Frontiers in Dentistry

Comparative Evaluation of Digital and Conventional Workflows for the Fabrication of Multi-Unit Implant-Supported Fixed Restorations: An Empty Review

Ali Mahmoud Hashemi[1], Mahya Hasanzadeh[2,3], Ameen Khraisat[4], Marzieh Alikhasi[1,2,3*]

1. Dental Implant Research Center, Dentistry Research Institute, Tehran University of Medical Sciences, Tehran, Iran
2. Dental Research Center, Dentistry Research Institute, Tehran University of Medical Sciences, Tehran, Iran
3. Department of Prosthodontics, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran
4. Department of Conservative Dentistry and Fixed Prosthodontics, Faculty of Dentistry, University of Jordan, Amman, Jordan

Article Info

Article type:
Review article

Article History:
Received: 24 May 2023
Accepted: 30 Nov 2023
Published: 09 Jun 2024

**** Corresponding author:***

Dental Research Center, Dentistry Research Institute, Department of Prosthodontics, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran

Email: malikhasi@razi.tums.ac.ir

ABSTRACT

Objectives: This study aimed to do a comprehensive systematic review on the comparison of digital and conventional workflows regarding prosthetic outcomes, accuracy of implant impressions, framework passivity and fit, and clinical fabrication of multi-unit implant-supported fixed restorations.

Materials and Methods: The EMBASE, PubMed, Scopus, and Cochrane Library databases were searched for relevant articles published up until April 2020.

Results: No in-vivo article was found to compare full digital and conventional workflows regarding the accuracy of implant impressions, passivity and fit of frameworks, and prosthetic outcomes. There was no study to investigate full digital and conventional workflows for clinical fabrication of multi-unit implant-supported fixed restorations.

Conclusion: This empty review highlights the need for further research to compare full digital and conventional workflows for implant-supported restorations.

Keywords: Dental Prosthesis, Implant-Supported; Computer-Aided Design; Review

➢ **Cite this article as:** Hashemi AM, Hasanzadeh M, Khraisat A, Alikhasi M. Comparative Evaluation of Digital and Conventional Workflows for the Fabrication of Multi-Unit Implant-Supported Fixed Restorations: An Empty Review. *Front Dent*. 2024:21:20.

INTRODUCTION

A precise impression is an important requirement for the fabrication of prosthetic restorations [1-4], and any error in this phase may compromise the accuracy of the subsequent steps [2-8]. Passive fit is a key factor in the long-term success of any prosthetic restoration. Restoration misfit can increase the risk of caries through enhancement of plaque accumulation and microleakage in tooth-supported restorations, and can compromise the osseointegration process in implant-supported restorations [9]. Recent technological advances have modified the impression and restoration fabrication techniques in prosthetic dentistry. The digital impression systems are increasingly used in clinical dental practice. The milling technologies have also advanced to ensure more accurate fabrication of restorations [5,6,10-12]. The main benefits of the digital workflow and digital technology include elimination of the fabrication steps that may cause misfit, fewer laboratory steps, lower cost, and less patient discomfort [13,14].

A standard treatment in the conventional method includes impression making and using the obtained gypsum cast for the fabrication of final restoration in a laboratory. In the digital method, the dental arch is initially scanned by an intraoral scanner, the restoration is designed by the respective software program and is then fabricated in a milling machine.

The selection of digital or conventional method is a clinical challenge for dental clinicians and requires attention to accuracy, fit, and passivity [14]. Few clinical studies have compared the digital and conventional workflows and their outcomes [15,16].

In the present review, it was important to evaluate the studies that assessed full digital and full conventional workflows from the onset to the end of treatment with the same workflow. The purpose of this review was to compare the digital and conventional workflows regarding prosthetic outcomes, accuracy of implant impressions, framework passivity and fit, and clinical fabrication of multi-unit implant-supported fixed restorations.

MATERIALS AND METHODS

This systematic review followed the guidelines of the Preferred Reporting Items for Systematic reviews and Meta-Analyses (http://prisma-statement.org/). The population, intervention, comparison, and outcome (PICO) framework was formulated to answer the following question:

In three-unit implant-supported restorations (P), does the digital workflow (I) compared with the conventional workflow (C) provide better results in terms of accuracy of implant impression, passivity, and fit (O)?

