prosthesis Material
Cappare et al, 2019	Open flap	Immediate	Yes (fixed). Acrylic resin for both groups.	Intraoral scanner CS 3600 Acquisition Software (Version 3.1.0), Carestream Dental LLC.	Not reported. "Gypsum Éclair Class II, Ultima." Open tray	Milled titanium framework with ceramic cemented to titanium structure
Cattoni et al, 2021	Open flap (Conventional group) Flapless (Digital group)	Immediate	Yes (fixed). Conventional: Acrylic resin. (Conventional group) Milled PMMA (Digital group)	Intraoral scanner CS 3500 Acquisition Software (Version 2.5), Carestream Dental LLC.	Polyether, Impregum Penta, 3M ESPE. Open tray	Zirconia monolithic with facial ceramic veneer
Elawady et al, 2022	Not reported	Delayed	Yes (removable). New dentures were fabricated for all patients. The material was not reported.	Intraoral scanner TRIOS (Version 3 Pod Wireless Color), 3Shape.	Polyether, Impregum, 3M ESPE. Open tray	Milled metallic framework with acrylic resin.
Gherlone et al, 2016	Open flap	Immediate	No	Intraoral scanner TRIOS, 3Shape. Version not reported.	Polyether, Permadyne, 3M ESPE. Open tray	Milled titanium framework with Cobalt chromium alloy prostheses and acrylic resin occlusal surfaces
Peñarrocha-Diago et al, 2017	Open flap	Immediate	No	Photogrammetry (PIC Camera) for implant position registration. + Irreversible hydrocolloid (Hydrogum 5, Zhermacks) for soft tissue contour registration. + Desktop scanner Solutionix 3D Rexcan (Version Ds3), Europac 3D.	Polyether, Impregum Penta, 3M ESPE.	Milled metal framework with feldspathic porcelain
Roig et al, 2021	Not reported	Not reported	No	Intraoral scanner TRIOS (Version 3), 3Shape.	Polyether, Impregum, 3M ESPE.	Monolithic zirconia

implants ranged from 87[17] to 300,[15] and the number of prostheses from 21[14] to 56.[18]

Scan and impression times were reported in 3 studies[13–15] (Table 3). Two digital scan devices were used: intraoral scanner (CS3600; Carestream and TRIOS, version not reported; 3Shape A/S) and photogrammetry. Mean scan time varied from 9 minutes using Carestream Dental[15] to 15.6 minutes using photogrammetry technology.[14] Mean ±standard deviation conventional impression time ranged from 16.8 ±4.8 minutes[15] to 27.1 ±1.3 minutes.[14] Conventional impressions used the open tray technique, while digital scans used scan bodies and intraoral scanners, except in 1 study[14] using a photogrammetry system.

Radiographic marginal bone level changes at 6, 12, and 24 months were analyzed in 3,[13,15,18] 5,[13–16,18] and 3 studies,[15,16,18] respectively (Table 4). All included studies reported implant survival ranging from 97.91% to 100%. Two studies,[13,15] reported prosthesis survival that was 100% in all groups of both studies.

One study[17] assessed passivity perception through a visual analog scale, marginal and radiographic fit, and tightening torque scores. The digitally processed prosthesis was preferred by 11 of 12 participants and exhibited improved clinical fit, as assessed by periapical radiographs, compared with the conventional workflow.

According to the risk of bias assessment, all included studies exhibited some concerns, as displayed in Figure 2. One study did not report how the randomization was performed.[13] Five studies presented some concerns related to selection of the reported result because the studies' protocols were not registered[13–16] or retrospectively registered.[18]

Three studies were included in the analysis of scan and impression times. The digital scan time, compared with conventional impression, was significantly lower

