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COMPARATIVE EVALUATION OF ACCURACY OF COMPLETE DENTURES FABRICATED BY SUBTRACTIVE AND ADDITIVE MANUFACTURING – A SYSTEMATIC REVIEW AND META- ANALYSIS

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Abstract:

Aim: To evaluate the accuracy of intaglio surface of complete dentures fabricated by additive and subtractive manufacturing methods.

Settings and Design: This was a systematic review and meta-analysis following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Methods and Material: An electronic search of PubMed (including MEDLINE), EBSCO host databases, Cochrane library and Google Scholar search engine for articles published fromJanuary 2011 to Feb 2023 was conducted. The literature search intended to retrieve all relevant clinical and in vitro studies about the accuracy of the intaglio surfaces of the complete dentures fabricated by additive and subtractive manufacturing methods.

Statistical analysis used: Meta-analysis was conducted in from the reported quantitative data

Results: A total of 1468 articles were obtained via electronic search; 10 studies met the inclusion criteria and were included in this systematic review out of which 8 were in vitro studies and 2 were clinical trials. Among the different parameters described, the accuracy of the intaglio surfaces of the complete dentures fabricated by different manufacturing methods were evaluated. Accuracy was measured by superimposition technique. 8 studies which evaluated the accuracy of the dentures were includedin meta-analysis.

Accuracy between the intaglio surfaces of dentures showed a statistically significant difference between milled and 3D printed complete dentures ($P < 0.05$, pooled mean difference ranging from -0.13 to 0.18)

Conclusions: There is an overall increased accuracy in the intaglio surface of the milled complete dentures when compared to the 3D printed dentures, thereby making them more preferred.

Keywords: Accuracy, complete dentures, CAD CAM, additive manufacturing, subtractive manufacturing

Introduction:

Edentulism can reduce the quality of life associated with dental health by affecting appearance, phonation, and function that can be restored by placing new removable dentures.[1,2] There are numerous techniques by which a complete denture can be fabricated and the purposes of each technique are to provide prosthesis with ultimate mucosal adaptability and reduce processing error resulting in good retention, support, and stability. The clinical protocols involved in the production of a conventional complete denture may be complicated, time-consuming, and difficult to control quality from the laboratory process.[3]

The adaptation of a removable complete denture to the underlying soft tissues is important for retention, masticatory performance, and overall function.[4] Moreover, well-adapted dentures may reduce trauma to the supporting tissues and thus minimize bone resorption, avoid the occurrence of traumatic ulcers, and improve denture wearing comfort, patient satisfaction, and quality of life. Thus, the accuracy of the intaglio surface of removable dentures is key to denture adaptation and to a successful treatment outcome in removable prosthodontics. Thus, came into role the CAD CAM (computer-aided design and computer-aided manufacturing) complete dentures which were first described in 1946 and now represent an improvement over conventional denture production.[5] There are several benefits of the CAD CAM complete dentures including reduced chair time, decreased number of patient visits, simplification of the laboratory process, produces fewer errors during the denture making process and can allow the efficient fabrication of a replacement prostheses i.e., duplicate dentures based on stored data available. This is highly helpful for elderly people who have underlying diseases and have difficulty to come to the dental office.6The fabrication of complete dentures by computer-aided design and computer-aided manufacturing (CAD-CAM) methods has gained popularity in clinical as well as laboratory practices.[7] There are three processes involved in the CAD/CAM workflow, the first two steps being collection of data and CAD. The last step, CAM process, can be done using either additive manufacturing (three-dimensional [3D] printing) or subtractive manufacturing (milling).[2]

The milling approach is a method of fabricating dentures by removing materials from prepolymerized PMMA (Polymethyl methacrylate) block to form the desirable shape. Milled dentures possess superior mechanical qualities over conventional complete dentures due to the absence of polymerized shrinkage resulting in better retention.[8] Milled maxillary complete dentures have been reported to be preferred by both dentists and patients.[9] The principal disadvantage of milling is waste product, a lot of material remains unused from the block and thus leads to large amounts of wastage. Moreover, milling technique has certain limitations such as the contour of the restoration relies on the size of cutting tools.[2] If the diameter of the cutting tool is bigger than the diameter of certain components, the internal fit accuracy will be compromised, or the marginal qualities will be degraded. Looking for alternatives that might solve these problems we came across 3D-printing technique.[10] Direct light processing (DLP) is the most extensively used type of 3D printing in dentistry. Complete dentures fabricated using the Rapid Prototyping(RP) technique have also elicited patient satisfaction comparable with that for conventional complete dentures.[11,12] The purpose of this study is to evaluate the accuracy of the intaglio surface

