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SYSTEMATIC REVIEW

Comparative assessment of complete-coverage, fixed tooth-supported prostheses fabricated from digital scans or conventional impressions: A systematic review and meta-analysis

Octave Nadile Bandiaky, DDS, MS,[a] Pierre Le Bars, DDS, MS, PhD,[b] Alexis Gaudin, DDS, MS, PhD,[c] Jean Benoit Hardouin, PhD,[d] Marjorie Cheraud-Carpentier, BTS, TS,[e] Elhadj Babacar Mbodj, DDS, MS, PhD,[f] and Assem Soueidan, DDS, MS, PhD[g]

ABSTRACT

Statement of problem. Intraoral scanners have significantly improved over the last decade. Nevertheless, data comparing intraoral digital scans with conventional impressions are sparse.

Purpose. The purpose of this systematic review and meta-analysis was to determine the impact of impression technique (digital scans versus conventional impressions) on the clinical time, patient comfort, and marginal fit of tooth-supported prostheses.

Material and methods. The authors conducted a literature search based on the Population, Intervention, Comparison, and Outcome (PICO) framework in 3 databases to identify clinical trials with no language or date restrictions. The mean clinical time, patient comfort, and marginal fit values of each study were independently extracted by 2 review authors and categorized according to the scanning or impression method. The authors assessed the study-level risk of bias.

Results. A total of 16 clinical studies met the inclusion criteria. The mean clinical time was statistically similar for digital scan procedures (784 ±252 seconds) and for conventional impression methods (1125 ±159 seconds) ($P>.05$). The digital scan techniques were more comfortable for patients than conventional impressions; the mean visual analog scale score was 67.8 ±21.7 for digital scans and 39.6 ±9.3 for conventional impressions ($P<.05$). The mean marginal fit was 80.9 ±31.9 µm and 92.1 ±35.4 µm for digital scan and conventional impressions, respectively, with no statistically significant difference ($P>.05$).

Conclusions. Digital scan techniques are comparable with conventional impressions in terms of clinical time and marginal fit but are more comfortable for patients than conventional impression techniques. (J Prosthet Dent 2022;127:71-9)

An accurate dental impression is the first step in the fabrication of indirect restorations.[1] Computer-aided design and computer-aided manufacturing (CAD-CAM) technology has become popular in prosthodontics and is expected to completely digitize the prosthesis fabrication process.[2] As the first step, intraoral scanning should be as accurate as and less time-consuming and more comfortable for patients than conventional impression making.

Restorations made with CAD-CAM technology have been reported to have marginal accuracy similar to that obtained with the conventional impression technique.[3-7] However, digital scanning has been reported to be faster than conventional impression making[8] while increasing the effectiveness of the treatment.[9] Patients have been reported to prefer digital scans because they are more comfortable and less time-consuming.[10-12]

[a]Graduate student, Graduate Prosthodontics, Department of Odontology, University of Dakar, Dakar, Senegal.
[b]Associate Professor, Division of Fixed Prosthodontics, CHU Nantes, Nantes, France.
[c]Associate Professor Biostatistics, UMR 1246 INSERM SPHERE “MethodS in Patients-Centered Outcomes and HEalth ResEarch”, Universities of Nantes and Tours, Nantes, France.
[d]Associate Professor of Endodontics and Restorative Dentistry, Department of Endodontics and Restorative Dentistry, University of Nantes, Nantes, France.
[e]Senior Industrial Technician and Clinical Study Coordinator, UIC Odontology, CHU, Nantes, France.
[f]Professor, Clinic of Fixed and Removable Prosthodontics, Department of Odontology, University of Dakar, Dakar, Senegal.
[g]Professor of Periodontology, Department of Periodontology, Rmes U1229, University of Nantes, Nantes, France.

Clinical Implications

Digital scanning offers significant benefits in terms of patient comfort but remains comparable with conventional impressions in terms of clinical time and marginal fit.

Despite the many advantages of CAD-CAM systems, there are still obstacles and deficiencies to address. Some systems require a layer of powder on the tooth surface, and scanner movement during the scanning process may affect accuracy.[2]

Biases at different levels have been identified in previous systematic reviews comparing the 2 recording techniques.[3-7,10] These reviews included both in vivo and in vitro studies, with some being randomized or only descriptive while others concerned implant-supported prostheses. These differences do not allow relevant conclusions to be drawn regarding the differences between the 2 techniques. The purpose of this systematic review and meta-analysis was to compare conventional impression making and digital scanning techniques in terms of clinical time, patient comfort, and the marginal fit of fixed tooth-supported prostheses. The null hypothesis was that conventional impression making and digital scanning techniques would result in restorations of fixed tooth-supported prostheses with similar clinical time, patient comfort, and marginal fit.