Table 3. Scan and impression times

Study Reference	Number of Patients/ Implants	Prosthesis Location (Maxillary and Mandibular)	Conventional Impression Material and Technique	Splinted Transfers	Digital System and Technique	Repetitions (Conventional Impressions/ Digital Scans)	Conventional Impression Time	Digital Scan Time	Group Difference	Results
Cappare et al, 2019	50/300 (150 in each group)	Maxilla	Not reported. "Gypsum Éclair Class II, Ultima." Open tray	Yes, with orthodontic wire and composite resin.	Intraoral scanner CS 3600 Acquisition Software (Version 3.1.0), Carestream Dental LLC. Splinted scan bodies.	7/2	16.8 min (SD ±4.8)	9 min (SD ±2.8)	D<C	Digital scan procedure took less time than conventional procedure (P<.05).
Gherlone et al, 2016	25/120 (64 in conventional group and 56 in digital group)	Maxilla and mandible	Polyether, Permadyne, 3M ESPE. Open tray	Not reported	Intraoral scanner TRIOS, 3Shape. Version not reported. Splinted scan bodies.	9/3	18.4 min (SD ±5.6)	8 min (SD ±3.1)	D<C	Digital scan procedure took less time than conventional procedure (P<.001).
Peñarrocha-Diago et al, 2017	18/131 (65 in conventional group and 66 in digital group)	Maxilla and mandible	Polyether, Impregum Penta, 3M ESPE. Open tray	Yes, with with autopolymerizing acrylic resin (Pi-Ku-Plast, East Midlands, Chesterfiel, England)	Photogrammetry (PIC Camera) for implant position registration. + Irreversible hydrocolloid (Hydrogum 5, Zhermacks) for soft tissue contour registration + Desktop scanner Solutionix 3D Rexcan (Version Ds3), Europac 3D.	Not reported	27.1 min (SD ±1.3)	15.6 min (SD ±1.2)	D<C	Digital scan procedure took less time than conventional procedure (P<.001)

(MD 10.01 [7.46, 12.55], P<.001, I^2=80%) (Fig. 3). The sensitivity analysis showed that the removal of a single study did not alter the results.

Three studies were included in radiographic marginal bone level change analysis. The marginal bone level changes when using digital scans and conventional impressions were similar at 6 months (MD −0.03 [−0.14, 0.08], P=.58, I^2=0%) (Figure 4), 12 months (MD −0.06 [−0.24, 0.12], P=.12, I^2=45%) (Figure 5), and 24 months (MD −0.12 [−0.32, 0.09], P=.28, I^2=58%) (Figure 6). The sensitivity analysis revealed that the exclusion of any individual study did not significantly affect the overall findings.

The certainty of the evidence is reported in Table 5 and was "low" for the analysis of the scan and impression times. The significant heterogeneity and the number of participants that was lower than the optimal information size led us to downgrade the certainty of evidence. A moderate certainty of the evidence was found for the analysis of marginal bone level changes at 6-, 12-, and 24-month follow-ups. The reason for downgrading one level on the certainty of evidence was the number of participants that was lower than the optimal information size (total number of participants of 400).

DISCUSSION

The null hypothesis of no difference in the scan and impression times was rejected. The findings from the present systematic review indicated that digital scans are more efficient than conventional impressions in terms of the time required. Specifically, the meta-analysis of impression time found that digital scans were significantly faster than conventional impressions, with a mean difference of 10.01 minutes, suggesting that digital scans offer an advantage in terms of efficiency. These findings were consistent with the results of a systematic review on single implant-supported crowns,[19] where digital workflows were favored in terms of time efficiency. Moreover, it was also consistent with results from a systematic review on different types of prostheses[20] that reported more efficiency for the laboratory fabrication of implant-supported prostheses and more effectiveness (no chairside adjustments) in posterior single implant-supported crown fabrication when digital technologies were implemented.

One study[14] included in the present analysis used a photogrammetry system, which involved a conventional impression for registering soft tissue contours. The digital group had a significantly faster procedure time (mean 15.6 ±1.2 minutes) compared with that of the conventional group (mean 27.1 ±1.3 minutes). The mean time in the digital group was higher compared with that

