

Effectiveness Of Cad Cam Milled Vs Dmls Titanium Framework for Hybrid Denture Prosthesis - A Systematic Review

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Abstract

Objectives: The main objective of this study is to critically review articles that have used printed and milled CAD CAM designed metal as a framework for hybrid denture and evaluate its clinical effectiveness.

Search Strategy: An electronic search was performed in PubMed, Google scholar and Cochrane Library until December 2021. The assessment of the articles was done using selection criteria.

Selection Criteria : All prospective/retrospective studies on conventional, milled and printed metal frameworks for implant supported hybrid dentures were included in this systematic review. Case series, case reports, conference paper, animal studies were excluded from this review.

Data Collection: We used standard methodological procedures to select studies and collect the data. The risk of bias was evaluated and findings were synthesised.

Results: Out of the 22 articles selected 5 were excluded based on title and abstract. Out of the remaining 17 studies, 10 were excluded based on inclusion and exclusion criteria, and finally 7 were selected on the basis of core data.

Based on the observation from these 7 studies we were able to substantiate the difference between the conventional, milled and printed metal frameworks for hybrid denture prosthesis.

Conclusion: DMLS as well as CNC milling are viable and better alternatives for production of titanium bar for implant supported hybrid denture frameworks, when compared to the conventional production methods. DMLS and CNC milling both have a few pros and cons over each other. While the accuracy of CNC milling is greater, its fabrications costs make it difficult to bring into daily practice. DMLS is cheaper, faster and although less accurate, clinically acceptable. Thus further research in this topic is imperative to best understand its potential.

Keywords: Implant, hybrid, milling, framework

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INTRODUCTION

An implant-supported hybrid prosthesis is a framework covered with acrylic resin and denture teeth. This prosthesis would typically consist of a metallic (base metal alloys, noble metals) or non-metallic (zirconia, PEEK) bar (1). Hybrid prosthesis offer a number of benefits, including reduced dynamic occlusal load impact force (2), lower fabrication costs (3), and highly aesthetic

outcomes (4). The bar splints 6-8 endosseous implants (5) which would decrease the mechanical complications within the entire bone-implant and framework complex (6). Hence hybrid denture treatment option allows patients to have a fixed dental prosthesis that can only be removed by a dentist (7). However, one of the mechanical parameters that influences the longevity of an implant bar based prosthesis is the passive fit of the implant framework(8). According to Dr.Branemark if the gap between the framework and abutment was less than 10 μm it was passively fitting, while Dr.Jemt proposed that a framework misfit of less than 150 μm can be considered acceptable (9). To avoid biomechanical failures of the prosthesis due to increased stress or strain, it is crucial to aim for the best framework fit possible.

Traditionally the internal metallic frameworks were fabricated using conventional casting procedures (1,10). However, it was observed that casting procedures were more successful in noble metal frameworks such as gold and Ag-Pd, compared to base metal alloys (11). However the long run use of pnable metals wasn't feasible due to their high cost. Titanium, a material with superior qualities such as biocompatibility (12), corrosion resistance, low cost and good mechanical properties (13) was a popular choice for the framework. However, it was difficult to cast due to its high melting temperatures, low density, and reactivity with elements in casting investments (14).This problem could be overcome with the advent of CAD CAM manufacturing.

Advancements in the world of digital dentistry have enabled the fabrication of precise and large volume restorations used in fixed dental prosthesis. Within digital dentistry, milling is the most common manufacturing method (MI). Rapid prototyping (RP) has recently gained popularity, as it is cost-time saving, eliminates wear of tools and loss of material (15). Multiple studies have displayed greater fit and accuracy of milled structures when compared to those produced using rapid prototyping, although they were within clinically acceptable limits (16). Hence although there are studies comparing the economics of manufacturing or the fit and accuracy, milled and laser sintered RPD'S there are very few studies comparing the difference between milled and printed titanium frameworks and the bone loss they produce, due to the alteration in internal structure because of the difference in technique of digital fabrication.

Hence the aim of this systematic review is to evaluate the clinical difference between a milled and laser sintered titanium framework used for implant supported hybrid denture prosthesis.

