RESEARCH PAPER

Clinical Impact of CAD/CAM - Fabricated Dentures Compared with Conventional Fabricated Dentures: A Systematic Review

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ABSTRACT

Background: Digital technologies have increasingly influenced the field of removable prosthodontics, particularly through the introduction of Computer-Aided Design and Computer-Aided Manufacturing (CAD/CAM) systems. Dentures are processed using CAD/CAM technology, which can be subtractive (milling) or additive (3D - printing). Although digital workflows are often used for their efficiency and accuracy, the clinical advantages of CAD/CAM FRDs over CFRDs remain uncertain. The purpose of this systematic review was to analyse the existing clinical data comparing patient satisfaction, oral health-related quality of life, and clinical outcomes for CAD/CAM FRDs against CFRDs.

Materials and Methods: A structured search of MEDLINE (PubMed), EMBASE (OVID), and the Cochrane Central Register of Controlled Trials (CENTRAL) was conducted from database inception to the predefined search date. Multiple reviewers worked separately on study selection, data extraction, and risk of bias assessment. A quantitative meta-analysis was not conducted due to the variations in study design, outcome measures and fabrication process. As a result, the findings were presented narratively.

Results: Six clinical studies fulfilled the inclusion criteria and were included in the qualitative analysis. According to the findings of all included studies, CAD/CAM FRDs and CFRDs had equal patient satisfaction and oral health-related quality of life. Some studies found minimal benefits linked with CAD/CAM FRDs in certain clinical outcomes, whereas others found similar or slightly improved results with CFRDs. Overall, the available evidence suggests that both fabrication methods provide similar levels of clinical outcomes and patient-reported outcomes.

Conclusions: Present clinical research does not prove that there exists a consistent or clinically significant superiority of CAD/CAM FRDs over CFRDs. CAD/CAM FRDs represent an alternate treatment option for the rehabilitation of edentulous patients.

Keywords: Digital dentures; Conventional dentures; Computer-aided design and manufacturing; Additive manufacturing; Edentulism.

How to cite this article: Vasudevan R, Sreedevi V, Bhuminathan S, Chaturvedula BB, Vikram, Varma RA. Clinical Impact of CAD/CAM - Fabricated Dentures Compared with Conventional Fabricated Dentures: A Systematic Review. Int J Drug Deliv Technol. 2026;16(67s):931-939. DOI: 10.25258/ijddt.16.67s.79

INTRODUCTION

Edentulism is a major oral health concern globally, particularly among the adult population. Despite major advances in preventative dental care and restorative procedures, many individuals still are partial or complete edentulous, necessitating prosthodontic rehabilitation. Removable dentures therefore remain an important treatment modality for restoring mastication, speech, facial appearance and overall quality of life in affected individuals (1).

Although implant-supported prostheses have expanded the available therapeutic options for edentulous patients, their use may be limited by financial constraints, systemic health considerations and restricted access to specialized care (2). As a result, Conventionally Fabricated Removable Dentures (CFRDs) continue to be widely used in clinical practice. CFRDs typically involve multiple clinical and laboratory stages, including impression making, recording jaw relations, wax try-in procedures and laboratory processing of the denture base material.

In recent years, digital technologies have been introduced into the field of removable prosthodontics. Computer - Aided Design and Computer-Aided Manufacturing (CAD/CAM) technology helps in processing of dentures using digital workflows that involves intraoral scanning, digital design software and automated manufacturing processes. Dentures produced through these methods may be fabricated using subtractive manufacturing techniques such as milling or additive manufacturing methods like three-dimensional printing (3).

Proponents of digital denture fabrication suggest several potential advantages compared with conventional laboratory techniques (4). These include improved reproducibility of denture bases, reduced polymerization distortion, simplified clinical workflows and the possibility of fewer patient visits during the treatment process. In addition, digital records can be stored and reproduced when replacement dentures are required (5).