Table 4. Marginal bone loss

Study Reference	Number of Implants	Surgery (Guided/ Tilting of Implants)	Conventional Material and Technique	Digital System and Technique	Temporary Prosthesis/ Loading	Definitive Prosthesis Material	Follow-up	Results
Cappare et al, 2019	300 (150 in each group)	Not guided. Tilted implants (number not reported).	Not reported. "Gypsum Éclair Class II, Ultima." Open tray. Splinted transfers.	Intraoral scanner CS 3600 Acquisition Software (Version 3.1.0), Carestream Dental LLC. Splinted scan bodies.	Yes, screw-retained Acrylic resin. Immediate loading.	Screw-retained Milled titanium framework with ceramic cemented to titanium structure.	3, 6, 12, and 24 months after implant placement	Marginal bone loss was greater at conventional group compared with digital group, but with no significant differences ($P > .05$)
Cattoni et al, 2021	200 (100 in each group)	Guided. 50 tilted and 50 axial in each group.	Impregum (Impregum Penta, 3M) Open tray. No information about splinted transfers.	Intraoral scanner CS 3500 Acquisition Software (Version 2.5), Carestream Dental LLC. Splinted scan bodies.	Yes Screw-retained. Digital -Milled PMMA Conventional - Acrylic resin. Immediate loading.	Screw-retained zirconia monolithic with facial ceramic veneer	12, 24, 36 and 48 months after implant placement	Marginal bone loss greater at digital group compared with conventional group, with significant differences ($P<.0001$).
Elawady et al, 2022	224 (120 in each group)	Guided. 56 axial and 56 tilted in each group.	Polyether, Impregum, 3M ESPE. Open tray. Splinted transfers.	Intraoral scanner TRIOS (Version 3 Pod Wireless Color), 3Shape,. Scan bodies not splinted.	Yes Removable acrylic resin. Delayed.	Screw-retained milled metal framework with resin acrylic	6, 12 and 24 months after implant placement	Marginal bone loss was greater in the digital group compared to the conventional group. However, no significant differences were observed when comparing conventional impressions to digital scans in axial or tilted implants ($P > .05$).
Gherlone et al, 2016	120 (64 in conventional group and 56 in digital group)	Not guided. 32 tilted and 32 axial in the conventional group. 28 tilted and 28 axial in the digital group.	Polyether, Permadyne, 3M ESPE. Open Tray. No information about splinted transfers.	Intraoral scanner TRIOS, 3Shape. Version not reported. Scan bodies not splinted.	No. Immediate loading.	Screw-retained milled metallic framework with resin acrylic	3, 6 and, 12 months after implant placement	Marginal bone loss greater at conventional group compared with digital group, but with no significant differences ($P > .05$). No significant difference in marginal bone loss between tilted and upright implants detected at 6- or 12-month follow-up in either arch ($P > .05$).
Peñarrocha-Diago et al, 2017	131 (65 in conventional group and 66 in digital group)		Polyether, Impregum Penta, 3M ESPE. Open tray. Splinted transfers.	Photogrammetry (PIC Camera) for implant position registration + Irreversible hydrocolloid (Hydrogum 5, Zhermacks) for soft tissue contour registration + Desktop scanner Solutionix 3D Rexcan (Version Ds3), Europac 3D.	No. Immediate loading.	Screw-retained milled metallic framework with feldspathic porcelain	12 and 24 months after implant placement	Marginal bone loss greater at conventional group compared with digital group, but with no significant differences (Mann-Whitney U test, $P=.72$).