MATERIAL AND METHODS

The protocol was registered at the International Prospective Register of Systematic Reviews (PROSPERO) (http://www.crd.york.ac.uk/PROSPERO) under the number CRD42019137141. This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines.[13] The Population, Intervention, Comparison, and Outcome (PICO) framework was used to formulate the following 3 questions: Are digital scans made with intraoral scan systems less time-consuming than conventional impressions (PICO 1)? Do digital scan techniques cause significantly less discomfort to patients than conventional impression techniques (PICO 2)? Are digital scans more accurate than conventional impression methods in terms of marginal fit (PICO 3)?

The Medline/PubMed, Cochrane Library, and Science Direct databases were used to carry out an electronic search for articles published through 2020 with no date and language restrictions. Within the databases, the following keyword combinations (medical subject headings [MeSH] and free-text terms) were used: "clinical efficiency"/"patient comfort"/"patient preference"/"digital workflow"/"conventional workflow"/"systematic review"/"meta-analysis"/"internal fit"/"marginal fit"/"randomized controlled trials"/"fixed dental prosthesis"/"prospective study"/"comparative study"/"time work" AND/OR "conventional impression"/"dental impression techniques"/"digital scans"/"computer-aided design"/"computer-aided manufacturing"/"intraoral scanner" to identify prospective or randomized controlled clinical studies concerning fixed tooth-supported prostheses and those in which the authors compared conventional impression techniques with digital scans. The articles were selected based on the following inclusion criteria: controlled and randomized clinical trials, as well as prospective comparative studies; comparison between conventional and digital scan techniques for complete-coverage, fixed, tooth-supported prosthetic rehabilitations; and studies evaluating clinical time, patient comfort, and marginal fit.

Table 1. Characteristics of excluded studies

Study	Reason for Exclusion
Chochlidakis et al,[3] Tsirogiannis et al,[4] Nagarkar et al[7]	Systematic review and meta-analysis
Joda et al,[5] Ahlholm et al,[6] Gallardo et al,[10] Cave and Keys[24]	Systematic review
Burhardt et al,[11] Burzynski et al,[12] Grünheid et al[17]	Orthodontic patients
Flügge et al[18]	Not prosthodontic treatment
Schaefer et al,[19] Almeida e Silva et al,[20] Alfaro et al,[21] Solaberrieta et al,[22] Afify et al[23]	In vitro study
Sailer et al,[25] Benic et al[26]	Double publication by same authors
Mühlemann et al,[27] Sailer et al[28]	Laboratory procedures
Batisse et al,[29] Berrendero et al[30]	No data available
Al Hamad et al[31]	One patient

Meta-analyses or literature reviews, in vitro studies or those without available data, fixed prosthetic rehabilitations that were not tooth-supported, noncontrolled clinical studies, clinical case reports or duplicate publications on the same subject with the same participants, studies that did not compare conventional and digital scan techniques, clinical case series, and studies with fewer than 10 participants were excluded.

Bibliographic research was performed by one of the authors (O.N.B.). All references found in the 3 databases were imported into a reference management software program (Zotero; Corporation for Digital Scholarship) for article management, including removal of duplicate articles. In the software program, 2 reviewers (P.L.B., O.N.B.) analyzed the studies independently in 3 phases by searching the titles, analyzing the abstracts, and identifying full-text articles. Supplemental manual searches were performed on all the eligible articles to enlarge the list of retained articles. Disagreements were resolved through discussion. An identifier was assigned to each included study.