Four databases including the PubMed, EMBASE, Scopus and Cochrane Library were electronically searched to find relevant articles published until September 2021. The search strategy was assembled from a combination of qualified medical subject headings (Mesh terms) as well as unspecific free-text words in simple or multiple conjunctions. Manual search of the reference lists of the pertinent papers and reviews was also conducted to find additional articles. The search strategy for all databases is shown in Table 1. The comparator terms from the search strategy were abolished in an additional search to confirm that no possibly eligible studies were excluded.

Eligible studies included clinical trials that compared full digital and conventional workflows in fabrication of multi-unit implant-supported restorations in the same study and used the same methods of all digital and all conventional for the comparison. In addition, studies had to report at least one of the following outcomes: accuracy of implant impressions and/or restoration fit. The exclusion criteria were studies that made no comparison, or used a mixed digital-conventional workflow, duplicates, case reports, and articles containing insufficient information. Therefore, studies that did not compare full digital and full conventional workflows from the beginning to the end were excluded.

For screening and study selection, two authors (A.M.H and M.H) initially reviewed the titles independently. Next, the abstracts of the selected titles were read, and if an agreement was not reached, a third author was consulted (M.A). The same two authors retrieved and reviewed the full text of the selected articles. Articles were chosen based on a consensus between the two reviewers, and in case of disagreement, a third author (M.A.) was consulted. A protocol was designed for data extraction, and two calibrated reviewers (A.M.H. and M.H.) extracted the data from the selected articles and tabulated them in Microsoft Excel 2016 (Microsoft, Redmond, WA). Disagreements were resolved by discussion and consultation with a third reviewer (M.A) until a consensus was reached. The risk of bias of each study was assessed using the Cochrane Collaboration tool (http://ohg.cochrane.org).

RESULTS

The systematic search was completed on September 2021. Of the 459 retrieved titles, 318 abstracts were selected; subsequently, 20 articles were chosen for the full-text review (Table 2). Of the remaining 20 articles, 9 papers were excluded as they had an in vitro design [17-25], 5 articles were excluded since they assessed only single-unit restorations [26-30], and one study investigated digital and conventional workflows on natural teeth [31]. All clinical studies evaluated mixed workflows for the fabrication of implant-supported partial dentures and no study compared full digital and conventional workflows [32-36] leaving no study for the final analysis (Figure 1). Based on the adopted search strategy and

Table 1. Search strategy based on the PICO (population, intervention, comparison, and outcome) focused question

Search	Query	
Population #1	((((((((((("Denture, Partial, Fixed"[MeSH Terms]) OR "Denture, Partial, Fixed"[MeSH Terms]) OR "Dental Prosthesis, Implant-Supported"[MeSH Terms])) OR "implant supported partial denture"[Title/Abstract]) OR "implant-supported partial denture"[Title/Abstract]) OR "implant supported partial denture"[Title/Abstract]) OR "implant supported bridge"[Title/Abstract]) OR "implant-supported bridge"[Title/Abstract]) OR "implant supported fixed partial denture"[Title/Abstract]) OR "implant-supported fixed partial denture"[Title/Abstract]) OR "Dental implant"[MeSH Terms]) OR "dental implant*"[Title/Abstract]	
Intervention #2	((((((((((("digital workflow"[Title/Abstract]) OR "cad/cam"[Title/Abstract]) OR "cad-cam"[Title/Abstract]) OR "Cad cam"[Title/Abstract]) OR "computer aided design-computer aided manufacturing"[Title/Abstract]) OR "computer aided design/computer aided manufacturing"[Title/Abstract]) OR "intra oral scanning"[Title/Abstract]) OR "intraoral scanning"[Title/Abstract]) OR "intra-oral scanning"[Title/Abstract]) OR "digital impression"[Title/Abstract]) OR "Computer-Aided Design"[MeSH Terms]) OR "digital implant impression" [Title/Abstract]) OR "digital fabrication"[Title/Abstract]) OR "Optical impression"[Title/Abstract]	
Comparison #3	(((((((("conventional impression"[Title/Abstract]) OR "conventional workflow"[Title/Abstract]) OR "silicone impression"[Title/Abstract]) OR "siloxane impression"[Title/Abstract]) OR "addition silicone"[Title/Abstract]) OR "additional silicone"[Title/Abstract]) OR "conventional technique"[Title/Abstract]) OR casting[Title/Abstract]) OR "traditional impression"[Title/Abstract]) OR "impression technique"[Title/Abstract]	
Outcome #4	((((((((((((Passivity[Title/Abstract]) OR "Framework fitness"[Title/Abstract]) OR "Mechanical performance"[Title/Abstract]) OR "clinical performance"[Title/Abstract]) OR "clinical outcome"[Title/Abstract]) OR Survival[Title/Abstract]) OR Accuracy[Title/Abstract]) OR "Dimensional Measurement Accuracy"[MeSH Terms]) OR "Treatment Outcome"[MeSH Terms]) OR "Prosthesis Fitting"[MeSH Terms]) OR "Data Accuracy"[MeSH Terms]) OR "Prosthesis Failure"[MeSH Terms]) OR "Prostheses complication"[MeSH Terms]) OR "patient satisfaction"[MeSH Terms]) OR Esthetic[MeSH Terms]	
Database	Query	Items Found
PubMed	#1 AND #2 AND #3 AND #4=54	77
Embase	#1 AND #2 AND #3 AND #4=42	51
Scopus	#1 AND #2 AND #3 AND #4=295	315
Cochrane	#1 AND #2 AND #3 AND #4=13	16