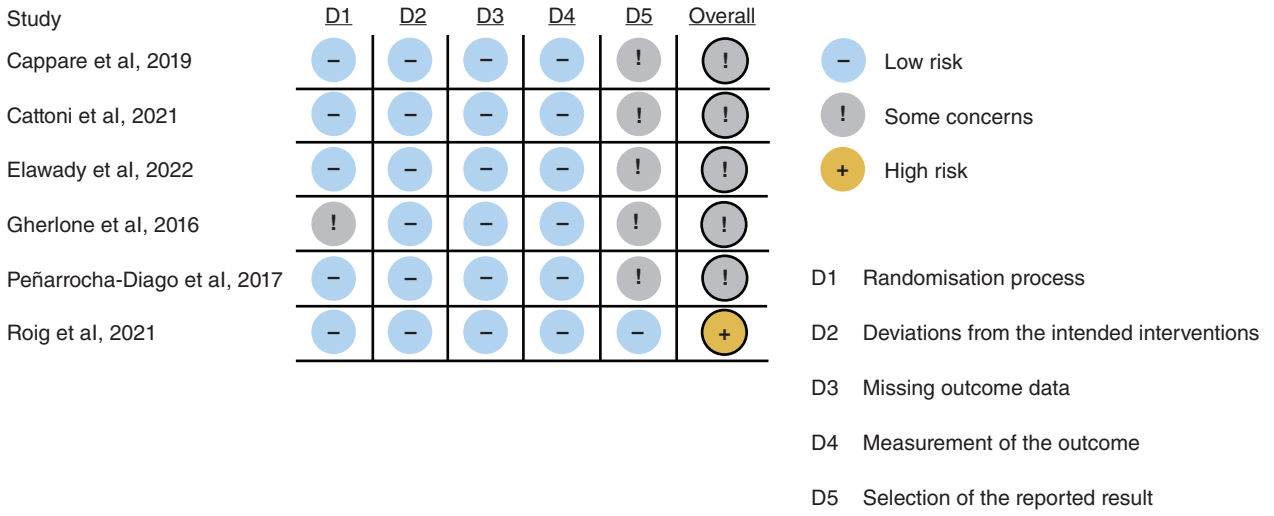

Figure 2. Assessment of risk of bias in included studies.

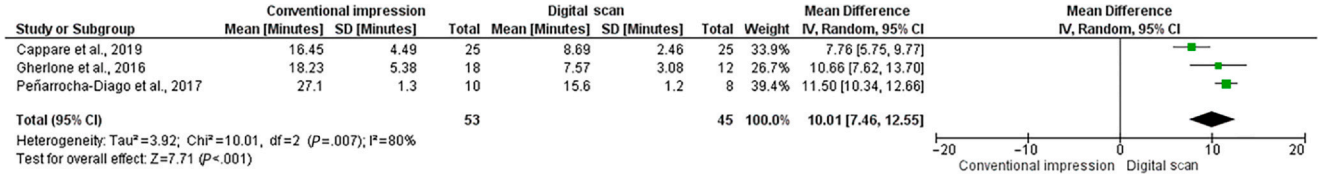

Figure 3. Forest plot of mean differences in time taken for conventional and digital scans.

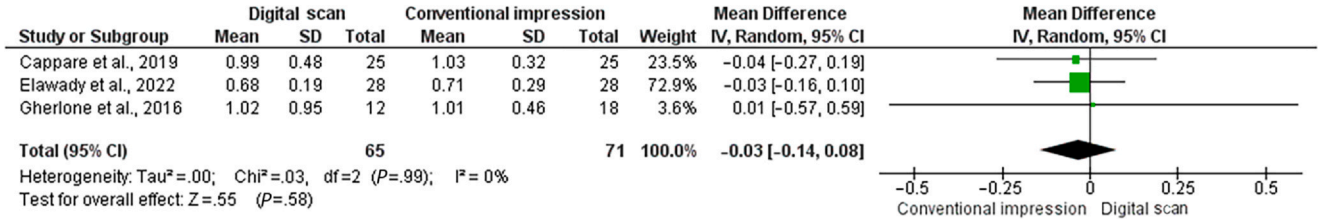

Figure 4. Forest plot of mean differences in marginal bone levels at 6 months.

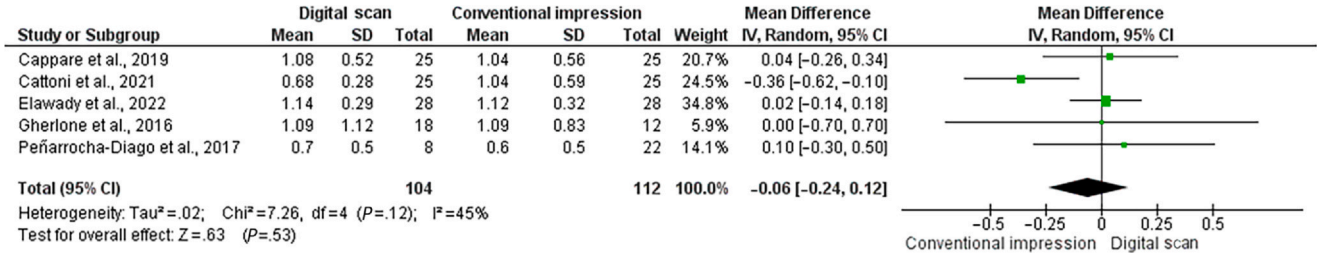

Figure 5. Forest plot of mean differences in marginal bone levels at 12 months.