Aim

The aim of the current review is to evaluate the clinical effectiveness of a hybrid denture supported by DMLS fabricated titanium framework in comparison to one supported by a milled titanium framework in an edentulous arch.

Structured Question

In cases requiring hybrid denture prosthesis, is there a significant difference in effectiveness of hybrid prosthesis supported by DMLS titanium metal framework in comparison to hybrid prosthesis supported by milled titanium metal framework?

Pico Analysis

Population

Healthy completely edentulous individuals with sufficient bone support for the fabrication of implant supported hybrid denture.

Intervention

Fabrication Of hybrid denture with DMLS titanium metal framework

Comparison

Fabrication of hybrid denture with milled titanium framework

Outcome Measures

Cumulative survival rate of the prosthesis

Crestal bone loss around the supporting implants Patient satisfaction

Vertical Fit of the framework

Biofilm adherence to the framework

Adherence of Biofilm to the framework

Materials And Methods

Protocol And Registration

PRISMA statement was followed for developing the protocol as well as during conduct and reporting (Liberati et al., 2009).

Eligibility Criteria

Inclusion Criteria

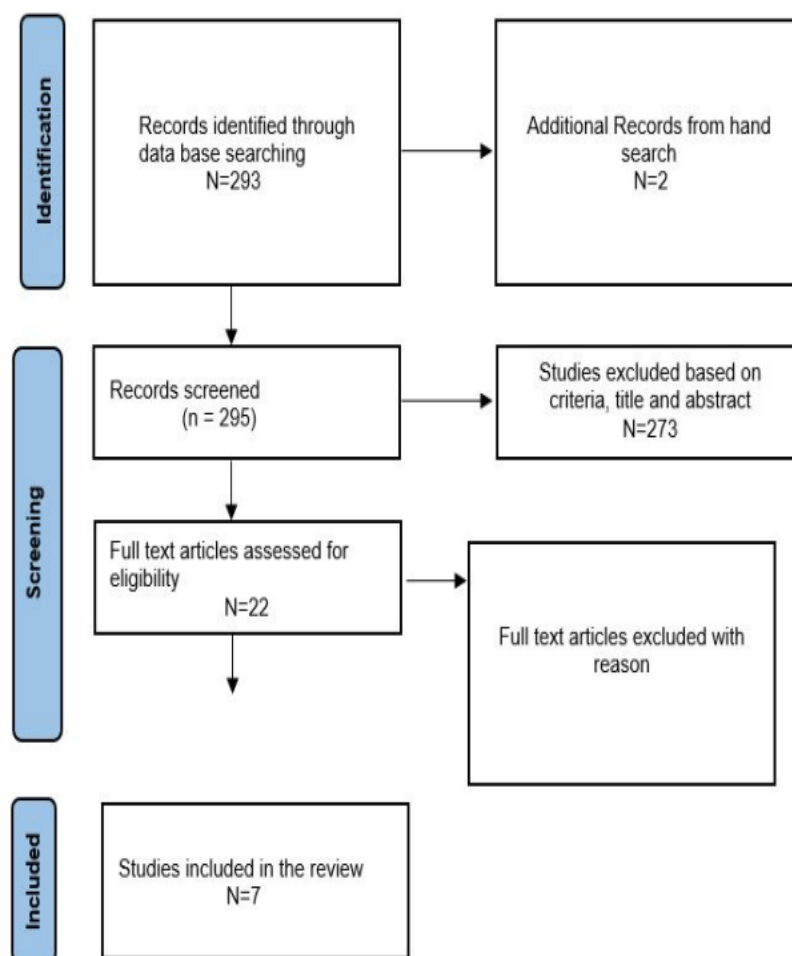
- Articles on hybrid dentures which have used metal as framework material
- Articles that compare printed and milled metal as framework materials for hybrid dentures
- Randomised control studies, Non-Randomised control studies, Prospective or Retrospective cohort, Invitro study, Animal studies

Exclusion criteria

- Review articles
- Case Reports

Search Strategy

A systematic search in the medical literature produced between January 2000 to December 2021 was performed to identify all peer-reviewed articles potentially relevant to review's question. The following databases were looked up to get the list of potential publications for the review: PubMed, PubMed Central, Cochrane Library, LILAC's, Scopus, and Google Scholar.