the eligibility criteria, no clinical article was found on the comparison of full digital and conventional workflows for the accuracy of implant impressions, and the passivity and fit of frameworks. Other articles used digital and conventional methods only for impressions, and used one method for the frameworks [17,32-34,36]. Assessment of the risk of bias and data extraction were not possible because there was no eligible study for inclusion.

DISCUSSION

The digitalization trend is a universal phenomenon in all aspects of life as well as in dental practice in today's world [37,38]. Dental clinicians can use intraoral scanners instead of conventional impression making. The computer-aided design/computer-aided manufacturing technology systems offer some benefits such as simplicity of the process, reduced storage requirement, higher patient comfort, easy

Table 2. Studies excluded at the full-text level with reasons

	Study	Reasons for exclusion
1	**Abdel-Azim et al. (2014) [17]**	In vitro design
2	**Aktas et al. (2014) [26]**	Single unit restoration
3	**Al Quran et al. (2012) [18]**	In vitro design. No comparison made between fully conventional and digital workflows
4	**Al-Fadda et al. (2007) [19]**	In vitro design. No comparison made between fully conventional and digital workflows
5	**Benic et al. (2019) [31]**	Comparison of full digital and full conventional workflows on teeth.
6	**Cappare et al. (2019) [32]**	No comparison made between fully conventional and digital workflows
7	**Di fiore et al. (2018) [27]**	Single unit restoration
8	**Drago et al. (2010) [20]**	In vitro design. No comparison made between fully conventional and digital workflows
9	**Ferrini et al. (2018) [33]**	No comparison made between fully conventional and digital workflows
10	**Gherlone et al. (2016) [34]**	No comparison made between fully conventional and digital workflows
11	**Jemt et al. (1999) [35]**	No comparison made between fully conventional and digital workflows
12	**Jiang et al. (2019) [36]**	No comparison made between fully conventional and digital workflows
13	**Joda et al. (2015) [28]**	Single unit restoration
14	**Joda et al. (2015) [29]**	Single unit restoration
15	**Karl et al. (2012) [21]**	In vitro design
16	**Karl et al. (2008) [22]**	In vitro design. No comparison made between fully conventional and digital workflows
17	**Mello et al. (2019) [23]**	In vitro design. No comparison made between fully conventional and digital workflows
18	**Pesco et al. (2018) [24]**	In vitro design
19	**Rattanapanich et al. (2019) [30]**	Single unit restoration
20	**Tahmaseb et al. (2010) [25]**	In vitro design. No comparison made between fully conventional and digital workflows