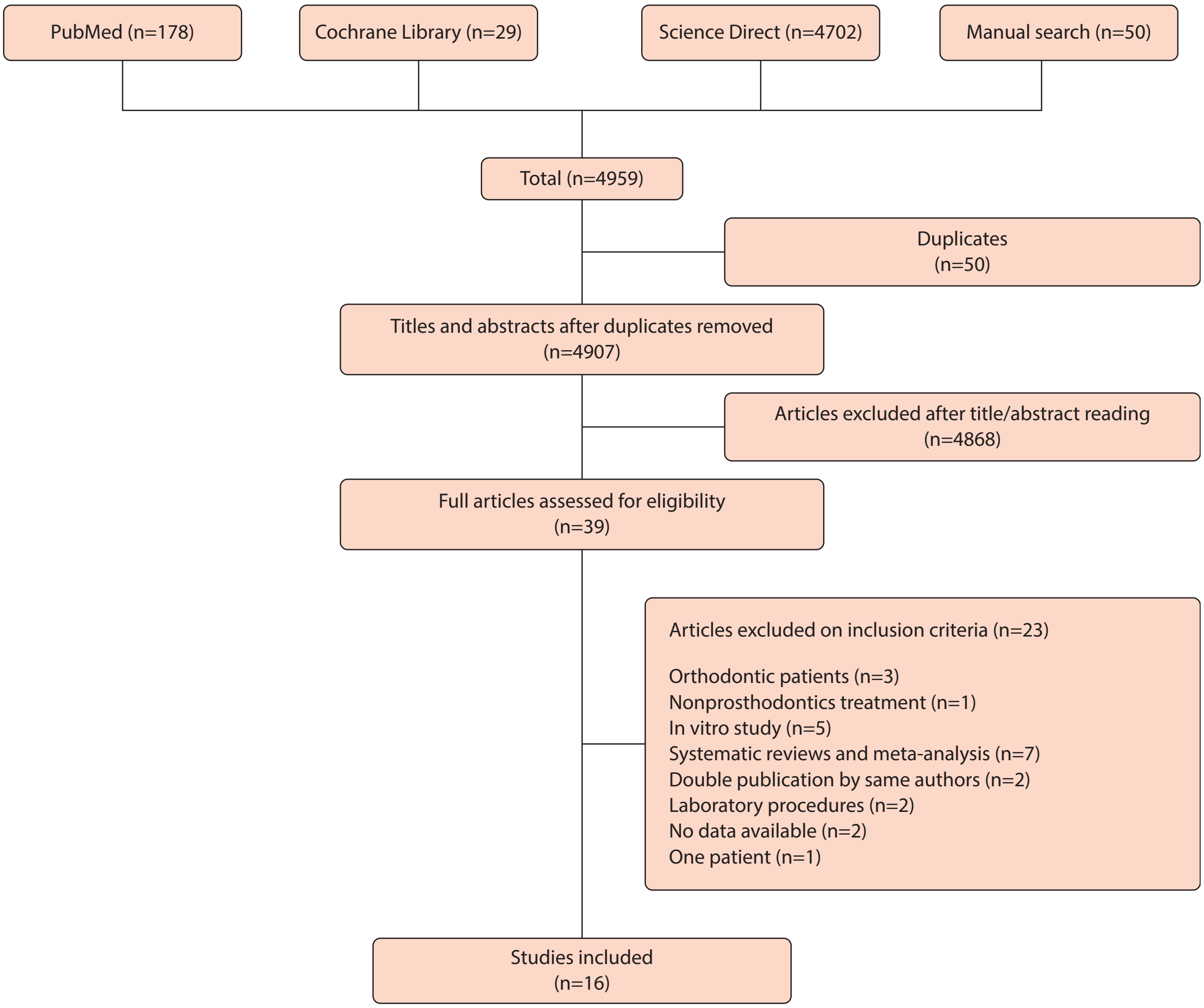

Figure 1. Flowchart of included studies.

Data extraction and synthesis were performed independently by the authors (P.L.B., O.N.B.) with a spreadsheet (Excel 2010; Microsoft Corp). Missing data or additional study information were requested by contacting the studies' corresponding authors. If additional data were not received after 3 contact attempts, the study was excluded from the quantitative aspect and included in the qualitative aspect of the review. The author and year of publication, country, sample size, study design, study group, type of material covering the crown, variables evaluated, evaluation method, and main results were extracted.

Bias risks were evaluated for all included studies by the 3 authors of the review (P.L.B., O.N.B., A.G.) in accordance with the criteria proposed in the Cochrane Handbook regarding randomized controlled studies. This evaluation concerned the generation of the randomization sequence (selection bias), concealment of the allocation (reporting bias), blinding of the investigator and the participant (confusion bias), blind evaluation of the results (performance bias), management of missing data (attrition bias), selection of the reporter, and other types of bias. From these criteria, the bias risk level was determined to be low, unclear, or high.[14]

A qualitative synthesis of the findings from the included studies, structured around different outcomes, was conducted. The intervention effects for each study were summarized by calculating the mean differences for continuous outcomes or risk ratios (for dichotomous outcomes). However, when studies used the same type of intervention and comparison groups with the same outcome measure, the results were pooled by using a random-effects model (DerSimonian and Laird method),[15] with mean differences for continuous outcomes and risk ratios for dichotomous outcomes and calculated 95% confidence intervals and P values for each outcome. Heterogeneity between the studies was