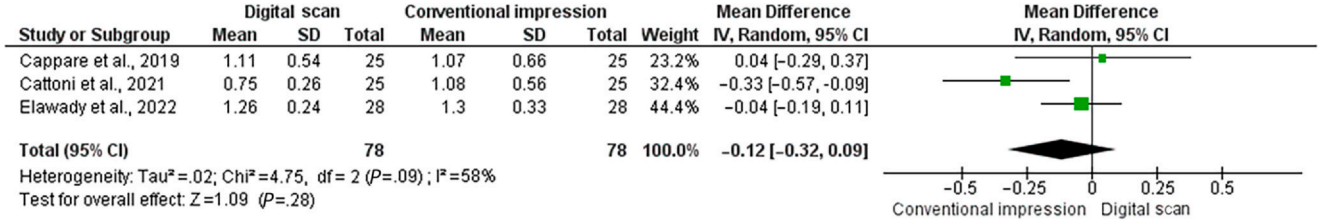

Figure 6. Forest plot of mean differences in marginal bone levels at 24 months.

Table 5. Certainty of evidence using GRADE approach

Certainty Assessment							No of Patients		Effect		Certainty
№ of Studies	Study Design	Risk of Bias	Inconsistency	Indirectness	Imprecision	Other Considerations	Digital Workflow	Conventional Workflow	Relative (95% CI)	Absolute (95% CI)	
Scan and impression times (assessed with: minutes)											
3	randomized trials	not serious	serious[a]	not serious	serious[b]	none	45	53	-	MD 10.01 higher (7.46 higher to 12.55 higher)	⊕⊕ Low
Marginal bone loss (follow-up: 6 months; assessed with: millimeters)											
3	randomized trials	not serious	not serious[c]	not serious	serious[b]	none	65	71	-	MD 0.03 lower (0.14 lower to 0.08 higher)	⊕⊕⊕ Moderate
Marginal bone loss (follow-up: 12 months; assessed with: millimeters)											
5	randomized trials	not serious	not serious[c]	not serious	serious[b]	none	104	112	-	MD 0.06 lower (0.24 lower to 0.12 higher)	⊕⊕⊕ Moderate
Marginal bone loss (follow-up: 24 months; assessed with: millimeters)											
3	randomized trials	not serious	not serious[c]	not serious	serious[b]	none	78	78	-	MD 0.12 lower (0.32 lower to 0.09 higher)	⊕⊕⊕ Moderate

CI, confidence interval; MD, mean difference

[a] *P* value for heterogeneity significant and I^2 of 80% verified. Overlapping confidence intervals generated by individual studies, except for Cappare et al., 2019 and Peñarrocha-Diago et al., 2017 studies.

[b] Total number of participants in this comparison lower than Optimal Information Size (400).

[c] *P* value for heterogeneity not significant and overlapping confidence intervals generated by individual studies.

in other studies that did not involve conventional steps in their techniques. A sensitivity analysis, excluding this study, reduced heterogeneity from 80% to 59%, with nonsignificant heterogeneity (*P*=.12). However, the statistical significance of the difference between digital scans and conventional impressions remained. Nevertheless, reducing heterogeneity would raise the evidence certainty from low to moderate. The downgrade of one level in certainty resulted from heterogeneity influenced by the photogrammetry study.