Search Protocol

The search strategy led to obtaining 468 articles from PubMed, 36 articles from Google scholar. 64 clinical trials were included from the PubMed search of which 52 were excluded based on title and abstract and a total of 8 articles were selected. Of the 36 articles obtained from Google scholar, 24 were eliminated based on the relevance of the heading and abstract, and a total of 12 articles were selected. The total number of studies which were selected from the database were 22, of which 10 were eliminated as they did not meet the inclusion criteria and/or outcome measures and 5 were excluded based on title and abstract and finally 7 articles were included on the basis of core data. These 7 articles were reviewed and consolidated as given in the table below.

Data Extraction

The data of the selected studies were extracted using standardised abstraction tables. The following were listed in one table as general study features using data that was taken from each study.

- 1) Title
- 2) Author and year
- 3) Study Design
- 4) Duration
- 5) Intervention
- 6) Groups
- 7) Sample size
- 8) Types Of statistical method
- 9) Outcome Measure

The outcome variables of the extracted data from the studies were interpreted in detail. The level of evidence according to the Oxford Centre for Evidence-Based Medicine was also tabulated.

S.NO	AUTHOR NAME	JOURNAL	REASON FOR EXCLUSION
1)	Moraschini V	Implant Dent	Different Intervention
2)	Chochlidakis K	J Prosthet Dent	Different Intervention
3)	Rohlin M	Int J Prosthodont	Different Intervention
4)	Drago C	J Prosthodont	Review Article
5)	Gherlone EF	Biomed Res Int	Different Outcome measures
6)	Bagegni A	J Prosthodont Res	Different Intervention
7)	Papaspyridakos P	Clin Implant Dent Relat Res	Different Intervention
8)	Messias A	Int J Prosthodont	Different Outcome measures
9)	Ni D	Zhonghua Kou Qiang Yi Xue Za Zhi	Different Intervention
10)	Takaichi A	J Prosthodont Res	Different Intervention

Study(Name of the first author and year of study)	Title	Study Type and Study Design	Type Of Implants Used	Study characteristics	Type Of Framework Assessed	Outcomes Assessed
Örtorp A (2009)	CNC-milled titanium frameworks supported by implants in the edentulous jaw: a 10-year comparative clinical study	Retrospective Comparative follow up study	Branemark system, Nobel Biocare AB	Both Maxilla and mandible 67 CNC- milled titanium framework Control-62 Gold alloy frameworks	gold-alloy casting,titanium frameworks	Cumulative survival rate Mean marginal bone loss
Örtorp A (2008)	Early laser-welded titanium frameworks supported by implants in the edentulous mandible: a 15-year comparative follow-up study	Retrospective Comparative follow up study	Branemark system, Nobel Biocare AB	Edentulous Mandible 15 year follow up study G1- Implants placed in central canine and first molar bilaterally G2-Implants placed in 1st and 2nd premolar,1st molar region	Gold alloy framework, Laser welded Titanium	Cumulative survival rate Mean marginal bone loss, prosthetic failures
Örtorp A (2006)	Clinical experiences with laser-welded titanium frameworks supported by implants in the	Retrospective Comparative follow up study	Branemark system, Nobel Biocare AB	Edentulous Mandible 10 year follow up study G1- Implants placed in central canine and first molar bilaterally G2-Implants placed in 1st and 2nd	Gold alloy framework, Laser welded Titanium	Cumulative survival rate Mean marginal bone loss, prosthetic failures

	edentulous mandible: a 10-year follow-up study			premolar,1st molar region		
Jemt T (2002)	Implant-supported welded titanium frameworks in the edentulous maxilla: a 5-year prospective multicenter study	Non-randomised controlled trial	Branemark system, Nobel Biocare AB	Edentulous Maxilla 5 Year Follow-Up Study G1-28 Laser Welded Titanium Framework G2-30 Cast-Gold Alloy Framework	Gold alloy framework, Laser welded Titanium	Cumulative survival rate Mean marginal bone loss
Revilla-León M (2018)	Discrepancy of complete-arch titanium frameworks manufactured using selective laser melting and electron beam melting additive manufacturing technologies	in vitro study	Not applicable	Edentulous mandibular definitive cast- 4 implant analogs, replica screw-retained interim restoration(EBM,SLM - geomagic)	EBM titanium group, SLM titanium	Accuracy
Kanazawa M (2014)	Fabrication of titanium alloy frameworks for complete dentures by	in vitro study	Not applicable	Two titanium alloy frameworks, SLM-1, SLM-2, fabricated(edentulous maxilla-DICOM)Plate-shaped specimens cut tested- Vickers	SLM titanium framework	Vicker's hardness test, Optical microscopy(internal microstructure)