Table 2. Characteristics of included studies and main results

ID	Study Reference	Study Design	Study Group	Sample Size Restoration Material	Parameters Evaluated	Evaluation Method	Main Results
1[32]	Koulivand et al, 2019, Iran	PCS, crossover 2-armed design	CG (n=15): one-step impression technique (PVS)+casts+EOS GT (n=15): TRIOS	30 MCC	Marginal gap (PICO3) Clinical time (CT) (PICO1)	Marginal fit measured with RT under stereomicroscope at ×50 magnification CT steps for CI and DS: selection tray, adhesive/uploading patient information, putty preparation, maxillary/madibular impression/scan, placement cord, occlusion record, cord removal and writing laboratory prescription	Marginal gap in digital technique (GT) significantly lower than values in CI (CG) and digital technique superior in terms of impression time.
2[33]	Haddadi et al, 2019, Denmark	RCT, crossover 2-armed design	CG (n=19): one-step impression technique (PVS)+stone casts+EOS GT (n=19): TRIOS	38 LDCs	Marginal gap (PICO3)	Marginal fit evaluated with RT using Macroscope M420 at ×40 magnification on computer screen.	Comparing to CI (CG), crowns based on IOS (GT) significantly better marginal adaptation at all points except at cusp tip.
3[34]	Haddadi et al, 2018, Denmark	RCT, crossover 2-armed design	CG (n=19): one-step impression technique (PVS) GT (n=19): TRIOS	38 LDCs	Clinical time (PICO1) Patient comfort (PICO2)	Steps of CI and DS CT: tray selection and adhesive, maxillary/mandibular impression/scan, interocclusal record, shade selection Patient perception associated with each method recorded using visual analog scale (VAS) scored 0-100, with 100 indicating maximum discomfort.	DS (GT) less time consuming and caused significantly less discomfort to patients than CI (CG) made with PVS in complete-arch tray.
4[25]	Sailer et al, 2018, Switzerland	RCT, crossover 4-armed design	CG (n=10): polyether impression GT I (n=10): Lava C.O.S GT II (n=10): iTero GT III (n=10): Bluecam	NA	Clinical time (PICO1) Patient comfort (PICO2)	CT's steps: powdering, impressions, occlusal registration and number of impression remakes. Participant perceptions of comfort of both impressions rated by means of VAS scored 0 "very uncomfortable" to 100 "comfortable."	CI (CG) procedures objectively less time consuming and subjectively preferred by participants over digital scan procedures (GT I, II, II). System without need for powdering preferred to systems with powdering.
5[26]	Benic et al, 2018, Switzerland	RCT, crossover 4-armed design	CG (n=10): polyether impression+ stone casts+LWT GT I (n=10): Lava C.O.S GT II (n=10): iTero GT III (n=10): Bluecam	30 PFZFPDs 10 MFPDs	Marginal fit (PICO3)	Marginal discrepancy evaluated in 4 different regions of interest with RT using light microscope at ×200 magnification with replica technique.	Digitally (GT I, II, III) fabricated zirconia frameworks for 3-unit fixed dental prostheses have similar or better marginal fit than that of conventionally fabricated metal frameworks (CG).
6[35]	Sakornwimon and Leevailoj, 2017, Thailand	RCT 2-parallel groups	CG (n=8): One-step/ double−mix impression technique (PVS)+casts+EOS GT (n=8): Lava C.O.S	16 MZCs	Marginal fit (PICO3) Patient comfort (PICO2)	Marginal fit assessed by RT using stereomicroscope at ×40 magnification. VAS scores ranging from 0 "not satisfactory" to 10 "very satisfactory" used to assess patient comfort.	VAS scores for DS (GT) significantly higher than those for PVS impressions (CG) in every topic, except for occlusal registration. No differences found in clinical marginal fit of zirconia crowns fabricated from either DS compared with PVS impressions.
7[36]	Zeltner et al, 2017, Switzerland	RCT, crossover 5-armed design	CG (n=10): PVS impressions+stone casts+LWT GT I (n=10): Lava C.O.S GT II (n=10): iTero GT III (n=10): Bluecam GT IV (n=10): Bluecam	50 MLDCs	Marginal discrepancy (PICO3)	Dimensions of marginal discrepancy assessed RT using light microscopy at ×200 magnification.	LDCs fabricated with digital workflows (GT I, II, III, IV) similar marginal fit to that of conventionally (CG) fabricated LDCs. Differences between treatment modalities not statistically significant (*P*>.05).
8[37]	Rödiger et al, 2017, Germany	PCS, crossover 2-armed design	CG (n=20): one-step impression technique (PVS)+stone models+EOS GT (n=20): TRIOS	20 ZCs	Marginal fit (PICO3)	Marginal fit measured with RT on digital photographs captured by integrated camera of light microscope with magnification factor of ×35 and special measuring software program (Axio Vision LE 4.8; Carl Zeiss Microscopy GmbH).	Zirconia single crowns produced with both digital (GT) and traditional (CG) impression techniques showed no significant differences in terms of marginal fit between 2 groups.
9[38]	Gjelvold et al, 2016, Sweden	RCT 2-parallel groups	CG (n=24): one-step impression technique (polyether) GT (n=24): TRIOS	13 LDCs 16 ZCs 19 MCCs	Marginal fit (PICO3) Clinical time (PICO1) Patient comfort (PICO2)	Marginal fit evaluated using explorers with defined tip diameters of 150 µm DS and CI CT's steps: cord placement, choice tray, entry patient data, laboratory requisition, impression time, interocclusal registration. Patients conveyed their assessments on nonnumerical 100-mm line ranging from 0 "not uncomfortable" at all to 100 "very uncomfortable."	Digital scanning technique (GT) less time consuming and more convenient for patients.

