

Accuracy of marginal adaptation of posterior fixed dental prosthesis made from digital impression technique: A systematic review

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Abstract

Aim: The aim of this systematic review was to investigate the marginal adaptation of three or four unit fixed dental prosthesis (FDP) fabricated with digital impression techniques to those fabricated using any other impression technique.

Settings and Design: Database/electronic searches were conducted till August 2019 in PUBMED-MEDLINE, SCOPUS, and Cochrane library. To identify published articles, multiple keywords were used to develop a search strategy in various combinations. Manual searching of articles was also done. Clinicaltrials.gov. in WHOICTRP and CTRI websites were also searched. Two independent reviewers (TP and VK) assessed eligibility for inclusion, extracted data, and assessed quality using the Cochrane risk of bias tool.

Results: Database search identified 497 citations and four citations through manual search. After removing duplicates and going through abstracts, 23 articles were perused for full-text screening. Two articles met the inclusion criteria; characteristics were described qualitatively, with two studies having overall low risk of bias.

Conclusions: Marginal adaptation of FDPs fabricated using the digital and conventional impressions method was within the clinically acceptable limits. However, more robust clinical trials need to be conducted with large sample size to validate the conclusions.

Keywords: Digital impressions, fixed dental prosthesis, marginal adaptation, posterior missing teeth, systematic review

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INTRODUCTION

All-ceramic restorations have gained popularity over the past few years due to their excellent esthetic properties

combined with improved material properties.^[1-3] Fixed dental prostheses (FDPs) fabricated using all ceramic systems, especially Zirconia, have been shown to have

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relatively high strength and good esthetics.^[4] The success of a good FDP depends on its marginal adaptation apart from biocompatibility, strength, and esthetics. Poor marginal adaptation leads to aggregation of bacterial plaque at the gingival margins and microleakage.^[5-10]

The fit of the restoration can be assessed by measuring the values of marginal and internal discrepancies after the prosthesis is seated on the teeth.^[11,12] Some studies have indicated the marginal gap, i.e., the distance between the tooth and restoration at the finish line area to be a true measure of crown adaptation.^[13,14] Thus, marginal adaptation reflects the fit of the restoration and is affected by the accuracy and precision of the impression.^[15]

The fabrication of all-ceramic crowns is generally done using conventional impression techniques with polyether or polyvinyl siloxane because of their high precision and excellent stability.^[1,2] The standard treatment approach consists of preparation of stone casts from the impressions for the fabrication of crowns and FDPs.^[16] Although high-quality impressions are achievable by these techniques and workflows, errors associated with the presence of blood, saliva, or during laboratory handling procedures such as during disinfection, pouring the impression may lead to inaccuracies.^[17]

Advancements in digital technology and dental processing has led to rapid improvements in computer-aided design/computer-aided manufacturing (CAD/CAM) applications. Restorations fabricated by CAD/CAM technology significantly improved fit of restorations, increased production efficiency, and increased acceptance by clinician as well as by patients.^[18] Direct digital impression techniques use intraoral scanners that can accurately scan abutments and transfer digital images from the dental office to the laboratory for fabrication of fixed prostheses.^[19,20] This system has advantages such as reducing impression time, patient burden, and gag reflex, thereby improving patient acceptance.^[19] Digital impressions also do not have the factor of error caused by distortion of impression materials.^[11]

Numerous studies have compared the accuracy of the fit of crowns made from both conventional and digital techniques, with most results showing similar accuracy.^[3,11] The majority of reports were *in vitro* studies that tested different materials with different methodologies.^[21-26] Randomized controlled trials that check the accuracy of the fit of fixed partial dentures fabricated using digital impression will be a true indicator for the accuracy of the technique used. The rationale of this systematic review is

to know how many studies have reliably recorded these findings and whether there is a need for further research in this area. Therefore, the aim and objective of this systematic review was to evaluate the marginal adaptation of posterior tooth supported FDP fabricated using digital impression techniques according to the criteria defined by the authors.