	selective laser melting			hardness,optical microscopy, x-ray diffraction measurements		
Ciocca L (2019)	Manufacturing of Metal Frameworks for Full-Arch Dental Restoration on Implants: A Comparison between Milling and a Novel Hybrid Technology	in vitro study	Not applicable	6-implant-supported full-arch framework(hybrid,milling)-optomechanical coordinate measuring machine	Titanium framework (milling,novel hybrid technology)	Trueness, Precision, Effect of PFI distance on framework trueness

TITLE	AUTHORS	JOURNAL	STUDY TYPE AND SETTING	GROUP 1	GROUP 2	GROUP 3	INTERVENTIONS	OUTCOMES	EVALUATION METHOD	MEAN ()	MEAN ()	MEAN ()	STANDARD DEVIATION ()	STANDARD DEVIATION ()	STANDARD DEVIATION ()	Duration of follow up	CUMULATIVE SURVIVAL RATE	PROSTHETIC FAILURE

			u p s t u d y	i n g s (c o n t r o l) i n 3 1 m a x i l l a s a n d 3 1 m a n d i b l	o r k s i n 2 3 m a x i l l a s a n d 4 4 m a n d i b l e s (T E S T)				o n	a s s e l i n e - 1 . 6 5 m m . 1 0 y e a r s - 2 . 8 m m) (m a n d - b	a s s e l i n e - 1 . 6 7 . 1 0 y e a r s - 1 . 9 6 m m) (m a n d - b a s		a s s e l i n e - 0 . 4 6 m m . 1 0 y e a r s - 0 . 8 0 m m) (m a n d - b	a s s e l i n e - 0 . 6 6 m m . 1 0 y e a r s - 0 . 5 9 m m) (m a n d - b				
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<p>Early laser-welded titanium frameworks supported by implants in the edentulous mandible: a 15-year comparative follow-up study</p>	<p>Ortorp A, Jemt T.</p>	<p>Clin Implant Dent Relat Res</p>	<p>Retrospective comparative para-tive follow-up study</p>	<p>Gold standard (Control group) (n = 53)</p>	<p>Laser welded (Test group) (n = 51)</p>	<p>Laser welded (Test group) (n = 104)</p>	<p>Baranek, Nobile AB</p>	<p>Cumulative survival rate Mean marginal bone loss, prosthetic failures</p>	<p>Radiographic, Clinical Examination</p>	<p>The average range 15 - year carbonyl examination</p>	<p>The average range 15 - year carbonyl examination</p>	<p>not applicable</p>	<p>SD 0.64 (Control)</p>	<p>SD 0.56 (Test 1 + Test 2)</p>	<p>not applicable</p>	<p>15 years</p>	<p>(Control - 100%), (Test 1 + Test 2 - 89.2%)</p>	<p>Ti 1 (31/51), Ti 2 (72/104), Au(40/53)</p>
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Implant-supported welded titanium frameworks in the edentulous maxilla: a 5-year prospective multicenter study	Jemt T, Bergendal B, Arvidson K, Bergendal T, Karlsson LD, Lindenberg, Rundcrantz T, Wendelhag I.	Int J Prosthodont	N o n - r a n d o m i s e d c o n t r o l l e d	G l (L a s e r W e l d e d T i t a n i u m F r	G 2 (C a s s - G o l d l i o y F r	n o t a p p l i c a b l e	B r a n d a p p l i c a t i o n	C u m u l a t i v e s u r v i v a l r a t e M a r g i n a l b o n e l o s s	R a d i o g r a p h y , C l i n i c a l E x a m	M e a n b o d y o f s u c c e s s f u l l o w e r l i m i t s	M e a n b o d y o f s u c c e s s f u l l o w e r l i m i t s	n o t a p p l i c a b l e	S t a n d a r d d e v i a t i o n - m e s s i a l	S t a n d a r d d e v i a t i o n - m e s s i a l	n o t a p p l i c a b l e	5 y e a r s	The p r o s t h e s i s C S R (G 1 - 9 6 . 4 %) (G 2 - 9 3 . 3 %)	not app lica ble