Despite these theoretical advantages, the clinical advantages of CAD/CAM Fabricated Removable Dentures (CAD/CAM FRDs) remain a subject of present research. Studies assessing these dentures have reported mixed findings, particularly with regard to patient satisfaction, denture retention and its clinical outcomes (6). Differences in study design, digital design software, workflows, processing methods and variations in clinical outcomes have made it difficult to draw definitive conclusions from the available study.

Presently, due to the increasing use of CAD/CAM technologies in prosthodontic rehabilitation, it is important to critically evaluate the clinical evidence

supporting their use. The purpose of this systematic review was therefore to evaluate the current literature comparing CAD/CAM-fabricated removable dentures with Conventionally Fabricated Removable Dentures in terms of patient-reported outcomes and clinical outcomes.

MATERIALS AND METHODS

Protocol and Registration

This systematic review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines. The review technique was prospectively registered in the International Prospective Register of Systematic Reviews (PROSPERO) under the registration number CRD420261297108.

Eligibility Criteria

The eligibility criteria were defined according to the Population, Intervention, Comparison and Outcomes (PICO) framework (Table 1).

Population - Studies involving fully edentulous or partially edentulous adult patients requiring removable prosthodontic rehabilitation were considered eligible. Most participants included in the eligible studies were geriatric patients.

Intervention - The intervention included dentures fabricated using CAD/CAM technologies, including both milled dentures (subtractive manufacturing) and 3D - printed dentures (additive manufacturing).

Comparison - The comparator consisted of CFRDs, including those produced using traditional laboratory processing methods such as compression moulding, injection moulding or conventional polymethyl methacrylate (PMMA) processing techniques.

Outcomes - The primary outcomes included:

- Patient satisfaction
- Oral health–related quality of life (OHRQoL)

The Secondary outcomes included:

- Denture fit

- Retention
- Stability

Study Design

Eligible studies included:

- Randomized controlled trials (RCTs)
- Controlled clinical trials
- Crossover clinical trials

Only English language articles published between January 2021 and December 2025 were taken into consideration.

Information Sources

A complete electronic search was conducted in the following databases:

- MEDLINE (via PubMed)
- EMBASE (via OVID)
- Cochrane Central Register of Controlled Trials (CENTRAL)

All databases were searched from the beginning to the most current search date indicated in the review process. In addition, reference lists from included studies and relevant review articles were manually screened to identify any more suitable studies.

Search Strategy

The search strategy involves both controlled vocabulary terms (MeSH/Emtree) and free-text keywords relating to CAD-CAM FRDs and CFRDs. The search phrases comprise combination of the following concepts:

Population terms - partially edentulous OR tooth loss OR missing teeth OR complete edentulism OR partial edentulism OR fully edentulous OR terminal dentition OR elderly patients OR adult patients OR geriatric patients

Intervention terms - CAD CAM denture OR digital denture OR computer-aided designing OR computer-aided manufacturing OR milled dentures OR subtractive manufacturing OR three-dimensional printed denture OR additive manufacturing denture OR rapid prototyping denture OR stereolithography denture

Comparison terms - conventional denture OR traditional denture OR conventionally fabricated denture OR conventionally processed denture OR traditional processing OR compression moulding OR injection moulding OR PMMA denture OR conventional acrylic denture

The complete search strategy was initially developed for EMBASE (OVID) and subsequently adapted for the other databases.

Study Selection

The study selection procedure had two phases. Initially, two independent reviewers (RV, V) examined the titles and abstracts of all obtained records using the established eligibility criteria. The entire texts of possibly relevant papers were then extracted and separately evaluated for eligibility by the same reviewers. Any differences among the reviewers were handled through conversation. If the disputes remained, a third reviewer (SV) was consulted to reach a final conclusion.

Exclusion Criteria

Studies were excluded if they met any of the following criteria:

- Narrative reviews or systematic reviews
- Conference abstracts without full-text data
- Case reports or case series
- In vitro studies without relevant clinical outcomes
- Articles published in languages other than English
- Studies lacking sufficient outcome data

Data Extraction

Data extraction was independently performed by two reviewers (RV and V) using a standardized data extraction form. The following variables were extracted from each included study:

- Study design
- Source of participants
- Sample size
- Interventions and comparators
- Outcome measures
- Risk of bias
- Participant withdrawal (if any)
- Clinical Outcomes

Following independent extraction, the datasets were compared and cross-checked. If there were any differences, they were resolved by discussion and verification of the source articles. A third reviewer (SV) was brought in to help resolve any persistent differences. When studies reported outcomes over numerous follow-up periods, the last follow-up period was utilised for analysis.