data transfer, and reduced requirement for manpower [39,40]. However, selection of a full digital or conventional workflow remains a challenging decision for many dental clinicians. The accuracy of impressions and fit and passivity of the frameworks are among the factors to consider when making a decision regarding selection of digital or conventional workflow. The fully digital and conventional methods have not been previously compared in the literature. The comprehensive literature search conducted in the present review revealed no in vivo study comparing the accuracy of implant impressions, and passivity and fit of the frameworks fabricated by the full digital and conventional workflows. Many studies compared the digital and conventional methods only at the impression level [1-4, 6] or compared the framework fabrication alone [5,7,17,19]. The majority of the retrieved articles were in vitro studies [6-8, 11, 13] or compared the digital and conventional methods only regarding single-unit implant-supported restorations [29, 30]. The results of the present empty review indicated that there was no study clinically comparing the digital and conventional methods for multi-unit implant-supported restorations.

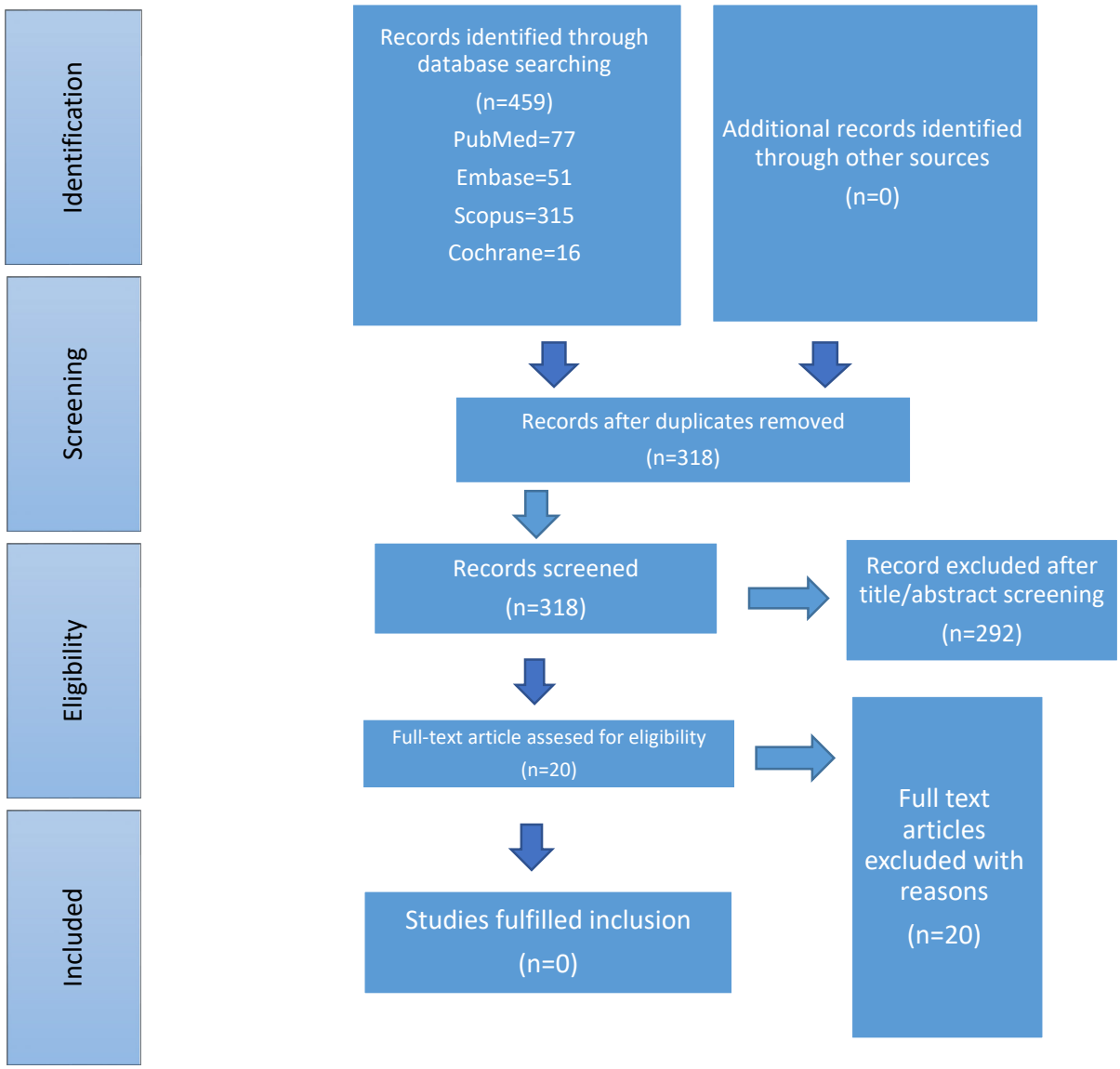

Fig. 1. Consort flow diagram of the study

One example of an excluded study was a clinical trial published by Gherlone et al, [34] in 2016, who compared the digital versus the conventional impression techniques for "all-on-four" restorations. Gherlone et al, [34] only assessed the impression accuracy (digital and conventional pick up impressions) and only used one method for the fabrication of milled screw-retained frameworks. There were several other articles that compared the two workflows only at the impression level, but adopted only one framework fabrication technique [17,18,32-34,36]. Despite the variety of such studies, most of the studies that compared the digital and conventional impression methods did not find a statistically significant difference in their accuracy; however, the digital technique had a shorter chair time [32-34]. Another reason of exclusion was in vitro design of most studies [17-25]. Abdel-azim et al. [17] investigated both the impression accuracy and misfit of the frameworks that were built with two workflows in an in vitro study. Mello et al. [23] compared the digital and conventional workflows for the resin casts for fabrication of digital and conventional frameworks, and then compared the framework fit. Benic et al, [31] clinically compared full digital and conventional workflows. There were 10 participants, each with 4 fixed partial denture frameworks fabricated for the same abutment teeth through the digital and conventional

methods. The conventionally fabricated 3-unit zirconia frameworks showed the same or less fit than the digitally fabricated metal frameworks. One study compared the digital and conventional workflows in 50 patients but all restorations were single-unit implant-supported restorations [30].