			t r i a l		a m e w o r k n =	r k n =				i n a t i o n	m m) d i s t a l (m m) d i s t a l ((0 . 9 6 m m) d i s t a l ((1 . 1 3 m m) d i s t a l (
Discrepancy of complete-arch titanium frameworks manufactured using selective laser melting and electron beam melting additive manufacturing technologies	Revilla-León M, Ceballos L, Martínez-Klemm I, Özcan M.	J Prosthet Dent	i n v i t r o s t r u c t u r e		G r o u p (E B M g r o u p	G r o u p (S L M g r o u p	n o t a p p l i c a b l e	n o t a p p l i c a b l e	A c c u r a c y	c o o r d i n a t e m e a s u r e	3 D d i s c r e p a n c y - 6	3 D d i s c r e p a n c y - 6	n o t a p p l i c a b l e	2 5 . 3	2 5 . 3	n o t a p p l i c a b l e	not applicable	not applicable	not applicable

					n = 3)	n = 3)				ring machine (CMM) - geometric	48 microns	0.2 microns						
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Fabrication of titanium alloy frameworks for complete dentures by selective laser melting	Kanazawa M, Iwaki M, Minakuchi S, Nomura N.	J Prosthet Dent	In vitro study		SLM (fabrication)	SLM (fabrication)	Not applicable	Not applicable	Vicker's hardness test, Optical microscopic (internal microrost structure)	Vicker's hardness test (HMV-1; Shimadzu)	Vicker's 's hardness test - 360HV .c / almatice	Vicker's 's Hardness test - 400HV .c / almatice	not applicable			not applicable	not applicable	not applicable
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									40kV and 40mA										
Manufacturing of Metal Frameworks for Full-Arch Dental Restoration on Implants: A Comparison between Milling and a Novel Hybrid Technology	Ciocca L, Meneghello R, Savio G, Scheda L, Monaco C, Gatto MR, Micarelli C, Baldissara P.	J Prosthet Dent	in vitro study		Labl = EOSTINMT270 (= 9)	Labl = ECOSTINMT270 (= 9)	Labl = COCOSTINMT270 (= 9)	Labl = COCOSTINMT270 (= 9)	Labl = COCOSTINMT270 (= 9)	Labl = COCOSTINMT270 (= 9)	Labl = COCOSTINMT270 (= 9)	Labl = COCOSTINMT270 (= 9)	Labl = COCOSTINMT270 (= 9)	Labl = COCOSTINMT270 (= 9)	Labl = COCOSTINMT270 (= 9)	Labl = COCOSTINMT270 (= 9)	Labl = COCOSTINMT270 (= 9)	Labl = COCOSTINMT270 (= 9)	Labl = COCOSTINMT270 (= 9)

						m a c h i n e (n = 9)	m i l l e d)		n f r a m e w o r k t r u e n e s s	n a t e m e a s u r i n g m a c h i n e	r r o r s r a n g e d f r o m 8 t o 1 6 μ m (L a b 1) . E f f e c t o f	r r o r s r a n g e d f r o m 9 t o 2 2 μ m (L a b 2) . E f f e c t o f	r r o r s r a n g e d f r o m 2 0 t o 3 5 μ m f o r c o n v e n t i o n a						
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Discussion

Hybrid prosthesis often refers to implant supported fixed rehabilitation of an edentulous arch composed conventionally of a metal based substructure covered with acrylic resin. Traditionally the metal frameworks were casted. However, due to the expansion and contraction that occurs during the casting process, cast metal frameworks are prone to porosity and distortion. This issue could be corrected with the advent of CAD-CAM dentistry. CAD-CAM dentistry allowed us to fabricate prosthesis with greater accuracy and homogeneity at lower costs. In this SR we have explored the various methods of fabrication of the hybrid bar and their properties, specifically for milled and printed titanium bars.