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Table 2. (*Continued*) Characteristics of included studies and main results

ID	Study Reference	Study Design	Study Group	Sample Size Restoration Material	Parameters Evaluated	Evaluation Method	Main Results
10[39]	Berrendero et al, 2016, Spain	RCT, crossover 2-armed design	CG (n=30):2-step impression technique (PVS)+master cast+EOS GT (n=30): TRIOS	60 PFZCs	Marginal fit (PICO3)	Marginal fit measured with RT at different areas using stereomicroscopy at ×40 magnification.	Ceramic crowns fabricated using IOS (GT) comparable to elastomer conventional impressions (CG) in terms of marginal fit. Mean marginal fit in both groups within limits of clinical acceptability.
11[40]	Ahrberg et al, 2016, Germany	RCT, crossover 2-armed design	CG (n=25): monophase impression technique (polyether)+stone models+EOS GT (n=25): Lava C.O.S	34 PFZCs 16 PFZFPDs	Marginal fit (PICO3) Clinical time (PICO1)	Marginal fit recorded using RT under light microscope at ×64 magnification DS and CI CT's steps: powdering/stock tray individualization; maxillary/ mandibular impressions or scan and occlusal registration	Significantly better marginal fit noted with direct digitalization (GT). Intraoral digital scans also less time consuming for patient than CI (CG).
12[41]	Boeddinghaus et al, 2015, Germany	RCT, crossover 4-armed design	CG (n=24): 2-step impression technique (polyether)+master model+EOS GT I (n=24): Omnicam GT II (n=24): Lava Tdef GT III (n=24): TRIOS	49 PFZCs	Marginal fit (PICO3)	Marginal fit evaluated with RT using microscope with ×40 magnification, built-in CCD camera (M420; Leica) and digital measuring devices attached (Digimatic Micrometer Head; Mitutoyo).	Digital scan (GT I, II, III) can be alternative to conventional impression (CG) with consecutive digital workflow when finish line clearly visible and possible to keep it dry.
13[42]	Zarauz et al, 2015, Spain	RCT, crossover 2-armed design	CG (n=20): one-step impression (PVS)+master models+EOS GT (n=20): iTero	52 PFZCs	Marginal gap (PICO3)	Marginal misfit measured with RT in micrometers using stereomicroscopy with magnification of ×40.	Ceramic crowns fabricated from intraoral digital scans (GT) demonstrated significantly better marginal fit than crowns from traditional impressions (CG).
14[43]	Pradíes et al, 2014, Spain	RCT, crossover 2-armed design	CG (n=32): 2-step impression technique (PVS)+master cast+EOS GT (n=32): Lava C.O.S.	60 PFZCs	Marginal fit (PICO3)	Marginal fit evaluated with RT by means of stereomicroscope (M-80; Leica) at magnification factor ×40, with built-in charge-coupled camera (Hitachi CCTV HV-720E; Hitachi).	Digital scans obtained from Lava C.O.S can be used for manufacturing ceramic crowns in normal clinical practice with better marginal fit than conventional impressions with elastomers.
15[44]	Yuzbasioglu et al, 2014, Turkey	RCT, crossover 2-armed design	CG (n=24): monophase impression technique (polyether) GT I (n=24): Omnicam	48 PFZCs	Clinical time (PICO1) Patient comfort (PICO2)	CI and DS CT steps: tray selection and adhesive/intering patient information, laboratory prescription, maxillary/ mandibular impression/scan, occlusal registration. VAS scored 0 "uncomfortable" to 100 "very comfortable" used to assess patient preferences and self-concerns.	Digital scans (GT) resulted in more time-efficient technique than conventional impressions (CG). Patients stated that digital scans more comfortable than conventional techniques.
16[45]	Syrek et al, 2010, Germany	RCT, crossover 2-armed design	CG (n=20): 2-step impression technique (PVS)+master model+EOS GT (n=20): Lava C.O.S.	—	Marginal fit (PICO3)	Marginal fit measured with RT by means of stereomicroscope (Stemi SVII; Zeiss) at ×66 magnification at buccal, lingual, mesial, and distal margin.	Crowns from IOS (GT) revealed significantly better marginal fit than crowns from silicone impressions (CG). Marginal discrepancies in both groups were within limits of clinical acceptability.