The null hypothesis of no difference in the radiographic marginal bone loss was not rejected. Pooled analysis of marginal bone level changes at 6, 12, and 24 months found no significant differences between digital scans and conventional impressions. These results suggest both techniques may be equally effective in capturing accurate scans and impressions, leading to prostheses with adequate fit and no significant differences in marginal bone loss. The accuracy of scans and impressions has a direct impact on the prosthesis fit and results in both technical and biological complications. Technical issues include screw loosening and subsequent loss of retention of prostheses, fracturing of the prosthesis components, and chipping of the veneering ceramic.[21] Biological complications, including peri-implant mucositis and peri-implantitis with bone loss, may result from increased biofilm accumulation, micromovements at the implant-abutment connection, and heightened strains in peri-implant tissues.[22]

Although these findings suggest that both digital scans and conventional impressions result in similar bone level changes, caution should be exercised when interpreting these results because of differences in the techniques adopted. In consideration of the multifactorial nature of radiographic marginal bone loss, other patient, surgical, or prosthetic factors may have influenced marginal bone loss. However, the low heterogeneity observed in the meta-analyses of marginal bone level changes indicated that randomization may have effectively controlled for confounding factors.

All studies used the same surgical approach for both groups, and interim prostheses were fabricated using the same materials and technology, except with Cattoni et al.[16] This RCT reported a statistically significant decrease in marginal bone loss in the digital group, contrasting with other studies in the meta-analysis. Excluding this study from a sensitivity analysis eliminated heterogeneity (*P*<.001) and reduced I^2 from 45% to 0%. However, the pooled mean difference between digital scans and conventional impressions remained not statistically significant. This significantly better result for the digital group might be related to the interim prostheses that were milled from polymethyl methacrylate (PMMA) in the digital group, while the conventional group received prostheses conventionally

made from acrylic resin. A systematic review reported that studies comparing the accuracy of dentures produced with CAD-CAM technology to traditional techniques have demonstrated the better fit and biologic aspects of milled dentures over traditional dentures.[23] Additionally, the digital group had flapless surgery and static guided implant placement, while the conventional group had open flap surgery. Although guided surgery has advantages in terms of invasiveness and accuracy,[24] evidence is lacking for clinically significant long-term outcomes. Only 1 randomized trial[25] compared marginal bone level changes between the 2 groups and reported no significant differences.

Limitations of the present systematic review and meta-analysis were that the included studies had heterogeneity in terms of sample size, clinical procedures (including differences in the surgical and prosthetic approaches and digital technologies), and evaluation methods, which may have influenced the results and reduced the certainty of the evidence. Moreover, variability in evaluation methods impaired study comparability for some outcomes. More comparable studies are needed for robust evidence confirmation. Additionally, 2 pilot studies with small sample sizes may have limited the power of the analysis.

The study had strengths contributing to its validity in that it included only RCTs, considered the standard for evaluating interventions. Moreover, it emphasized clinically important outcomes such as time efficiency and radiographic marginal bone loss. These strengths enhance the reliability of the study findings and underscore the clinical relevance of digital scans in such prostheses.

Future clinical trials using the same methods are strongly recommended. Standardizing the evaluation methods and outcomes in future studies would help increase the comparability of the results. Further studies evaluating patient preferences and using the same evaluation method are also recommended. Investigation into scan and impression accuracy, prosthesis fit, and their relationship with clinical outcomes could be highly beneficial in understanding the clinical significance of these findings. Cost-effectiveness studies comparing digital scans with conventional impressions may also be valuable in aiding clinical decision-making. Lastly, the prospective registration of RCT protocols is strongly encouraged to reduce selection bias and enhance research quality, as only 1 included RCT was registered.

CONCLUSIONS

Based on the findings of this systematic review and meta-analysis, the following conclusions were drawn:

1. Digital scans significantly reduced the required time compared with conventional impressions in complete arch implant-supported prostheses.
2. Using digital scans did not result in significant differences in radiographic marginal bone loss compared with conventional impressions in complete arch implant-supported prostheses.

APPENDIX A. SUPPORTING INFORMATION

Supplemental data associated with this article can be found in the online version at doi:10.1016/j.prosdent.2023.09.023.

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Corresponding author:
Dr Isabella Neme Ribeiro dos Reis
Department of Stomatology
School of Dentistry
University of São Paulo (USP)
Avenida Professor Lineu Prestes, 2227
São Paulo, São Paulo 05508-000
BRAZIL
Email: bellaneme@yahoo.com.br.

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