Researchers use the term 'empty' review when a search to address a research question yields no eligible studies. Systematic reviews are implemented for various reasons. For instance, authors may very well be aware that there are very few (if any) randomized clinical trials in a specific subject area, yet they cannot claim this for a fact until they carry out a systematic search. Once this effort results in no eligible studies found, they can use this evidence to empirically demonstrate "the need for future high-quality research" and pursue funding to carry out such primary research [41].

The current review was an empty review with no studies meeting the eligibility criteria. Lang et al. [42] introduced the term empty review to the literature in 2007. They highlighted the need for a guideline for reporting empty reviews in order to prevent investigators from deriving unsubstantiated implications for practice, or from simply concluding that no eligible studies were found [42]. Although the definite reason for this finding is not obvious, some potential reasons could be cited. First, the research field is new and clinical studies have not yet been conducted. Second, fabrication of multi-unit implant-supported restorations with a fully digital workflow might be limited to pioneer practitioners as it needs advanced technology and expertise. Third, during the scanning process, the accuracy of intraoral scanner decreases by an increase in the arch span, which increases the susceptibility to distortion [43-46]. As an intraoral scanner cannot capture the whole arch with one single scan, multiple overlapping scans have to be taken and combined via the stitching algorithm. Eventually, errors will be propagated for every stitching process [47-49]. Such factors can serve as limitations for clinicians that would like to adopt a fully digital workflow for the fabrication of fixed partial dentures.

According to another hypothesis, not finding any eligible article in empty reviews may be related to a highly specific PICO question. However, the inclusion criteria of the present study were simple and the search strategy was clear, broad, and comprehensive to find relevant articles. Many empty reviews might come out as a result of overly strict inclusion criteria that are imposed in favor of higher quality evidence. Such criteria may include the choice of study based on specific designs, conclusions, or comparison conditions that may not be available in preliminary studies [50]. In the current review, the main inclusion criterion was studies that compared the digital and conventional techniques, and no limitation was set in article enrollment based on the quality of studies.

Empty reviews are valuable for publication from two aspects. First, in cases that the focused question is derived from a clinical scenario, reporting no evidence indicates that it is hard to make a solid informed decision. Therefore, an optimal technique for the fabrication of multi-unit implant-supported restorations could not be introduced. Second, this study demonstrated a knowledge gap in the current status of digital implant dentistry and provided a direction for future research.