CG, control group; CI, conventional impression; CT, clinical time; DS, digital scan; EOS, extraoral scanner; GT, group test; IOS, intraoral scanner; LDCs, lithium disilicate ceramic crowns; LWT, lost-wax technique; MCC, metallo-ceramic crowns; MFPD, metal fixed partial denture; MLDCs, monolithic lithium disilicate ceramic crowns; MZC, monolithic zirconia crowns; NA, not applicable; PCS, prospective comparative study; PFZFPD, porcelain fused to zirconia fixed partial denture; PVS, polyvinyl siloxane; RCT, randomized controlled clinical trial; RT, replica technique; VAS, visual analog scale; ZC, zirconia single crown. Lava Chairside Oral Scanner (C.O.S); TRIOS (3Shape A/S); iTero (Align Technology); CEREC Bluecam (Dentsply Sirona); Cerec Omnicam (Dentsply Sirona).

assessed by using the Higgins I2 statistic.[16] An I2 value of 50% or more was considered the presence of substantial heterogeneity. A sensitivity analysis based on the risk of bias of the included studies (low risk of bias versus high or unclear risk of bias) was conducted. A stratified (subgroup) meta-analyses was used to explore heterogeneity in effect estimates according to the study design. Evidence of publication bias was also assessed by using the extended trim-and-fill method. When the study authors had used several scanners, the scanner with the greatest error was used for data pooling.

RESULTS

Electronic searches, complemented by manual searches, identified 4959 articles, of which 52 were duplicates and 4868 were excluded after reading the titles and/or the summaries. The texts of the 39 eligible articles were read

Table 3. Mean time recording for scanning with digital system scans and conventional impression material

Study Reference	No. Procedures Evaluated/-Group	Intraoral Scanners	DS sec		CI* sec		MD sec, 95% CI	P
			Mean	SD	Mean	SD		
1[32]	25	TRIOS	631	NR	1167	NR	-536	<.05
3[34]	19	TRIOS	311	NR	1119	NR	-808	<.05
4[25]	10	Lava C.O.S	1091	523	658	181	433	<.05
9[38]	24	TRIOS	873	327	1242	342	-369	<.05
11[40]	25	Lava C.O.S	1548	NR	1960	NR	-412	<.05
15[44]	24	Omnicam	249	23	605	24	-356	<.05
Total mean time (sec)			784	252	1125	159	-341 (CI, -974; 291)	>.05

CI*, conventional impressions; CI, confidence interval; DS, digital scans; MD, mean difference; No., number; NR, not reported; SD, standard deviation; sec, seconds. Lava Chairside Oral Scanner (C.O.S); TRIOS (3Shape A/S); Cerec Omnicam (Dentsply Sirona); significant at *P*<.05.

Table 4. Visual analog scale average characterizing patient comfort during digital scanning and conventional impressions

Study Reference	No. Patients	Intraoral Scanners	DS		CI*		MD, 95% CI	P
			Mean	SD	Mean	SD		
3[34]	19	TRIOS	62	NR	8.4	NR	53.6	<.05
4[25]	10	iTero	73	17	74	24	-1	>.05
6[35]	16	Lava C.O.S	80.3	10.9	60.8	10.4	19.5	<.05
9[38]	48	TRIOS	65	58.7	26.7	2.7	38.3	<.05
15[44]	24	Omnicam	59	37.7	28.1	18.4	30.96	<.05
Total			67.8	21.7	39.6	9.3	28.2 (CI, -1.1; 57.5)	<.05

CI*, conventional impressions; CI, confidence interval; DS, digital scans; MD, mean difference; NR, not reported; No., number of; SD, standard deviation. TRIOS (3Shape A/S); iTero (Align Technology); Lava Chairside Oral Scanner (COS); Cerec Omnicam (Dentsply Sirona); significant at *P*<.05.

in their entirety to select those that corresponded to the inclusion and exclusion criteria. According to these criteria, 23 articles were excluded,[3-7,10-12,17-31] and the reasons for their exclusion are presented in Table 1. Ultimately, only 14 randomized controlled crossover studies or parallel groups and 2 prospective comparative studies were included.[25,26,32-45] The bibliographic research flow chart is presented in Figure 1, and the characteristics of the included studies, the main parameters, and the results of the 16 articles are shown in Table 2.

The details of the answers to the 3 questions asked are summarized as follows:

The PICO 1 question (clinical time) was studied in 6 investigations by using a stopwatch to measure this parameter.[25,32,34,38,40,44] Data pooling showed no statistically significant difference between the 2 techniques (digital scans: 784 ±252 seconds; conventional impressions: 1125 ±159 seconds) (*P*>.05) (Table 3). The PICO 2 question (patient comfort) was evaluated in 5 studies by using a visual analog scale (VAS) to assess the comfort level or preferences of participants during the procedure.[25,34,35,38,44] A harmonization of this scale from “0=uncomfortable” to “100=very comfortable” was carried out to facilitate the synthesis of the data. The mean VAS score was lower in participants who received conventional impressions (39.6 ±9.3) rather than digital scans (67.8 ±21.7), and the difference was statistically significant (*P*<.05) (Table 4). These results show that patients preferred intraoral scanning over conventional impression methods.