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of the complete dentures fabricated using subtractive and additive manufacturing. This systematic review was conducted in accordance with the Preferred reporting items for systematic reviews and meta-analyses guidelines 2009 (i.e., the PRISMA statement).[13]

Material and Methods

This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines13 with prior registration in PROSPERO (Registration number CRD42023438705).

The focused question was "Is there a difference in the accuracy of complete dentures fabricated by subtractive manufacturing and additive manufacturing?" The PICO i.e., the Population, Intervention, Comparison, and Outcome format was used (Table 1). The inclusion criteria were studies that evaluated the accuracy of the intaglio surfaces of the complete dentures fabricated by additive and subtracting manufacturing methods and articles appearing in the English dental literature, published after year 2011 till 28th Feb 2023. The exclusion criteria were studies wherein either of the two manufacturing methods were not considered. Review articles, case series and case reports were also excluded.

Table 1: PICO Criteria

PICO	
Population	1. Studies on accuracy of complete dentures fabricated using subtractive manufacturing
	2. Studies on accuracy of complete dentures fabricated using additive manufacturing
Intervention	Complete dentures fabricated using additive manufacturing
Comparison	Complete dentures fabricated using subtractive manufacturing
Outcome	Accuracy of complete denture

Electronic search of PubMed (including MEDLINE), Cochrane Central, EBSCO host databases and Google Scholar search engine for articles published from 1st January 2013 to 28th Feb 2023 was conducted. The controlled vocabulary terms (i.e., MeSH terms) and free text terms were obtained by searching key concepts in the MeSH database and a thorough evaluation of related articles, thesaurus, dictionaries, and entry terms. The terms such as edentulous jaws, edentulous mouth, edentulous patients, fully edentulous arches, completely edentulous arches, CAD CAM, additive manufacturing, 3D printing, subtractive manufacturing, milling, dimensional accuracy, trueness, precision, surface adaptationwere combined using suitable Boolean operators (AND, OR, NOT) (Table 2).

An electronic search was conducted independently by two reviewers (D.A., S.G.)A total of 1468 articles were obtained via electronic search and manual search. The articles thus obtained were evaluated for duplicates. A detailed summary of data selection has been put forth in the PRISMA 2009 Flow Diagram[14] (Figure 1).

The study characteristics of each systematic review were extracted including study details, search details, analysis, and results/findings by two independent reviewers (D.A., S.G.)

A third reviewer (P.B.) was called in for a final decision if any disagreement persisted between the two calibrated reviewers.