Risk of Bias Assessment

The quality of the methodology of the included studies was assessed through the Cochrane Risk of Bias Tool version 2 (RoB 2). The following domains were assessed:

- Bias arising from the Randomization process
- Bias due to deviations from intended interventions
- Bias due to Missing outcome data
- Bias in measurement of the Outcome
- Bias in Selective reporting

Three reviewers conducted separate risk-of-bias evaluations. Any differences were settled by discussion and consensus.

Data Synthesis

Due to the variability among the included studies in terms of study design, denture fabrication techniques, outcome measures and follow-up durations, a quantitative meta-analysis was not performed. Therefore, the findings were synthesized using a narrative approach.

RESULTS

An electronic search of the selected databases and by manual screening of the reference lists of eligible articles, a total of 648 studies was found. After removal of duplicate articles, the remaining records were screened based on titles and abstracts. Studies that did not match the qualifying requirements were disqualified at this stage. The full texts of potentially relevant articles were subsequently assessed for eligibility, resulting in six studies that met the inclusion criteria and were included in the qualitative synthesis. The PRISMA 2020 flow graphic illustrates the study selection process (Figure 1).

Table 2 summarises the basic elements of the six included studies. All of the included studies were clinically evaluated and compared the results of CAD/CAM FRDs, which comprised both milled (subtractive manufacturing) and 3D-printed (additive manufacturing) dentures, to CFRDs in completely and partially edentulous patients.

The papers considered were published in English between January 2021 and December 2025, and they mostly used randomised crossover trial designs, controlled clinical trial designs or crossover clinical trials. The included studies had modest sample sizes in general.

The primary outcomes assessed in the included studies were patient satisfaction and oral health–related quality of life (OHRQoL). These outcomes were measured with validated tools such as the Oral Health Impact Profile (OHIP) and Visual Analogue tools (VAS). Secondary results included clinical criteria such as denture fit, retention, and stability. Finally, the findings from the included studies were summarised in tabular form (Table 3).

Primary Outcomes

Patient-reported outcomes were assessed using several validated instruments, including OHIP-14, OHIP-20, OHIP-49, OHIP-EDENT, the Denture Satisfaction Index and visual analog scales. Across the included studies, overall oral health–related quality of life did not differ significantly between CAD/CAM FRDs and CFRDs.

Although some variations were observed in specific subdomains, such as physical pain, functional limitation and psychological discomfort, particularly during early follow-up periods, these findings were inconsistent across studies and did not consistently favor either fabrication method. Overall, the available evidence suggests that patient satisfaction and oral health–related quality of life are broadly comparable between CAD/CAM FRDs and CFRDs.

Secondary Outcomes

The clinical outcomes assessed in the included trials were denture retention, stability, fit, occlusion, and aesthetics. Overall, the clinical performance of CAD/CAM FRDs was equivalent to that of CFRDs.

Most studies reported similar retention and stability between the two fabrication methods. But, some studies reported slightly reduced retention and occlusal accuracy in additively manufactured dentures. Overall, the findings did not prove consistent clinical superiority of either fabrication method across the assessed outcomes.

Follow-up and Attrition

All included studies reported participant attrition and protocol deviations. Minor attrition was seen in several studies due to aesthetic dissatisfaction or missed follow-up sessions. However, these incidents were rare and did not appear to have a substantial influence on the overall research results. In most cases, data from all participants were incorporated into the final analysis.

Feasibility of Meta-analysis

Although the included studies addressed a similar research question, quantitative meta-analysis was not feasible due to the variability among the studies. The sources of variability included the following factors:

Intervention heterogeneity - There was significant variety in the digital denture fabrication workflows, including variances in milling and 3D-printing methods, scanning protocols, software platforms and manufacturing procedures.