The PICO 3 question (marginal fit) was evaluated in 13 articles that measured the perpendicular distance from the internal surface at the margin of the restoration to the preparation finish line through the silicone replica technique or a 150-µm-diameter explorer.[26,32,33,35-43,45] To observe the gaps between the prosthesis and the tooth margin, 5 studies used a light microscope,[26,36,37,40,41] 7 used a stereomicroscope,[26,32,35,39,42,43,45] 1 used a macroscope,[33] and 1 used an explorer.[38] The average marginal fit values were lower for digital scanning techniques (80.9 ±31.9 µm) than for conventional impressions (92.1 ±35.4 µm), but the difference was not statistically significant (*P*>.05) (Table 5). These results were clinically acceptable, as the values were below the 100 µm typically cited.[7] The studies were heterogeneous, so a meta-analysis on this endpoint would have had little relevance.

Table 5. Data on measurements of marginal fit between conventional impression and digital scanning techniques

Study Reference	No. Protheses Evaluated	Intraoral Scanners	DS µm		CI* µm		MD µm, 95% CI	P
			Mean	SD	Mean	SD		
1[32]	30	TRIOS	60.1	NR	97	NR	-36.9	<.05
2[33]	38	TRIOS	72	NR	83	NR	-11	<.05
5[26]	10	infiniDent	108.3	93.8	117.7	129.4	-9.4	>.05
6[35]	16	Lava C.O.S	61.5	5.81	56.3	3	5.2	>.05
7[36]	10	iTero	127.8	58.3	90.4	66.1	37.4	>.05
8[37]	20	TRIOS	87.4	91.2	82.2	75.2	5.2	>.05
10[39]	30	TRIOS	106.6	69.6	119.9	60	-13.3	>.05
11[40]	33	Lava C.O.S	61.1	24.8	70.4	28.7	-9.3	<.05
13[42]	26	iTero	80.3	26.2	133.5	48.8	-53.2	<.05
14[43]	34	Lava C.O.S	76.3	65.3	91.5	72.2	-15.1	<.05
16[45]	20	Lava C.O.S	49	24	71	39	-22	<.05
Total	267	–	80.9	31.9	92.1	35.4	-11.1 [CI, -32.5; 10.4]	>.05

µm, micrometers; CI*, conventional impressions; CI, confidence interval; DS, digital scans; MD, mean difference; NR, not reported; No., number; SD, standard deviation. TRIOS (3Shape A/S); Cerec infiniDent (Dentsply Sirona); Lava Chairside Oral Scanner (COS); iTero (Align Technology); significant at *P*<.05.

Only 2 studies compared the conventional impression and digital scan techniques regarding practitioner difficulties,[25,38] and 9 analyzed the internal fit of the prostheses by measuring the distance between the die and the intaglio surface of the crown.[26,32,33,36,37,39,40,42,43] For practitioner difficulties, the authors’ findings were contradictory, and the 2 techniques were comparable in terms of internal fit values.

Among the studies included in this review, 9 presented an elevated risk of bias because of the absence of