Reaching a conclusion based on the excluded studies was offered by Lang et al [42]. However, Green et al. [51] argued that basing conclusions on studies that did not meet the defined inclusion criteria in a review protocol would increase the risk of bias of the review and may indeed, mislead the readers. Although no conclusion could be drawn from this systematic review regarding the superiority of digital versus the conventional workflow, it highlighted the need for future research in this regard.

CONCLUSION

The purpose of this study was to systematically collect, review, and appraise the studies that compared the digital and conventional workflows regarding impression accuracy, framework fit, and clinical fabrication of multi-unit implant-supported restorations. There were no relevant publications comparing the digital and conventional methods clinically.

This empty review highlighted the need for clinical research comparing the full digital and full conventional workflows.

CONFLICT OF INTEREST STATEMENT

None declared.

REFERENCES

1. Berrendero S, Salido M, Valverde A, Ferreiroa A, Pradies G. Influence of conventional and digital intraoral impressions on the fit of CAD/CAM-fabricated all-ceramic crowns. Clin Oral Investig. 2016 Dec;20:2403-10.
2. Pradíes G, Zarauz C, Valverde A, Ferreiroa A, Martínez-Rus F. Clinical evaluation comparing the fit of all-ceramic crowns obtained from silicone and digital intraoral impressions based on wavefront sampling technology. J Dent. 2015 Feb;43:201-8.
3. Chochlidakis KM, Papaspyridakos P, Geminiani A, Chen CJ, Feng IJ, Ercoli C. Digital versus conventional impressions for fixed prosthodontics: a systematic review and meta-analysis. J Prosthet Dent. 2016 Aug;116:184-190.e12.
4. Tsirogiannis P, Reissmann DR, Heydecke G. Evaluation of the marginal fit of single-unit, complete-coverage ceramic restorations fabricated after digital and conventional impressions: a systematic review and meta-analysis. J Prosthet Dent. 2016 Sep;116:328-335.e2.
5. Miwa A, Kori H, Tsukiyama Y, Kuwatsuru R, Matsushita Y, Koyano K. Fit of e. max crowns fabricated using conventional and CAD/CAM technology: a comparative study. Int J Prosthodont. 2016 Nov;29:602-7.
6. Shembesh M, Ali A, Finkelman M, Weber HP, Zandparsa R. An in-vitro comparison of the marginal adaptation accuracy of CAD/CAM restorations using different impression systems. J Prosthodont. 2017 Oct;26:581-6.
7. Euán R, Figueras-Álvarez O, Cabratosa-Termes J, Oliver-Parra R. Marginal adaptation of zirconium dioxide copings: influence of the CAD/CAM system and the finish line design. J Prosthet Dent. 2014 Aug;112:155-62.
8. Vennerstrom M, Fakhary M, Von Steyern PV. The fit of crowns produced using digital impression systems. Swed Dent J 2014 Jan;38:101-10.
9. Heckmann SM, Karl M, Wichmann MG, Winter W, Graef F, Taylor TD. Cement fixation and screw retention: parameters of passive fit. An in vitro study of three-unit implant-supported fixed partial dentures. Clin Oral Implants Res. 2004 Aug;15:466-73.
10. Miyazaki T, Hotta Y. CAD/CAM systems available for the fabrication of crown and bridge restorations. Aust Dent J. 2011 Jun;56:97-106.
11. Renne W, Ludlow M, Fryml J, Schurch Z, Mennito A, Kessler R, et al. Evaluation of the accuracy of 7 digital scanners: an in-vitro analysis based on 3-dimensional comparisons. J Prosthet Dent. 2017 Jul;118:36-42.
12. Richert R, Goujat A, Venet L, viguie G, Viennot S, Robinson P, et al. Intraoral scanner technologies: a review to make a successful impression. J Healthc Eng. 2017;2017:1-9.
13. Seelbach P, Brueckel C, Wöstmann B. Accuracy of digital and conventional impression techniques and workflow. Clin Oral Investig. 2013 Sep;17:1759-64.
14. Zeltner M, Sailer I, Mühlemann S, Özcan M, Hämmerle CH, Benic GI. Randomized controlled within-subject evaluation of digital and conventional workflows for the fabrication of lithium disilicate single crowns. Part III: marginal and internal fit. J Prosthet Dent. 2017 Mar 1;117(3):354-62.
15. Schepke U, Meijer HJ, Kerdijk W, Cune MS. Digital versus analog complete arch impressions for single-unit premolar implant crowns: operating time and patient preference. J Prosth Dent. 2015 Sep;114(3):403-6.
16. Joda T, Zarone F, Ferrari M. The complete digital workflow in fixed prosthodontics: a systematic review. BMC Oral Health. 2017 Sep;17(1):124.
17. Abdel-Azim T, Zandinejad A, Elathamna E, Lin W, Morton D. The influence of digital fabrication options on the accuracy of dental implant-based single units and complete-arch frameworks. Int J Oral Maxillofac Implants. 2014 Dec;29(6):1281-8.
18. Al Quran FA, Rashdan BA, Zomar AA, Weiner S. Passive fit and accuracy of three dental implant impression techniques. Quintessence Int. 2012 Feb;43(2):119-25.
19. Al-Fadda SA, Zarb GA, Finer Y. A comparison of the accuracy of fit of 2 methods for fabricating implant-prosthodontic frameworks. Int J Prosthodont. 2007 Mar;20(2):125-31.
20. Drago C, Saldarriaga RL, Domagala D, Almasri R. Volumetric determination of the amount of misfit in CAD/CAM and cast implant frameworks: a multicenter laboratory study. Int J Oral Maxillofac Implants. 2010 Oct;25(5):920-9.
21. Karl M, Graef F, Schubinski P, Taylor T. Effect of intraoral scanning on the passivity of fit of implant-supported fixed dental prostheses. Quintessence Int. 2012 Jul;43(7):555-62.
22. Karl M1, Wichmann MG, Heckmann SM, Krafft T. Strain development in 3-unit implant-supported CAD/CAM restorations. Int J Oral