Results

The 1467 articles that were obtained through

Table 2: PICO concept table

PICO	POPULATION	INTERVENTION	COMPARATOR	OUTCOME
Key Concepts	Complete denture	Additive manufacturing	Subtractive manufacturing	Accuracy
CONTROLLED VOCABULARY TERMS (MeSH TERMS)	Denture, Complete Jaw, Edentulous Mouth, Edentulous Denture, Complete, Upper Denture, Complete, Lower Denture, Complete, Immediate	Printing, Three-Dimensional Computer-Aided Design	Computer-Aided Design	Dimensional Measurement Accuracy
FREE TEXT TERMS/ TEXT WORDS/ TiAb	Complete Denture, Complete Dentures, (Dentures, Complete), Edentulous Jaw, Edentulous Jaws, (Jaws, Edentulous), edentulism, edentulous maxilla, edentulous mandible, Edentulous Mouth, Edentulous Mouths, (Mouth, Toothless), Toothless Mouth, digital denture, single complete denture	Additive manufacturing, 3d printed complete denture, 3 dimensional printed complete denture, (Printing, Three Dimensional), (Printings, Three-Dimensional), Three-Dimensional Printings, 3-Dimensional Printing, 3 Dimensional Printing, 3-Dimensional Printings, (Printing, 3-Dimensional), (Printings, 3-Dimensional), 3-D Printing, 3 D Printing, 3-D Printings, (Printing, 3-D), (Printings, 3-D), Three-Dimensional Printing, Three Dimensional Printing, 3D Printing, 3D Printings, (Printing, 3D), (Printings, 3D), digital denture, Computer Aided Design, Computer-Aided Designs, (Design, Computer-Aided), (Designs, Computer-Aided), Computer-Assisted Design, Computer Assisted Design, Computer-Assisted Designs, (Design, Computer-Assisted), (Designs, Computer-Assisted), Computer-Aided Manufacturing, Computer Aided Manufacturing, (Manufacturing, Computer-Aided), Computer-Assisted Manufacturing, Computer Assisted Manufacturing, (Manufacturing, Computer-Assisted), CAD-CAM	Subtractive manufacturing, milled complete denture, digital denture, Computer Aided Design, Computer-Aided Designs, (Design, Computer-Aided), (Designs, Computer-Aided), Computer-Assisted Design, Computer Assisted Design, Computer-Assisted Designs, (Design, Computer-Assisted), (Designs, Computer-Assisted), Computer-Aided Manufacturing, Computer Aided Manufacturing, (Manufacturing, Computer-Aided), Computer-Assisted Manufacturing, Computer Assisted Manufacturing, (Manufacturing, Computer-Assisted), CAD-CAM,	Accuracy, precision, trueness, adaptation, (Accuracies, Dimensional Measurement), (Accuracy, Dimensional Measurement), Dimensional Measurement Accuracies, (Measurement Accuracies, Dimensional), (Measurement Accuracy, Dimensional), denture base adaptation, denture adaptation, milled denture adaptation, 3D printed denture adaptation, trueness of denture, intaglio surface adaptation, trueness and precision, dimensional accuracy, adaptation accuracy, dimensional discrepancy, tissue adaptation, fit accuracy, fitting

the electronic searches were compared meticulously with respect to the author's name, year of publication, title, abstract as well as the journal name, issue, and volume number. The articles thus obtained after the electronic and manual searches, were evaluated for duplicates using the Mendeley Desktop software (v1.19.6). The 1 article obtained through the manual search was added manually using the 'add entry manually' feature of Mendeley Desktop software (v1.19.6). The 'check for duplicates' feature of this software was then used to identify and eliminate duplicates. 128 duplicate articles were identified and subsequently eliminated leaving behind 1340 articles. Two calibrated reviewers (D.A, S.G.) independently screened the relevant titles of the studies found through the electronic search. Out of 1340 articles,1288