Key Findings

This systematic review reveals 7 articles which report the use and properties of CAD-CAM as a manufacturing process for full arch prosthesis. Due to the lack of literature that compared the durability and strain by frameworks manufactured using different processes, we have selected articles that discuss the properties of these individual parameters and methods and why framework manufactured through that process would be suitable for use in an FP3 prosthesis.

Despite the popular use of CAD CAM technology in the manufacture of titanium hybrid bars, the availability of long term clinical trials is surprisingly limited. Of the 6 studies that discuss the use of titanium as a hybrid denture framework, 4 are clinical studies and 2 are in-vitro studies. Although the studies on metal framework for hybrid denture have long clinical follow up and review, there is limited research comparing the durability of titanium frameworks manufactured using various processes and the strain caused due to them on the implant and surrounding bone. However in this systematic review there are 3 studies included which compare gold hybrid frameworks with titanium frameworks either manufactured through CNC milling or laser sintering or welding. Bone Loss around implants and CSR (Cumulative Survival Rates) were the most commonly measured outcome. There was an obvious lack of

attempt to measure patient centric outcomes, and the kinds of prosthetic failures encountered.

Comparison Of Findings

CNC milled titanium bar as hybrid framework

With the advent of CAD-CAM dentistry, the use of CNC milled titanium bars for hybrid prosthesis has become common. A study by (17) compared the success of gold alloy frameworks to CNC milled titanium bars. The CSR of the test group framework was 95.6% while of the implants was 95%. In the test group, one prosthesis failed due to loss of all six inserted implants during the second year and the patient resumed to a denture in the maxilla. Another prosthesis in the mandible failed after 9 years in function due to framework fracture and was replaced by a new CNC framework. Due to the loss of two implants in the maxilla after three years, one CNC prosthesis was shortened, and the patient was given a partial removable denture held in place by the remaining implant-supported prosthesis. In addition, a second prosthesis in the upper jaw had to be reduced since one implant failed during its fifth year of use. At the end of a 10-year follow-up, a third prosthesis in the mandible fractured and was cut shorter. The mean marginal bone loss after ten years was 0.7mm for the test group while it was 0.6mm for the control group. However it was observed that most cases of implant loss or increased marginal bone loss occurred in smokers. While purely comparing the framework fracture, it was observed that 2 CNC-milled as well as gold alloy frameworks had fractured, which is much lesser than the conventional laser welded titanium frameworks(18). However, titanium frameworks showed significantly higher problems with veneer fractures as compared with gold-alloy frameworks. Still, this could be tackled by improvement of the supra construction and better acrylic resin matrix, irrespective of the metal being used. (19).

Laser Welded Titanium Framework

A study by (18) observed that the CSR for gold-alloy frameworks was 100%, while for laser welded titanium frameworks was 89.2%. 7.1% were recorded as total failures mainly because of severe or several fractures of the metal frames close to the terminal implant. Numerous fractures can be attributed to an early laser-welding technology that had little to no experience in implant dentistry. Similar results were observed in a study by (20). The fracture of the titanium welded framework could be

because the chemical composition of the highly reactive titanium is altered in the welded joint during the laser-welding operation, and this might in turn influence mechanical properties in this region(21). Also, different defects in welded specimens have been described, such as gas pores and cracks, at fractured surfaces in a study performed by (21). However it could also be because the joint could be significantly weakened when ground or polished by an inexperienced technician or dentist. This explains why in the study by (20) tendency of fractures in the Ti-2 group decreased possibly due to a learning pattern with a better awareness of the problem from the involved staff. The study by (18) also compared the marginal bone level of the gold and titanium frameworks. They observed a 0.59 mm bone loss around the titanium group, while a 0.98 mm bone loss around the gold group. Though there is no particular feasible explanation for this. Differences in framework stiffness, precision, and biocompatibility of the framework metal are factors that could be suggested(22)(23)(24,25). Speculations on the potential difference in plaque adherence and corrosion between the metals could also be forwarded. Similar results were observed in a 10 year follow up by (20).