MATERIALS AND METHODS

This systematic review of randomized controlled trials was conducted following PRISMA guidelines. A review proposal was prepared and registered on PROSPERO public registry of systematic review.

Review question

The following PICO question was used to frame search strategy:

- Population: Patients who had missing posterior teeth replaced with FDP
- Intervention: Posterior FDP fabricated using digital impression technique for replacing missing posterior teeth
- Comparison: Posterior FDP made using any other impression technique for replacing missing posterior teeth.

Primary outcomes

Accuracy of marginal adaptation of FDP as defined by the authors.

Secondary outcomes

- Patients' perception
- Dentist feasibility (ease of operation).

Literature search

Database/electronic searches were conducted on PUBMED-MEDLINE, SCOPUS, and Cochrane databases to identify articles published till August 2019. The keywords used to help with the search were fixed dental prosthesis, marginal gap, marginal fit, marginal adaptation, internal fit, and digital impression. Manual searching of bibliography of relevant articles was also done. Clinicaltrials.gov site was also searched to identify research in gray literature. A repeat search was performed in September 2019 to update any recent publication.

The type of studies included was randomized controlled/clinical trials. No language restrictions were followed in the search strategy.

The inclusion criteria were:

Patients between 18 and 60 years of age with missing posterior teeth.

Randomized clinical trials

Patients underwent treatment for missing posterior teeth with tooth-supported FDPs.

Patients were given FDP made from digital impression in treatment group and FDP made from another impression technique, either conventional impression or another type of digital impression namely direct/indirect digital impression (but not same as in the treatment group), in the comparison group. The marginal adaptation of FDP was assessed using clearly defined criteria as defined by authors.

The exclusion criteria were:

- Studies comparing tooth-supported FDP with implant-supported FDP/removable partial prosthesis
- Studies in which criteria were not clearly defined for assessing marginal adaptation.

In vitro studies

Clinical studies other than randomized clinical trials.

Selection of studies and quality assessment

Two review authors (TP and VK) independently assessed abstracts and titles identified as a result of this search strategy. Potential studies were included if they met the inclusion criteria. Full-text articles of selected abstracts were then assessed for their eligibility to be included in the review. Any difference in evaluation between reviewers was resolved by discussion with the help of third reviewer (CS) to arrive at an acceptable conclusion.

The Cochrane Collaboration's Risk of Bias tool was used to assess the quality of the included studies. Each study was assessed by two independent reviewers as having a low, unclear, or high risk of bias depending on information provided in the study regarding randomization, allocation concealment, blinding of participants, providers and assessors, and outcome data and selective outcome reporting. Any disagreement between reviewers was resolved through discussion with a third assessor.

Data extraction and meta-analysis

A customized form was designed to extract data on names of authors, year of publication, country of the trial, study design, characteristics of participants (age and gender), dropouts, operative diagnosis, randomization, type of impression technique, intraoral scanner, CAD/CAM, marginal adaptation, internal fit, methodological quality of the trials, and conclusions. The data were extracted and recorded into a specifically designed electronic spreadsheet.

RESULTS

Summary of the included studies

Database search identified 497 citations and 4 citations through manual search. After duplicates were removed, abstracts were perused by two independent reviewers and full-text articles were obtained relevant to search topic. Though 23 articles were identified for role of digital impressions technique on accuracy of marginal adaptation of FDP, only two studies fulfilled the criteria of accuracy of marginal adaptation of posterior FDP made from digital impression technique [Figure 1]. The study by Reich *et al.* compared the marginal adaptation of FDPs fabricated with indirect digital impression and another impression (conventional impression alginate impression) technique at different time periods.^[27] Another study by Reich *et al.* in 2008^[28] was a continuation study of their previous study which was published in 2005.^[27] In their 2008 study, treatment was performed only in one group with four-unit FDP, and it was compared with the observations of the previous study in which three-unit FDP treatment was done. As it is a single-arm trial, it was not included in our systematic review.