Outcome measure variability - Patient-reported outcomes were examined using several measurement tools with varied scoring systems, making it difficult to compare data across trials.

Methodological differences - Most studies used crossover designs, with variations in washout periods, reporting of period effects and statistical methods.

Variability in follow-up duration - Follow-up periods varied between studies, ranging from short-term evaluations after denture insertion to follow-up periods of approximately three months.

Due to these methodological differences, statistical pooling of the results was not considered appropriate and the findings were therefore synthesized using a narrative approach.

Risk of Bias and Certainty of Evidence

The risk-of-bias assessment of the six included studies is presented in Figures 2 and 3. The majority of studies were found to have a low to moderate risk of bias, mostly as a result of small sample sizes and blinding procedure limitations. Despite these limitations, the certainty of evidence for the primary outcomes was considered moderate, largely because of the overall consistency of findings across the included studies.

DISCUSSION

The present systematic review examined clinical studies comparing the CAD-CAM FRDs and CFRDs. Overall, the findings suggest that both fabrication approaches provide broadly similar outcomes in terms of patient satisfaction, oral health–related quality of life and general clinical performance.

Patient-reported outcomes represented the primary endpoints in most of the included studies. These outcomes were typically measured using validated scales such as the Oral Health Impact Profile (OHIP) or visual analog scales assessing comfort, stability and chewing ability. Among the studies reviewed, no significant difference was established between CAD/CAM FRDs and CFRDs. Although certain investigations reported slightly improved scores with digital dentures in specific domains, these differences were not consistently the same across the studies.

Clinical outcomes such as denture retention, stability and fit of the denture base were also assessed in some studies. Milled CAD/CAM FRDs often demonstrated retention and fit comparable to those of CFRDs. However, the results of additive CAD/CAM FRDs appeared to differ according to the printing method and post-processing protocols applied. These variances show that the clinical effectiveness of digitally generated dentures may be determined not only by the use of CAD/CAM technology, but also by the unique manufacturing workflow.

The absence of clear superiority of CAD/CAM FRDs in the available study may be explained by several methodological factors. Many of the included studies involved relatively small sample sizes and short follow-up periods. In addition, crossover trial designs were commonly used, which, although useful for minimizing interindividual variability, may introduce potential carryover effects despite washout periods.

Another important consideration is the variability in the processing of CAD/CAM FRDs protocols. Differences in scanning methods, digital design software, manufacturing methods and materials may have an impact on the final clinical outcomes. Consequently, comparisons between studies remain challenging and the variability in these workflows may partly explain the inconsistent findings reported in the study.

From a clinical perspective, the results of this review suggest that CAD/CAM FRDs can be considered a reliable alternative to CFRDs rather than a replacement. While CAD/CAM workflows may offer logistical advantages for clinicians and dental laboratories, the currently available evidence does not indicate that they consistently provide superior clinical outcomes for patients.

Future scope of this review should focus on well-designed RCTs involving large patient population and longer follow-up periods. Standardization of outcome assessment methods would also facilitate more reliable comparisons between studies and may allow future systematic reviews to perform meta-analysis.

CONCLUSION

Based on the available clinical evidence, CAD/CAM FRDs appear to provide patient satisfaction and functional outcomes comparable to those achieved with CFRDs. No consistent clinical superiority of CAD/CAM FRDs was identified in the studies included in this review. At last, CAD/CAM FRDs may be considered a clinically acceptable alternative for the rehabilitation of partially or completely edentulous patients. Further high-quality clinical trials with standardized outcome measures and extended follow-up periods are necessary to arrive at a conclusion for long-term benefits and limitations of CAD/CAM FRDs.

Acknowledgement

We would like to thank Sree Balaji Dental College and Hospital, Chennai for providing us full support to complete our research.

Conflict of Interest

Authors have no conflict of interest to declare.