3 D Printing of Titanium Framework for Hybrid Denture

A study conducted by (26) evaluated the microstructure and hardness of thin titanium alloy frameworks fabricated using selective laser melting. It was observed that the hardness value for the printed titanium (400 Hv) was greater than the cast titanium(360Hv). These findings are in accordance with the findings of (27). When comparing the accuracy of cast frameworks to printed. It was concluded that titanium was difficult to cast accurately because the melting temperature of titanium alloy (Ti-6Al-4V) is substantially higher than that of any other dental casting alloy; it exhibits relatively high inherent casting shrinkage. Based on previous research on the fit of metal frameworks it was found that the mean gaps between cast cobalt-chromium alloy frameworks and the corresponding gypsum cast ranged from 100 to 200 mm while the mean gap for Ti-6Al-4V was 105 mm(26). Hence it was possible to print clinically significant designs using selective laser sintering. Optical microscopy images of the SLM-1 and SLM-2 microstructure showed that the specimens did not exhibit pores, indicating that dense frameworks were successfully obtained with the selective laser melting process(26). ((26,28) compared accuracy of two different additive manufacturing methods, namely :selective laser melting and electron beam melting. It was concluded that the titanium frameworks analysed for a complete-arch implant-supported prosthesis fabricated using either the SLM or EBM additive technologies showed a clinically acceptable implant-prosthesis discrepancy, where similar discrepancies on the x-, y-, and z-axes were found between the additive manufacturing technologies. The ability to construct the STL file additively along the x, y, and z axes was comparable for both systems. Hence both were clinically acceptable.

Strength and limitations of the study

This systematic review appraises both the features of DMLS and CNC milling along with different metal alternatives like gold, cobalt-chromium in the fabrication of framework for a hybrid denture prosthesis. This provides a better

understanding of the clinical and mechanical properties of titanium as an option for

framework for hybrid denture prosthesis, the difference in its various methods of production hence enabling the clinician to make better treatment choices.

This systematic review is written following the PRISMA guidelines. Electronic databases were

searched using various combinations of search terms. All potentially eligible studies up to

December 2021 were included in this review. Article screening, data extraction, assessment of study characteristics, risk of bias as well as assessment of level of evidence were performed independently by two authors and were combined together. All quality assessments were done based on the respective universal guidelines. Any disagreements aroused were resolved by discussion. All efforts were made to reduce the level of bias in the review.

The number of studies reported on this topic is minimal and their evidence is moderate to low. This impacts the interpretation along with the observations of the systematic review. Hence, there is a need for further studies of better qualities and elimination of confounders in this field. Although the results are encouraging, this topic would need further investigation, with randomised clinical trials and a larger sample size. Compared to prospective research, retrospective studies have some drawbacks. Selection bias, misclassification, and information bias as a result of the retrospective nature of this type of study are among the biases that can compromise its objectivity. However, due to the challenges in obtaining a sufficient sample size, it is highly challenging to execute a prospective study assessing the consequences of an uncommon clinical procedure.

Implication For Future Research

- RCT with a larger sample.
- Prospective studies with a similar control group.
- Studies directly comparing the effects of DMLS and CNC milled titanium with conventionally used metal frameworks

Implications For Practice

DMLS as well as CNC milling are viable and better alternatives for production of titanium bar for implant supported hybrid denture frameworks, when compared to the conventional production methods. DMLS and CNC milling both have a few pros and cons over each other. While the accuracy of CNC milling is greater, its fabrications costs make it difficult to bring into daily practice. DMLS is cheaper, faster and although less accurate, clinically acceptable.

Thus further research in this topic is imperative to best understand its potential

Conclusion

DMLS as well as CNC milling are viable and better alternatives for production of titanium bar for implant supported hybrid denture frameworks, when compared to the conventional production methods. DMLS and CNC milling both have a few pros and cons over each other. While the accuracy of CNC milling is greater, its fabrications costs make it difficult to bring into daily practice. DMLS is cheaper, faster and although less accurate, clinically acceptable.

Thus further research in this topic is imperative to best understand its potential.

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Anders Ortorp et al 2006	⊖	⊖	?	?	+	+	+
Anders Ortorp et al 2009	⊖	⊖	?	?	+	+	+
Anders Ortorp et al 2012	⊖	⊖	?	?	+	+	+
Tortsen Jemt et al 2002	?	⊖	?	?	+	+	+

Risk Of Bias Summary

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