The study by Ahrberg *et al.* evaluated the marginal adaptation with direct digital impression and indirect digital impression.^[29] Table 1 shows the characteristics of the included studies.

Demographic data were not reported by any of the studies included in this systematic review. The study by Ahrberg *et al.*^[29] reported that 15 females and 10 males were recruited in his study. In this systematic review, a total of 56 FDPs were evaluated. Four different extraoral scanners namely Digident, Lava, CerecInlab, and Lava Scan ST, and one intraoral scanner namely Lava C. O. S were used in the two studies included in our systematic review.^[27,29] In all the two studies marginal adaptation and internal fit was evaluated using replica technique. Reich *et al.* reported a satisfactory marginal adaptation of CAD/CAM three-unit bridges using indirect digital impression technique.^[27] However, Ahrberg *et al.* reported that Zirconia three-unit FDPs fabricated from computer-aided impressions demonstrated significantly better marginal fit than those fabricated from indirect digital impressions.^[29]

Qualitative review

Risk-of-bias assessment was done using Cochrane risk bias tool for two studies included in the systematic review [Figure 2]. Out of the two studies included for risk-of-bias assessment, both the studies were considered as low risk of bias.^[27,29] All the criteria, i.e., sequence generation, allocation concealment,

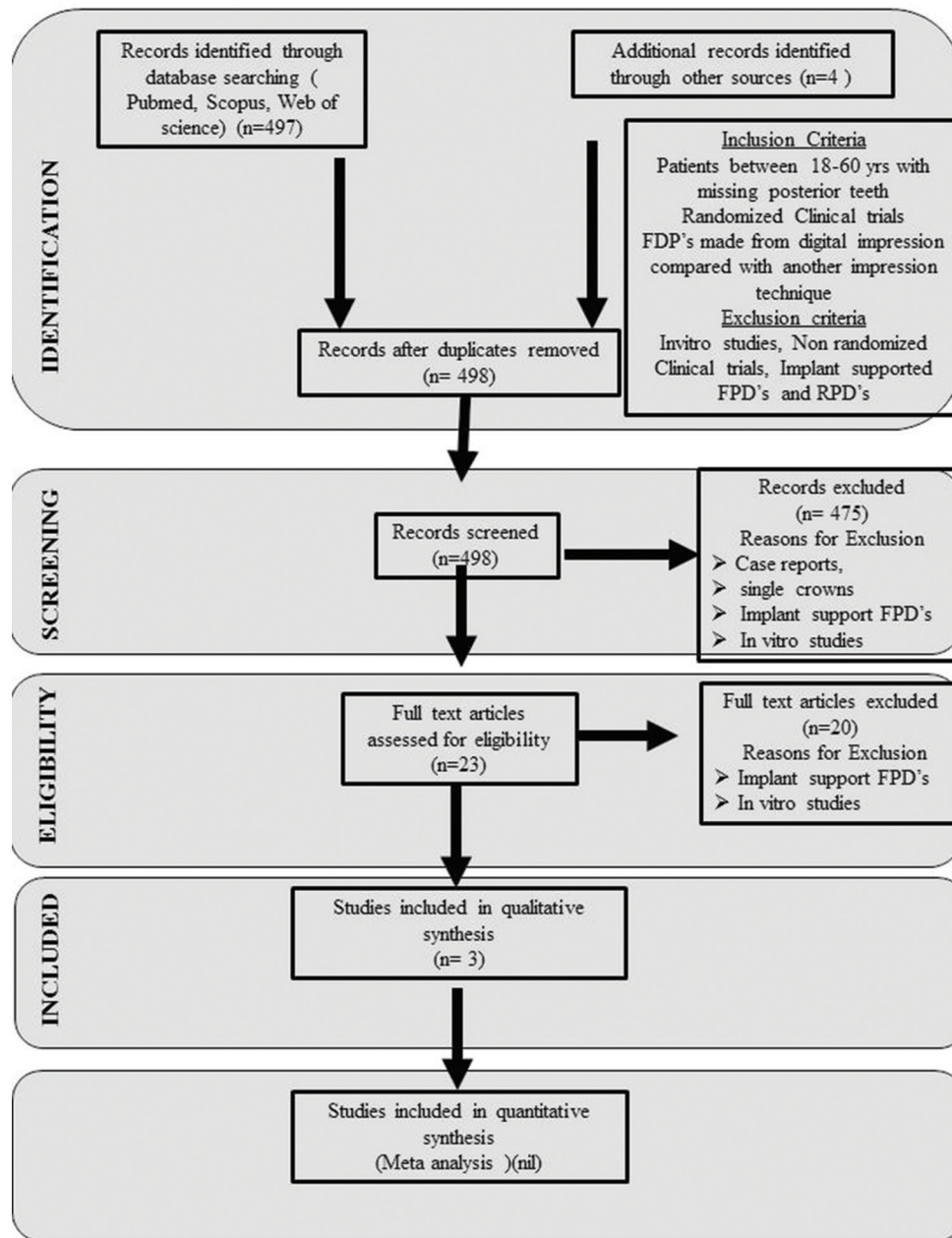


Figure 1: Preferred Reporting Items for Systematic Review and Meta-Analyses flow diagram

blinding of participants and personnel, blinding of outcome assessors, incomplete outcome data, selective outcome reporting, other sources of bias were marked yes in both the studies [Figure 2]. Hence, in the present systematic review, both included studies had a low risk of bias.

Though the two studies included in the systematic review compared marginal fit of FDPs fabricated with different impression techniques, a meta-analysis could not be done due to the heterogeneity of the data between the included studies. While Ahrberg *et al.*^[29] compared marginal fit of FDPs with direct digital impression and indirect digital impression, Reich *et al.* in their 2005^[27] study compared