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Tables:

Table 1: PICO

Population	**Intervention**	**Comparison**	**Outcome**
Edentulous or partially edentulous adult patients requiring removable complete or partial dentures.	Dentures fabricated using CAD/CAM technology (milled or 3D - Printed)	Dentures fabricated using conventional laboratory techniques (compression moulding, injection moulding or traditional processing).	Patient satisfaction, Oral health related quality of life, clinical outcomes like fit, retention and stability.

Table 2: Characteristics of the included studies.

S. NO	Author, Year	Design	Sample Size assessed (n)	Intervention / Comparator	Outcome Measures	Main Findings
1	Al-Kaff et al., 2023	Controlled clinical trial	20	3D-printed CAD-CAM dentures (IOS + cast digitization) vs Conventional	OHIP-EDENT, clinical evaluation	Comparable satisfaction; intraoral scan group showed slightly inferior fit
2	Peroz et al., 2022	Randomized controlled blinded crossover	16	Digital vs conventional complete dentures	Fit, extension, patient satisfaction	Digital dentures clinically comparable

3	Iwaki et al., 2024	Randomized crossover trial	18	3D-printed dentures vs conventional	OHRQoL, satisfaction	3D-printed dentures non-inferior to conventional
4	Ohara et al., 2022	Randomized crossover trial	15	3D-printed digital dentures vs conventional	Patient satisfaction, microbial counts	Lower microbial adhesion on 3D-printed dentures
5	Lana Zupancic Cepic, et al., 2023	Randomized crossover	10	Digital vs conventional dentures	Masticatory efficiency, satisfaction	Digital dentures showed similar satisfaction
6	Maniewicz et al., 2024	Clinical controlled crossover	19	CAD-CAM vs conventional denture bases	Retention force, fit	CAD-CAM showed comparable or superior retention

Table 3: Summary of Findings.

Clinical Endpoint	General Findings
Patient satisfaction	Generally comparable between digital and conventional dentures.
Oral health-related quality of life	Similar or non-inferior for 3D-printed dentures
Retention, fit and stability	CAD-CAM (printed & milled) comparable or sometimes better than conventional
Clinical function (chewing/phonetics)	Some evidence of slightly inferior masticatory performance for digital dentures