Maxillofac Implants. 2008 Aug;23(4):648-52.
23. Mello C, Santiago Junior F, Lemos C, Galhano G, Evangelisti E, Scotti R, et al. Evaluation of the accuracy and stress distribution of 3-unit implant supported prostheses obtained by different manufacturing methods. Mater Sci Eng C Mater Biol Appl. 2019 Sep;102:66-74.
24. Pesce P, Pera F, Setti P, Menini M. Precision and accuracy of a digital impression scanner in full-arch implant rehabilitation. Int J Prosthodont. 2018 Mar;31(2):171-5.
25. Tahmaseb A, van de Weijden JJ, Mercelis P, De Clerck R, Wismeijer D. Parameters of passive fit using a new technique to mill implant-supported superstructures: an in vitro study of a novel three-dimensional force measurement-misfit method. Int J Oral Maxillofac Implants. 2010 Mar;25:247-57.
26. Aktas G, Özcan N, Aydin DH, Şahin E, Akça K. Effect of digitizing techniques on the fit of implant-retained crowns with different antirotational abutment features. J Prosthet Dent. 2014;111(5):367-72.
27. Di Fiore A, Vigolo P, Graiff L, Stellini E. Digital vs conventional workflow for screw-retained single-implant crowns: A comparison of key considerations. Int J Prosthodont. 2018 Nov;31(6):577-9.
28. Joda T, Brägger U. Digital vs. conventional implant prosthetic workflows: a cost/time analysis. Clin Oral Implants Res. 2015 Dec;26(12):1430-5.
29. Joda T, Brägger U. Time-efficiency analysis comparing digital and conventional workflows for implant crowns: A prospective clinical cross-over trial. Int J Oral Maxillofac Implants. 2015 Sep;30(5):1047-53.
30. Rattanapanich P, Aunmeungtong W, Chaijareenont P, Khongkhunthian P. Comparative study between an immediate loading protocol using the digital workflow and a conventional protocol for dental implant treatment: A randomized clinical trial. J Clin Med. 2019 May;8(5):622-34.
31. Benic GI, Sailer I, Zeltner M, Gütermann JN, Özcan M, Mühlemann S. Randomized controlled clinical trial of digital and conventional workflows for the fabrication of zirconia-ceramic fixed partial dentures. Part III: Marginal and internal fit. J Prosthet Dent. 2019 Mar;121(3):426-31.
32. Cappare P, Sannino G, Minoli M, Montemezzi P, Ferrini F. Conventional versus digital impressions for full arch screw-retained maxillary rehabilitations: A randomized clinical trial. Int J Environ Res Public Health. 2019 Mar;7;16(5):829.
33. Ferrini F, Capparé P, Vinci R, Gherlone EF, Sannino G. Digital versus traditional workflow for posterior maxillary rehabilitations supported by one straight and one tilted implant: A 3-year prospective comparative study. Biomed Res Int. 2018 Nov;2018:4149107.
34. Gherlone E, Capparé P, Vinci R, Ferrini F, Gastaldi G, Crespi R. Conventional versus digital impressions for "all-on-four" restorations. Int J Oral Maxillofac Implants. 2016 Mar;31(2):324-30.