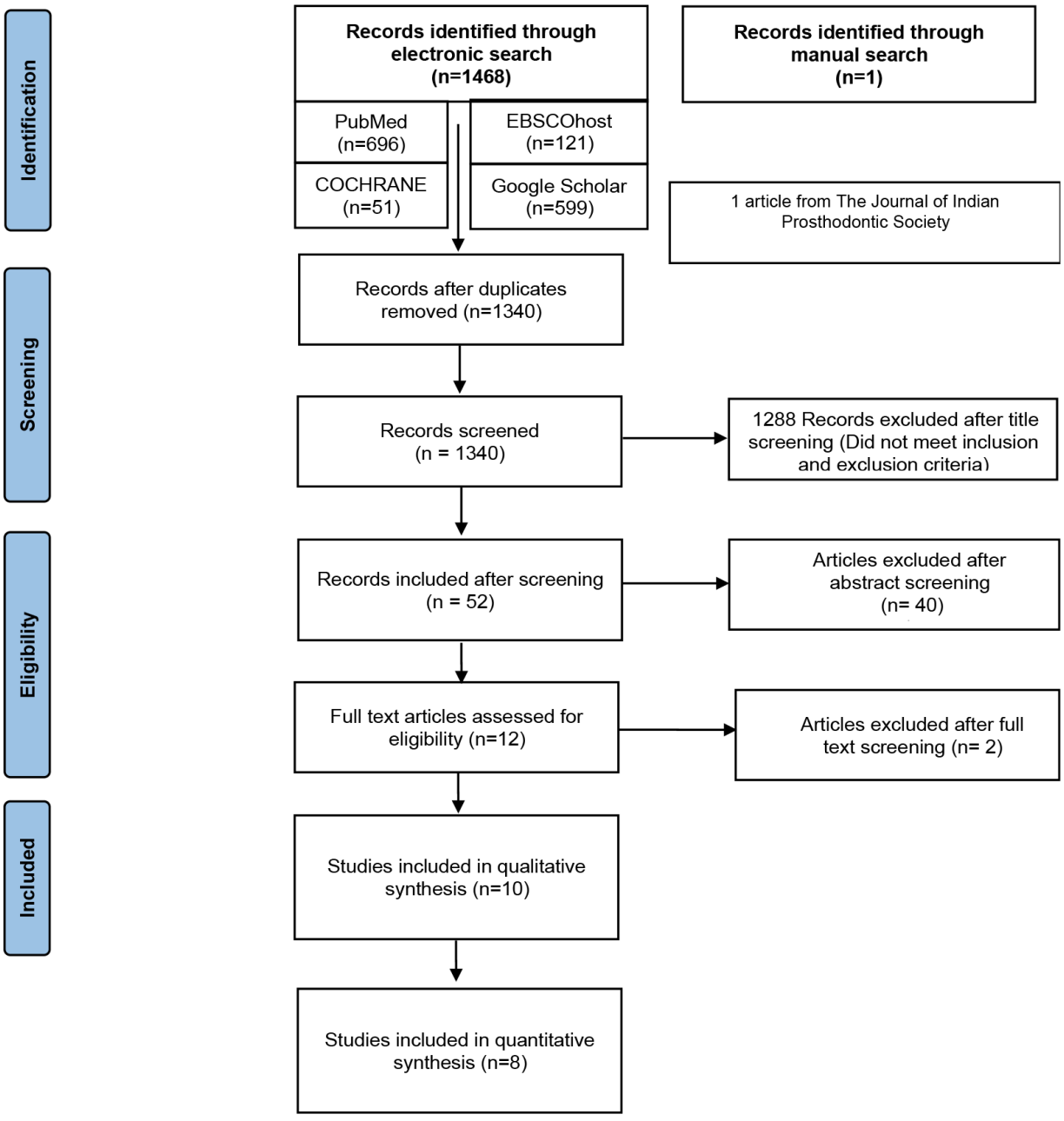

Fig. 1: PRISMA 2009 Flow Diagram

Table 3: Characteristic Data extraction table of included studies

SR. NO.	AUTHOR	STUDY DESIGN	MODEL	SAMPLE SIZE	COMPARISON GROUPS	MEASUREMENT VARIABLES	METHOD OF MEASUREMENT	SOFTWARE USED	TEST OF ANALYSIS	OUTCOME
1	Kalberer et al.[19] (2019)	In-vitro study	Maxillary complete dentures	10	Milling And 3D Printing	Trueness	Superimposition	Blue Sky Plan3 Software	Independent t tests, ANOVA, and post hoc tests	CAD-CAM milled complete dentures were better than rapidly prototyped complete dentures in terms of trueness of the intaglio surfaces.
2	Hwang et al.[20] (2019)	In-vitro study	Maxillary complete dentures	30	Injection Molding, Milling And 3D Printing	Trueness AND tissue surface adaptation	Superimposition	Geomagic Verify, 3D Systems	Mann-Whitney test and Kruskal-Wallis	The 3D-printed group revealed better trueness and tissue surface adaptation than the milled and compression molded group
3	Lee et al.[21] (2019)	In-vitro study	Maxillary complete dentures	30	Injection Molding, Milling And 3D Printing	Accuracy	Superimposition	Geomagic control X, 3D systems	ANOVA, and post hoc tests	The denture base's overall accuracy was higher in the milled and 3D-printed methods than the injection molding method
4	Yoon et al.[22] (2020)	RCT	Maxillary and mandibular complete dentures	36	Compression Molding, Milling And 3D Printing	tissue surface adaptation	Silicone replica technique was used for the measurement of the adaptation.	Stereomicroscope	Kruskal-Wallis test and the McNemar test	No statistically significant differences were found amongst the 3 denture base fabrication techniques.
5	Hsu et al.[18] (2020)	In-vitro study	Maxillary and mandibular complete dentures	120	milled, 3d printed, and conventional heat-polymerized resin fabrication techniques	denture base adaptation	Superimposition	Geomagic Control X 2018, 3D Systems Inc	Wilcoxon signed rank test and Kruskal-Wallis analysis	The milled groups illustrated the best denture adaptation. The compression and injection molding groups had similar features and produced greater denture adaptation in the maxilla. The 3D-printed groups recorded divergent results and the lowest trueness values.
6	Wemken et al.[23] (2020)	In-vitro study	Maxillary complete dentures	48	IM, MIL, And Stereolithography (Sla) Printed Denture Bases After Manufacturing, Hydrothermal Cycling, And Microwave Sterilization.	Trueness	Superimposition	Geomagic Control X, 3D Systems	Post hoc Tukey-HSD tests	Before the aging process, the milled group demonstrated the lowest surface deviation, followed by the injection molded and 3D-printed groups. Hydrothermal cycling did not affect the milled group's trueness in contrast to the injection-molded and 3Dprinted groups. Microwave sterilization caused no effect on the 3D-printed group's dimensional trueness; but led to clinically critical deformations of the injection molded and milled groups