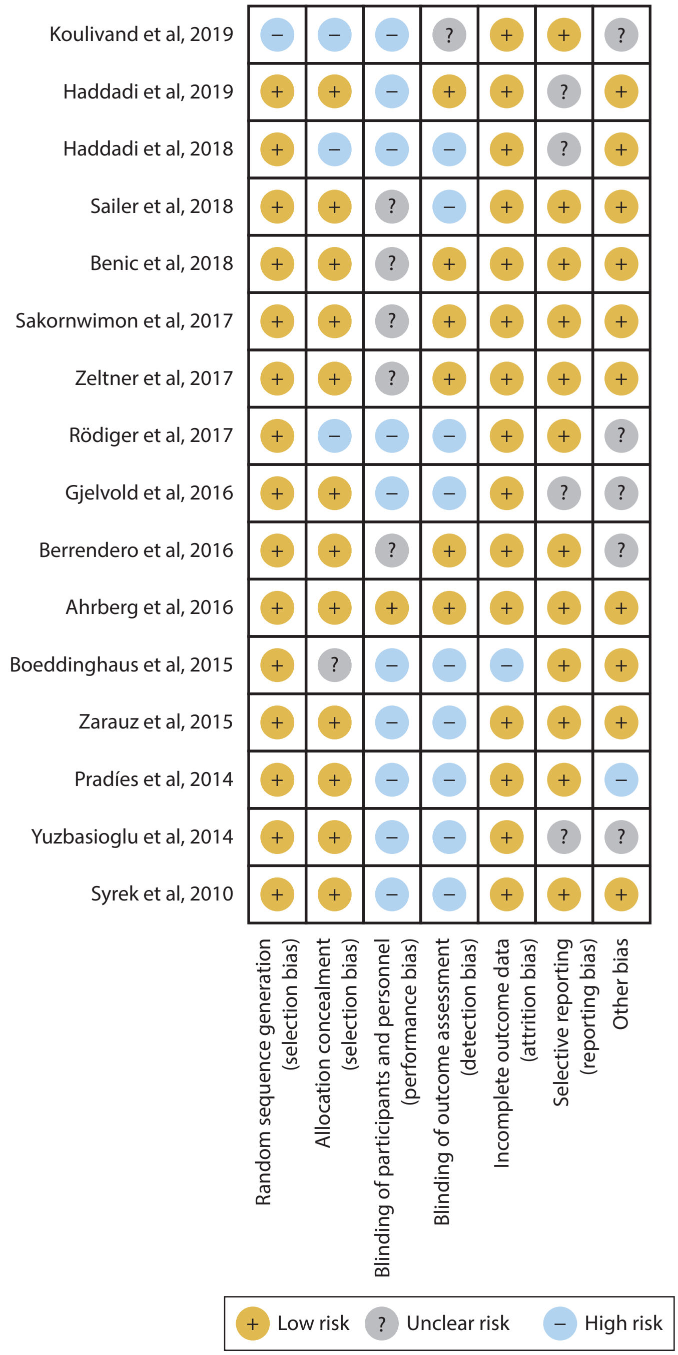

Figure 2. Risk of bias of included studies. *Yellow* indicates low risk of bias, *gray* indicates unclear risk of bias, and *blue* indicates high risk of bias.

blinded investigators and participant or result evaluation. However, 7 studies showed an unclear to low risk of bias (Fig. 2). The overall quality of evidence was low in all studies.

DISCUSSION

This systematic review included 16 clinical studies that compared digital scanning and conventional impression techniques in terms of clinical time, patient comfort, and marginal fit.

The null hypothesis was rejected for patient comfort but not for clinical time or marginal fit.

For the clinical time, the findings were divergent. Sailer et al[25] reported that conventional impression procedures were objectively less time-consuming than digital scanning procedures ($P<.05$). Nevertheless, other authors[32,34,38,40,44] reported that the digital scan was a more time-efficient technique than conventional impressions (P<.05). The steps used to evaluate this parameter differed among studies, which explains the variability in the results. In addition, the learning curve and practitioner experience seemed to play a decisive role in impression-making duration. However, Haddadi et al[34] suggested that the operator has the option to "repair" a scan if a certain area is assessed as substandard. With the conventional technique, a defect is discovered only after complete polymerization of the impression material. If a defect is present, the only option is to remake the impression. It would seem wise to standardize the steps of the clinical time to draw pertinent conclusions in favor of one technique or the other.

Patient comfort was evaluated in 5 studies,[25,34,35,38,44] and pooled data showed that the digital scan technique was more comfortable than conventional impression making (P<.05). However, one factor reducing the comfort for the patients was the need to powder the intraoral environment for some of the digital scanners.[25] This explains why today scanners such as Itero, Cerec Omnicom, and TRIOS that do not use powder present advantages in terms of clinical time and patient comfort compared with conventional impressions.

The replica technique was used in 12 studies[26,32,33,35-43,45] to measure the marginal fit of the crown before cementation. No statistically significant differences were found in terms of the marginal fit of tooth-supported prostheses based on conventional and digital scan techniques. These results are consistent with those reported by Nagarkar et al,[7] who noted no significant differences between the mean marginal gap values of the 2 techniques. However, the studies included in this review had heterogeneous study designs, the use of different types of restorations or different laboratory fabrication techniques, and the methods used to measure the marginal fit (light microscope, stereomicroscope, macroscope, or explorer). Furthermore, the authors used the silicone replica technique to reproduce the marginal fit. The process requires the manipulation of elastomers that can lead to imprecisions. To avoid this inconvenience, the authors recommended the use of optical coherence tomography, which allows for the measurement of the gap directly on the gypsum casts.[46] Concerning the difficulties of the practitioner in conventional versus digital scan techniques, additional studies are required to assess this aspect.[26,39]

Limitations of this systematic review and meta-analysis included the small number of studies per parameter and the small number of participants included in each study. The evidence level remained low for the studies that were otherwise heterogeneous. Therefore, these results should be interpreted with caution.

CONCLUSIONS

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

1. No statistically significant difference was found between the 2 recording techniques in terms of clinical time.
2. Digital scan procedures are more comfortable for patients than conventional impressions.
3. Crowns or 3-unit fixed partial dentures fabricated by using intraoral scan techniques are comparable with conventional impressions in terms of their marginal fit.

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Corresponding author:
Dr Assem Soueidan
Periodontology Department
Rmes U1229, University of Nantes
1 Place Alexis Ricordeau, Nantes 44042
FRANCE
Email: assem.soueidan@univ-nantes.fr

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