35. Jemt T, Bäck T, Petersson A. Photogrammetry--an alternative to conventional impressions in implant dentistry? A clinical pilot study. Int J Prosthodont. 1999 Jul;12(4):363-8.
36. Jiang X, Lin Y, Cui HY, Di P. Immediate loading of multiple splinted implants via complete digital workflow: A pilot clinical study with 1-year follow-up. Clin Implant Dent Relat Res. 2019 Jun;21(3):446-53.
37. Fasbinder DJ. Digital dentistry: innovation for restorative treatment. Comp Cont Educ Dent. 2010 Oct;31:2-11.
38. Weston J. Closing the gap between esthetics and digital dentistry. Comp Cont Educ Dent. 2016 Feb;37(2):84-91.
39. Goracci C, Franchi L, Vichi A, Ferrari M. Accuracy, reliability, and efficiency of intraoral scanners for full-arch impressions: A systematic review of the clinical evidence. Eur J Orthod. 2016 Aug;38(4):422-8.
40. Gimenez B, Ozcan M, Martinez-Rus F, Pradies G. Accuracy of a digital impression system based on active wavefront sampling technology for implants considering operator experience, implant angulation, and depth. Clin Implant Dent Relat Res. 2015 Jan;17:54-64.
41. Schlosser R, Sigafoos J. Empty reviews and evidence-based practice. Evidence-Based Communication Assessment and Intervention. 2009;3(1):1-3.
42. Lang A, Edwards N and Fleiszer A. Empty systematic reviews: Hidden perils and lessons learned. J Clin Epidemiol. 2007 Jun;60(6):595-7.
43. Ender A, Mehl A. Accuracy of complete-arch dental impressions: a new method of measuring trueness and precision. J Prosthet Dent. 2013 Feb;109(2):121-8.
44. Ender A, Zimmermann M, Attin T, Mehl A. In vivo precision of conventional and digital methods for obtaining quadrant dental impressions. Clin Oral Investig. 2016 Sep;20:1495-504.
45. Ender A, Mehl A. In-vitro evaluation of the accuracy of conventional and digital methods of obtaining full-arch dental impressions. Quintessence Int. 2015 Jan;46(1):9-17.
46. Jeong ID, Lee JJ, Jeon JH, Kim JH, Kim HY, Kim WC. Accuracy of complete arch model using an

intraoral video scanner: An in vitro study. J Prosthet Dent. 2016 Jun;115(6):755-9.
47. Flugge TV, Schlager S, Nelson K, Nahles S, Metzger MC. Precision of intraoral digital dental impressions with iTero and extraoral digitization with the iTero and a model scanner. Am. J Orthod Dentofacial Orthop. 2013 Sep;144(3):471-8.
48. Ender A, Attin T, Mehl A. In vivo precision of conventional and digital methods of obtaining complete-arch dental impressions. J Prosthet Dent. 2016 Mar;115(3):313-20.
49. Abduo J, Elseyoufi M. Accuracy of Intraoral Scanners: A Systematic Review of Influencing Factors. Eur J Prosthodont Restor Dent. 2018 Aug;26(3):101-21.
50. Yaffe J, Montgomery P, Hopewell S, Shepard LD. Empty reviews: a description and consideration of Cochrane systematic reviews with no included studies. PLoS One. 2012 May;7(5):e36626.
51. Green S, Higgins JP, Schunemann, HJ, Becker L. Response to paper by Lang A, Edwards N, and Fleiszer A. J Clin Epidemiol. 2007 Jun;60(6):598-9.