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articles were excluded after screening of the title. The articles thus eliminated were either literature reviews, scoping reviews, case reports, case series, or articles not utilising additive or subtractive manufacturing for complete denture fabrication. Thus, 52 articles were selected after title screening.

Two calibrated reviewers (D.A, S.G.)now independently screened the abstracts of the studies found relevant during the screening of the titles and a total of 40 articles were further excluded after abstract screening. The articles eliminated through abstract screening were mainly involving different manufacturing methods for the dentures. 12 articles were included after abstract screening. Out of the 12 articles, 10 met the inclusion criteria and thus were included in this systematic review. Out of all the included studies, 8 were invitro studies and 2 were clinical trials.

A third reviewer (P.B.) was called in for a final decision, if any disagreement over article selection persisted between the two calibrated reviewers. Inter-reviewer reliability was checked via Cohen's kappa coefficient.[15] The Cohen's kappa coefficient values obtained for title, abstract and full text screening was 0.62, 0.68 and 0.75 respectively, indicating moderate inter-reviewer agreement for title, abstract and full text screening.

The data was subsequently extracted from the 10 included studies and recorded in 2 excel data extraction sheets as mentioned in the summary

7	Yoshi-dome et al.[12] (2021)	In-vi-tro study		20	Milling And 3D Print-ing and Injection Moulding	trueness and fitting accuracy	Superimpo-sition	Geo-magic Control X, 3D Systems	ANOVA AND Turkey's multiple compari-son test	The milled CD bases showed the highest trueness and fitting accuracy among all the manufacturing methods.
8	Charoen-phol and Peam-pring[10] (2022)	In-vi-tro study		20	Milling and 3D Printing	Fit accuracy	Superimpo-sition	Geo-magic Control X, 3D Systems	Inde-pendent two-sam-ple t test	Milled denture bases fit better in the overall and primary stress-bearing areas than 3D-printed den-tures, while 3D-printed dentures appeared more accurate in the peripheral seal area, which had a minor undercut that is not suitable for using mill-ing technology.
9	You et al.[24] (2022)	In vitro study		15	Milling and 3D Printing	Trueness and socket-ed surface adaptation of denture bases	Superimpo-sition	Geo-magic Verify	Krus-kal-Wallis test	Within the limits of this invitro study, the MDB group showed better trueness and socketed surface adaptation than the DLP groups (HDB and VDB).
10	Russo et al.[25] (2023)	RCT	6 partic-ipants: Double eden-tulous arches 8 partic-ipants: Single eden-tulous arch	20	Milling and 3D Printing	Trueness	Silicone replica tech-nique was used for the measure-ment of the adaptation	Geo-magic Control X, 3D Systems	Inde-pendent two-sam-ple t test	Milling can provide a slightly better trueness of the intaglio surface of digital dentures than 3D-printing, with less variation across sever-al zones of interest.

table (Table 3).