marginal fit of FDPs with indirect digital impression and conventional impression. However, Ahrberg *et al.* calculated the data for marginal gaps of single clinical crowns and FDPs (digital 61.08 μm and conventional 70.40 μm) together and hence the data from this study could not be pooled with the other study for meta-analysis. An attempt was made to contact the authors, but till the period of submission of this review, no reply was obtained.

DISCUSSION

CAD/CAM FPD fabrication techniques involve a digital workflow commencing with an optical impression,

Table 1: Characteristics of included studies

	Author	
	Reich S <i>et al.</i>	Ahrberg D <i>et al.</i>
Year of publication	2005	2015
Country of trial	Germany	Germany
Study design	Randomized clinical trial	Randomized clinical trial
Characteristics of participants		
Age	NR	NR
Gender	NR	15 female-10 male
Sample size	19 patients 24 three-unit FDP	8 three-unit FDP
Sample teeth	Maxillary and mandibular posterior teeth	Posterior teeth
Operative diagnosis	Missing teeth	Missing teeth
Randomization	Dice	Envelope method
Type of impression technique	Indirect digital impression	Direct digital impression
Comparator group	Conventional impression	Indirect digital impression
Type of scanners used	Digident extra oral scanner Lava extra oral scanner Cereclnlab extra oral scanner	Lava C.O.S. intraoral scanner Lava scan ST extraoral scanner
Marginal adaptation evaluation	Replica technique	Replica technique
Internal fit	Replica technique	Replica technique
Conclusions	All CAD CAM systems tested can compete well with conventional system for clinical fit	Zirconia three-unit FDP frame works fabricated from computer aided impression demonstrated significantly better marginal fit than those fabricated from indirecr digital impression

NR: Not reported, CAD: Computer-aided design, CAM: Computer-aided manufacturing, FDP: Fixed dental prosthes, C.O.S: Chairside oral scanner