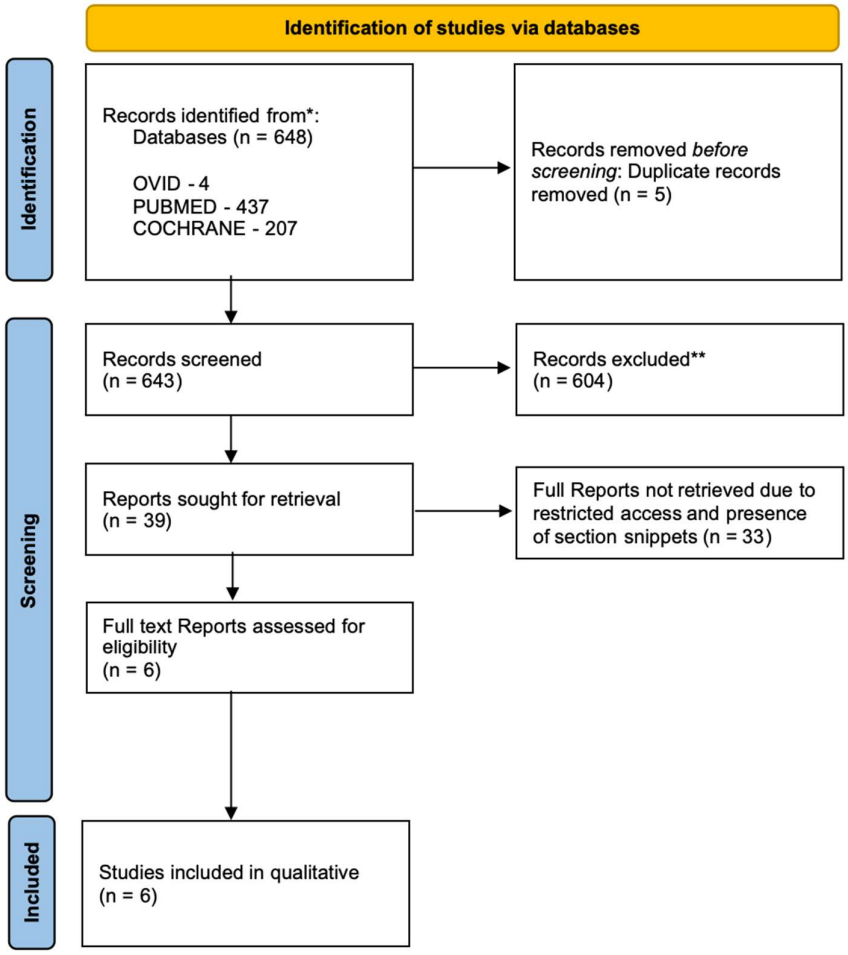

Figure 1: PRISMA flow diagram

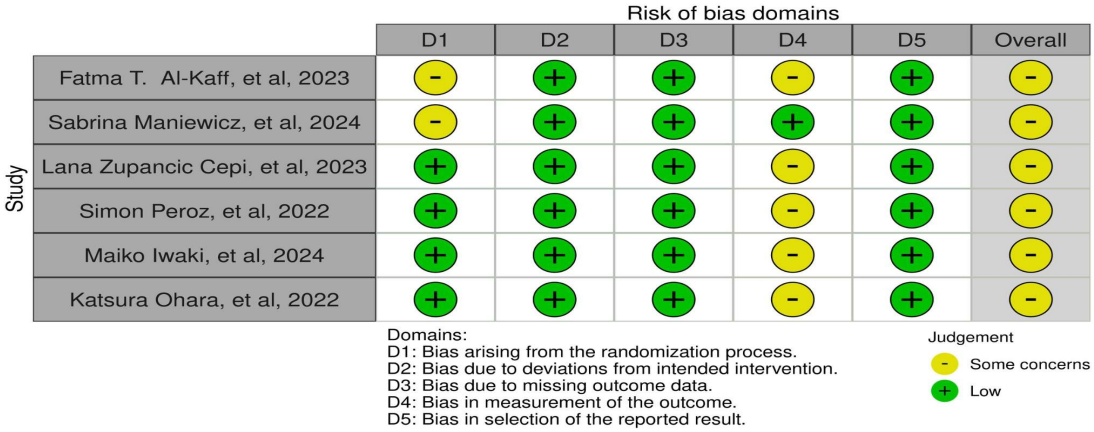

Figure 2: Assessment of risk of bias of the included studies using Cochrane Risk of Bias tools.

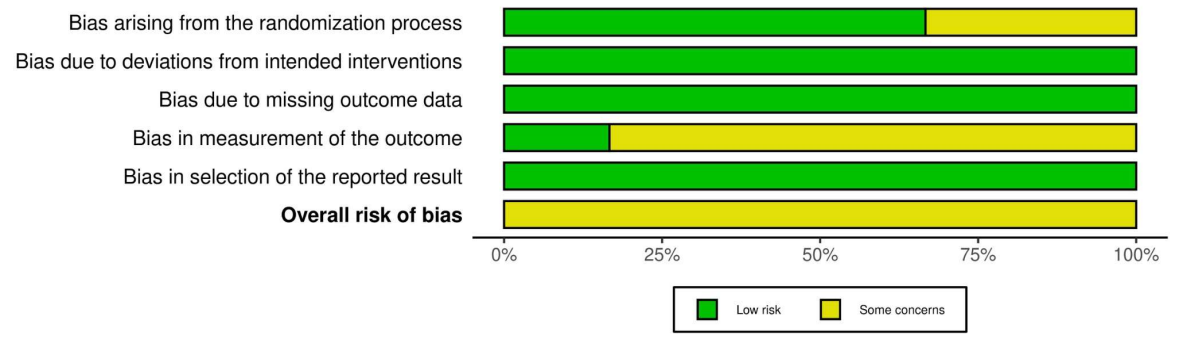

Figure 3: Assessment of various risk of bias of included studies using Cochrane Risk of Bias tools

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