The data extracted was entered under the following headings: Author and Year of publication, Study design, Study model, Sample Size, Comparison groups, Measurement variables, Method of measurement, Software used, Test of Analysis, Outcome.

Table 4: Included Studies = 10

STUDY ID	AUTHOR	YEAR	TITLE
1.	Kalberer et al.[19]	2019	CAD-CAM milled versus rapidly prototyped (3D-printed) complete dentures: An in vitro evaluation of trueness
2.	Hwang et al.[20]	2019	Assessment of the trueness and tissue surface adaptation of CAD-CAM maxillary denture bases manufactured using digital light processing
3.	Lee et al.[21]	2019	Comparing accuracy of denture bases fabricated by injection molding, CAD/CAM milling, and rapid prototyping method
4.	Yoon et al.[22]	2020	Tissue surface adaptation of CAD-CAM maxillary and mandibular complete denture bases manufactured by digital light processing: A clinical study
5.	Hsu et al.[18]	2020	Effects of fabrication techniques on denture base adaptation: An in vitro study
6.	Wemken et al.[23]	2020	Do hydrothermal aging and microwave sterilization affect the trueness of milled, additive manufactured and injection molded denture bases?
7.	Yoshidome et al.[12]	2021	Trueness and fitting accuracy of maxillary 3D printed complete dentures
8.	Charoenphol and Peampring[10]	2022	Fit Accuracy of Complete Denture Base Fabricated by CAD/CAM Milling and 3D-Printing Methods
9.	You et al.[24]	2022	Evaluation of trueness in a denture base fabricated by using CAD-CAM systems and adaptation to the socketed surface of denture base: An in vitro study.
10.	Russo et al.[25]	2023	Intaglio surface trueness of milled and 3D-printed digital maxillary and mandibular dentures: A clinical study

Risk of bias assessment of the included studies was done using the QUIN tool scale[16] for in vitro studies and The Cochrane Collaboration's tool[17] for Randomized controlled trials for RCTs by two independent reviewers (S.G., D.A.).

Out of the 10 studies, 8 included studies were in-vitro studies, hence the Quin tool scale was considered apt for the risk of bias evaluation for them in this systematic review. The changes made to the scale were validated by the third reviewer (P.B.) (Table 4).

The risk of bias of all the 8 included in vitro studies ranged from 79% to 87%, which falls under the category of low risk of bias.

For the 2 excluded clinical studies, The Cochrane Collaboration's tool was considered apt (Table 5).

The changes made to the scale were validated by the third reviewer (P.B.)

Meta Analysis

10 studies evaluating the accuracy of digital complete dentures fabricated either by additive manufacturing or subtractive manufacturing were included in the systematic review.

Table 5 : Excluded Studies = 2

SR. NO.	AUTHOR	YEAR	TITLE	REASON FOR EXCLUSION
1.	McLaughlin et al.[31]	2019	Comparison of Fit of Dentures Fabricated by Traditional Techniques Versus CAD/CAM Technology	Only one group considered with no comparison group.
2.	Grande et al.[32]	2022	Comparison of the Accuracy between Denture Bases Produced by Subtractive and Additive Manufacturing Methods: A Pilot Study	It is a pilot study.

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Two studies which compared the accuracy of the intaglio surface of the complete dentures fabricated either by milling or by 3D printing (Hsu et al. 2020 and Yoshidome et al. 2021)[12,18] were excluded from meta-analysis due to lack of data availability in terms of mean and standard deviation values respectively. The eight studies which evaluated the intaglio surfaces of the complete dentures fabricated by additive and subtractive manufacturing (Kalberer et al. 2019, Hwang et al. 2019, Lee et al. 2019, Yoon et al. 2020, Wemken et al. 2020, Charoenphol and Peampring 2022, You et al. 2022, Russo et al. 2023)[10,19-25] were included for meta-analysis.

The Review Manager software (Version 5.4.1) was used to perform meta-analysis. Mean values and standard deviations for accuracy by assessing surface deviation of dentures fabricated by milling and 3D printing were included for the analysis.