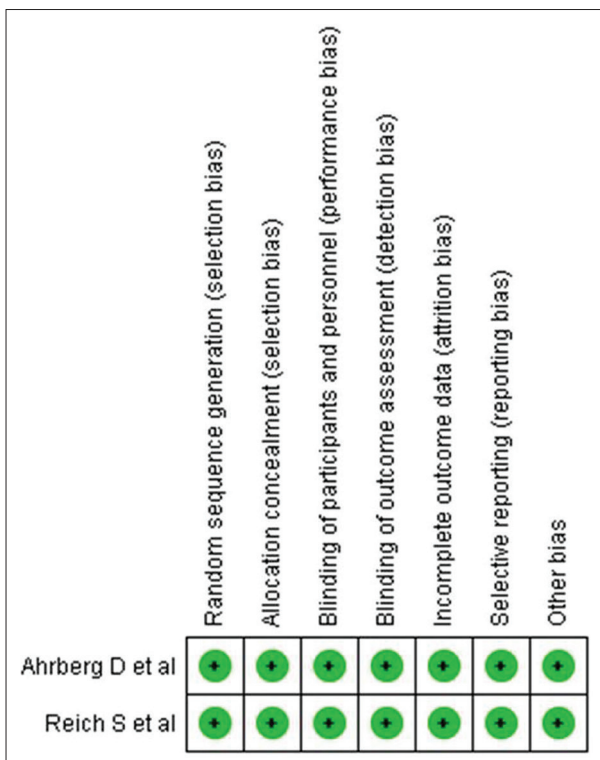


Figure 2: Risk-of-bias assessment

made with an intraoral or extraoral digital scanner, and culminating in the manufacture of the prosthesis. A major parameter for clinical success of an FPD is its fit. The data obtained for clinical fit and marginal adaptation provide a valuable tool to assess the quality of these prostheses. A larger marginal discrepancy may result in increased plaque accumulation and alteration of microflora and

contribute to higher risk of caries in the abutment tooth, ultimately resulting in failure of the treatment.^[30] Studies have reported the marginal discrepancy to be between 50 µm and 200 µm, but the clinically acceptable value, as proposed by McLean and von Fraunhofer, is 120 µm.^[9]

The internal and marginal fit of the prosthesis can be greatly influenced by the accuracy of the impression-making technique. Impression techniques used in the fabrication of FDP are conventional impression techniques with single- or dual-stage method and digital impressions with scanners. Digital impressions can be taken either directly, i.e., using an intraoral scanner or indirectly by scanning the cast or die made from the impression in the dental laboratory. In recent years, many new systems with direct, intraoral digitalization have been introduced in dentistry with the aim of reducing the workflow. A recent systematic review concluded that there was no significant difference in the marginal discrepancy of single-unit ceramic restorations fabricated using either digital or conventional impressions.^[3] Another systematic review by Papadiochou and Pissiotis concluded that there was no clear evidence showing a superior marginal fit for single crowns, FDPs and implant-supported FDPs fabricated by CAD/CAM technique over conventional impression technique.^[30]

The method of fabrication and span length of FDPs also determine the marginal adaptation. Published systematic reviews have evaluated marginal fit of single crowns, but no review has taken adaptation of only three- or four-unit FDPs for consideration. Till date, to our

knowledge, there has been no systematic review published in the literature about the evaluation of marginal fit of FDPs fabricated with digital impression to other impression techniques. The aim of this systematic review was to evaluate the marginal fit of FDPs fabricated with digital impression compared to other impression techniques.

A systematic review by Joda *et al.* concluded that the overall scientific evidence in the field of completed digital workflows for the treatment with fixed prosthodontics reconstructions was extremely low. No randomized clinical trial could be identified for multi-unit reconstructions.^[16] Another systematic review and meta-analysis by Chochlidakis *et al.* stated that digital impressions in fixed prosthodontics have several advantages compared with conventional techniques such as elimination of laboratory production steps that may cause misfit, lessen transport time between clinic and dental laboratory, and reduce patient discomfort. However, they also stated that conventional impressions show high detail and accuracy and that they are routinely and successfully used. The study analyzed both *in vitro* and *in vivo* studies and concluded that dental restorations fabricated with digital impression technique presented similar marginal discrepancy compared with those obtained with the conventional impression technique.^[31]