The primary outcome measures the accuracy of the intaglio surface of the complete dentures. The data was tabulated under the headings of study name, group, and effect size. The effect size was calculated on the continuous raw data entered for mean, standard deviation, and sample size. 95% confidence interval for each effect size was also computed. The heterogeneity of effects was assessed by the Higgin's I2 test.[26,27] The I2 statistic describes the percentage of variation across studies that is due to heterogeneity rather than chance and is denoted by the formula: I2= 100% x (Q-df)/Q. According to Higgins et al, calculation of heterogeneity is essential in determining the generalizability of the findings of meta-analysis.[27]

The result of the meta-analysis for accuracy of CAD CAM complete dentures showed less surface deviation in milled complete dentures (subtractive manufacturing) when compared to 3D printed complete dentures (additive manufacturing). (Figure 2)

Discussion:

The advent of computer aided designing and computer aided manufacturing (CAD CAM) technology has paved the way for a highly precise and efficient digital work flow.[28] There are three processes involved in the CAD/CAM workflow. The first two steps in the process are collection of data and CAM. The last step, CAM process, can be done using either additive manufacturing (three-dimensional [3D] printing) or subtractive manufacturing (milling).[29] These two methods have been considered in this systematic review.

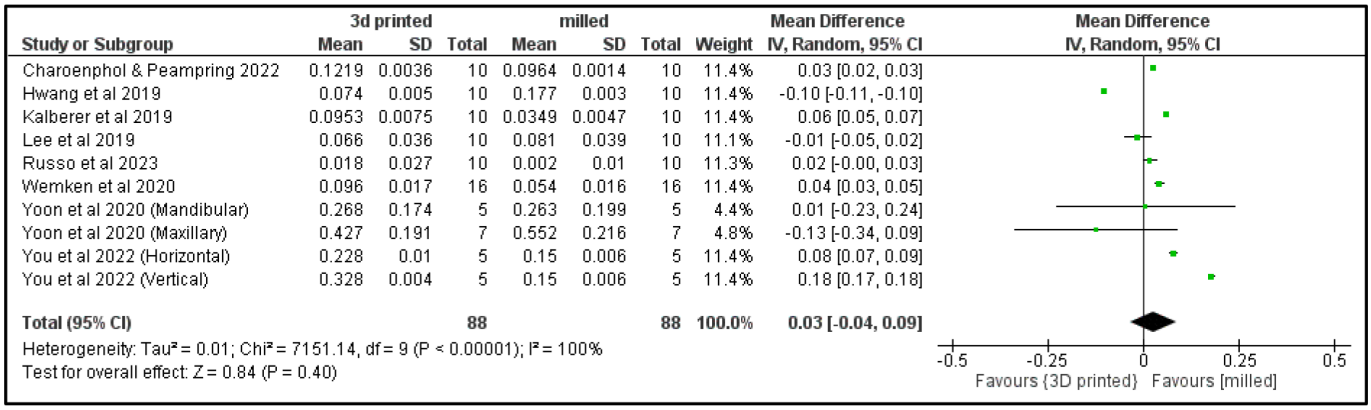

Fig. 2: Forest plot of results for accuracy (mm) measured in 3D printed and milled complete dentures

This systematic review has segregated the accuracy achieved on using additive and subtractive methods for manufacturing complete dentures. The two techniques used to assess the accuracy were superimposition technique for studies where scanning was performed to attain impressions and the silicon replica technique in situations where manual impressions were made.