Our present review assessed only randomized clinical trials to evaluate the effect of digital impression on FDPs in comparison with any other impression technique. Only two randomized clinical trials could be included in the systematic review. Ahrberg *et al.* in his study evaluated the marginal and internal fit of CAD/CAM fabricated zirconia crowns and three-unit FDPs resulting from direct versus indirect digitalization.^[29] The only differences in these two techniques are that the scanning of the prepared teeth in direct impression was done intra orally whereas in indirect impression the prepared teeth were scanned on the poured casts extra orally. The other study included in our systematic review evaluated marginal and internal fit of CAD/CAM fabricated all-ceramic three-unit fixed partial denture, fabricated by indirect digitalization, to metal ceramic fixed partial denture fabricated with conventional impression technique.^[27] The workflow of indirect digitalization and conventional impression technique still requires impression making, pouring and transfer of casts to labs and there are chances of errors creeping in. The workflow of the direct digital impression has eliminated these steps and at the same time has showed less marginal discrepancy of FDPs. In this study the marginal discrepancies of all FDPs fabricated from both the techniques were similar except for Digident group where marginal discrepancy was more.^[27] The other study by the same author in 2008 was a

single arm study where four unit FDPs were fabricated and compared with three-unit FDPs of the previous study.^[28]

Apart from marginal fit, patients' perception, treatment comfort, time taken for impression procedures, and treatment effectiveness are important variables influencing the choice of impression technique. In the present systematic review, patients' perception and dentist feasibility, i.e., ease of operation, were assessed as secondary outcomes. Only one study reported digital impressions may be more time efficient when compared with conventional impressions. The other included study did not reported on these outcomes.

Digital impressions may offer a distinct advantage in patient comfort as some patients find the process of conventional impression making unpleasant while some may have a strong gag reflex. From the dentist's perspective, the virtual impressions can be E-mailed to the laboratory, rather than send a traditional impression or stone model via regular mail. This can speed up patient treatment and increase efficiency and productivity while maintaining accuracy. There are very few studies that have assessed patient perception, comfort, and time taken for treatment comparing different impression techniques. A randomized clinical trial compared digital impression techniques versus conventional technique for the same patients and found that over all treatment time for conventional impression was longer than that for digital impression technique.^[19] Further, the digital impression technique was accepted as the preferred and effective technique according to patients perception. Treatment comfort was also reported to be higher for digital impression technique.^[19] However, another randomized clinical trial by Benic *et al.* concluded that there was no difference in working time between conventional impressions and digital impressions and patient comfort was also similar.^[32] A recent systematic review by Gallardo *et al.* concluded that patients were more likely to prefer digital workflow than the conventional technique.^[33]

Although there are few *in-vitro* studies^[34,35] that have compared the marginal and internal fit of FDPs fabricated using conventional or digital impressions, very few studies have compared the same *in-vivo*.^[36] Studies conducted *in-vitro* may give a fair idea about the restoration fit, however *in-vivo* studies give the genuine picture in the actual clinical scenario. The paucity of such randomized controlled trials available in literature may be a drawback of our review. There is a clear indication that further clinical trials are needed for assessing marginal fit of posterior FDPs fabricated using digital impressions.

CONCLUSION

Within the limits of this systematic review, we can conclude that:

1. Marginal adaptation of three-unit FDPs fabricated from direct digital impressions was better than FDPs fabricated from indirect digital impressions and conventional impressions
2. Studies included for evaluating the accuracy of marginal adaptation of FDPs with digital impressions and conventional impressions were found to be clinically acceptable, i.e., below 120 μm
3. Digital impressions were found to be more time efficient than conventional impressions.

Further clinical trials with greater sample size are necessary to correlate these results.

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Conflicts of interest

There are no conflicts of interest.

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