Amongst the articles included in this systematic review, Kalberer et al[19] (2019) concluded that milled complete dentures, under the present manufacturing standards, were superior to the 3D printed complete dentures in terms of trueness of the intaglio surfaces. However, further research is needed on the biomechanical, clinical, and patient-centered outcome measures to determine the true superiority of one technique over the other about fabricating complete dentures by CAD-CAM techniques. Hwang et al[20] (2019) conducted an in vitro study and stated that the 3D printed maxillary denture base showed better trueness and tissue surface adaptation than the milled and pressed denture bases. The printed denture bases reproduced the morphologic irregularity of the residual ridge, while the milled denture bases had minor inaccuracies. However, the study design was in vitro and therefore more clinical evidence is required to draw any conclusion. Lee et al[21] (2019) and Yoon et al[22] (2020) addressed that both 3D printed and milled denture bases were likely to show intimate adaptation compared with other techniques. Both the studies showed no significant differences amongst both the groups. Hsu et al[18](2020) concluded that the milling technique had the best denture adaptation, whether using the silicone thickness measurement or digital superimposition analysis. Milling technique improves the adaptation whether for maxillary or mandibular denture bases, but the printing technique presents divergent accuracy. Wemken et al[23] (2020) concluded that subtractive manufacturing of denture bases results in the highest trueness, followed by injection moulding and 3D printing. The author also subjected the dentures to hydrothermal cycling and microwave sterilization. In contrast to injection moulding and 3D printing, hydrothermal cycling did not affect milled denture bases. However solely SLA printed denture bases remained dimensionally stable after microwave sterilization. In a clinical study conducted by Russo et al[25] (2023), within the limits of the manufacturing methodologies used for complete dentures, milling provided better trueness of the intaglio surface when compared to 3D printed dentures. The in vitro studies conducted by Yoshidome et al[12] (2021), Charoenphol and Peampring[10] (2022) and You et al[24] (2022) concluded that milled complete denture bases showed the highest trueness and fitting accuracy among all the manufacturing methods. Thus, a systematic review compiling the conclusions of these in vitro and clinical studies was conducted to draw a conclusion regarding the improved accuracy of complete dentures when fabricated by different methodologies i.e., additive, and subtractive manufacturing.

The Quin tool16 for invitro studies and Cochrane tool[17] for RCTs has been used to identify the risk of bias of the individual studies.

Eight out of the 10 included studies seemed to be relatively homogenous in their study design and outcome variables. Hence, a quantitative analysis by means of a meta-analysis was planned. Meta-analysis is a systematic procedure for assessing and combining statistical information based on results of available independent studies regarding the same topic.[30] The results of the quantitative analysis have been provided in the form of forest plots for easy visualization.

The heterogeneity of the primary studies has

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been evaluated using the Higgins's I2 test.[11] Heterogeneity refers to differences in results between primary studies that are greater than expected by chance alone.

The result of the meta-analysis for accuracy based on surface deviation showed less accuracy for 3D printed dentures compared to the milled complete dentures.

Limitations of this systematic review were; The search for this study was limited to articles published in the English language. Also, grey literature has not been searched for relevant literature. This could have resulted in mild selection bias.

The results of this systematic review should be applied with caution to the clinical scenario since most of the included studies are in-vitro in their study design.

Conclusion

Within the limitations of this systematic review and meta-analysis, the following conclusions could be drawn:

1. Milling can provide a slightly better accuracy of the intaglio surface of digital dentures than 3D-printing, with less variation across several zones of interest.

2. The meta-analysis revealed that milled complete dentures were better than 3D printed complete dentures in terms of accuracy measured by surface deviation of the intaglio surfaces of the dentures.

However, further research is needed on the biomechanical, clinical, and patient-centred outcome measures to determine the superiority of one technique over the other regarding manufacturing complete dentures by CAD-CAM techniques.

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List of Abbreviations:

Abbreviation	Definition
CAD CAM- Computer-Aided Design-Computer-AidedManufacturing (Or Computer-Assisted Machining)	REMOVABLE COMPLETE DENTURE: A removable dental prosthesis that replaces the entire dentition and associated anatomy of the maxillae or mandible; the removable complete denture can be readily inserted and removed from the mouth by the patient.
	CAD-CAM Acronym for COMPUTER-AIDED DESIGN-COMPUTER-AIDEDMANUFACTURING (or Computer-Assisted Machining) is the process of interacting with or manipulating data in a digital environment to create a 3D object for production via an additive or a subtractive process that is also guided or controlled in the digitalenvironment.
	ACCURACY: It is closeness of agreement between a test result and the truevalue.
	TRUENESS: It is closeness of agreement between the expectation of test results and a true value.
	PRECISION: It refers to closeness of agreement between independent test resultsobtained under stipulated conditions.