Heliyon 11 (2025) e42166

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Review article

CAD/CAM single prosthesis: A 25 years bibliometric assessment of prosthetic outcomes

Letícia Del Rio Silva, Daniele Valente Velôso, Valentim A. R. Barão, Marcelo Ferraz Mesquita [*,1], Guilherme Almeida Borges [1]

Universidade Estadual de Campinas (UNICAMP), Piracicaba Dental School, Department of Prosthodontics and Periodontology, Piracicaba, SP, Brazil

A R T I C L E I N F O

Keywords:
Dental prosthesis
Implant-supported
Computer-aided design

A B S T R A C T

Background: Computer-aided design and computer-aided manufacturing (CAD/CAM) single prostheses on teeth or implants are a viable option to restore edentulous spaces, using crowns. However, a comprehensive study that presents an overview of bibliometric factors related to the characteristics of this type of rehabilitation on teeth or implant is still lacking.
Objective: The purpose of this bibliometric study was to assess the review progress of papers in the field of CAD/CAM single prostheses regarding bibliometric parameters of year, framework material, technology, retention, and impression.
Material and methods: Four databases were assessed, and 5 bibliometric parameters were evaluated. An incidence rate ratio (IRR) was applied by using a multiple Poisson regression model (a = .05) to assess the association between single prostheses and each bibliometric parameter.
Results: A 25-year bibliometric research was carried out and 1019 studies were evaluated. Of these, 805 papers met the inclusion criteria. Over time, an upward trend was observed in the publication of articles on CAD/CAM single prostheses. Studies using only additive manufacturing had a higher IRR than papers that used both technologies (P = .016, IRR = 1.286). Aesthetic materials showed a higher IRR compared with studies that used titanium as framework material (P = .012, IRR = 1.258). Cemented prostheses (P < .001, IRR = 2.272) and both retentions systems (P = .005, IRR = 1.436) exhibited a higher IRR compared to screwed design. Scanning (P = .036, IRR = 1.107) had a higher IRR than hybrid method.
Conclusions: The number of studies that reports CAD/CAM single crowns has increased over time. Likewise, as the volume of publications with aesthetic frameworks. Additive manufacturing has been increasingly present in the most publications assessed, as well as the use of intraoral scanners for impressions. Single prostheses cemented retained were most commonly found.

1. Introduction

The rehabilitation of missing teeth with single crowns on teeth or implants is a validated treatment option that presents reliable

* Corresponding author. Department of Prosthodontics and Periodontology, Piracicaba Dental School, University of Campinas (UNICAMP), Av. Limeira, 901, Piracicaba, São Paulo, 13414-903, Brazil.
E-mail address: mesquita@unicamp.br (M.F. Mesquita).
[1] Marcelo Ferraz Mesquita and Guilherme Almeida Borges share the position of senior authors.

https://doi.org/10.1016/j.heliyon.2025.e42166
Received 21 June 2024; Received in revised form 13 January 2025; Accepted 21 January 2025
Available online 22 January 2025

long-term results of comfort, function, and aesthetics [1–5]. The ongoing development of new technologies and materials over the years has established this treatment modality as a standard of care in dentistry [1,6,7]. Similarly, indirect restorations are reliable and effective options for the rehabilitation of lost crowns [2]. For this purpose, metal-ceramic crowns have long been used [8], however, due to the subjective perception of the patient of preferring more aesthetic prostheses [9,11,12], new materials such as monolithic zirconia, lithium disilicate, and leucite-reinforced glass-ceramics were aesthetic solutions developed to mimic natural teeth [1,7,13,14].

Research into techniques that are less reliant on manual craftsmanship and human skills culminated in the development of computer-aided design and computer-aided manufacturing (CAD/CAM) technology [15–17]. The first step in manufacturing prostheses via CAD/CAM in a fully digital workflow involves the use of intraoral scanners [18,19], which have undergone continuous evolution since the 1980s [20–23]. CAD/CAM enables the systematic production of dental prostheses through subtractive or additive methods [24,25]. The subtractive approach, commonly referred to as milling, involves removing material from a prefabricated block using milling burs to create the prosthesis designed in the computer-aided design (CAD) stage [26]. This process can be executed by computer-assisted machines with 3, 4, or 5 axes, with 5-axis milling machines offering higher precision [15]. However, a limitation of subtractive technology is that the reproduction of fine details depends on the smallest available bur diameter [27]. Conversely, additive technology constructs objects layer by layer until the final geometry is achieved. This method offers several advantages, including the ability to print complex geometries, produce larger objects, and enhance sustainability, as unused powder can be recycled [15,27]. Today, both technologies are suitable for producing single prostheses with reliable dimensional stability. Subtractive technology is known for its standardization, while additive manufacturing continues to evolve rapidly [16,25,26].

Table 1
MeSH terms and search strategy.

PubMed
#1
Crowns[MeSH Terms] OR Denture, Partial, Fixed[MeSH Terms] OR Denture, Complete[MeSH Terms] OR Denture, Overlay[MeSH Terms] OR Dental Prosthesis [MeSH Terms] OR Crown*[Title/Abstract] OR Fixed[Title/Abstract] OR Complete[Title/Abstract] OR denture*[Title/Abstract] OR Overdenture*[Title/Abstract] OR dental[Title/Abstract] OR Removable[Title/Abstract] OR Overlay*[Title/Abstract]
#2
Computer-Aided Design[MeSH Terms] OR Printing, Three-Dimensional[MeSH Terms] OR "Computer Aided"[Title/Abstract] OR CAD/CAM[Title/Abstract] OR "Computer Assisted Design"[Title/Abstract] OR Subtractive*[Title/Abstract] OR Additive*[Title/Abstract] OR "Metal block"[Title/Abstract] OR Milling[Title/Abstract] OR EBM[Title/Abstract] OR "electron beam melting"[Title/Abstract] OR SLM[Title/Abstract] OR "selective laser melting"[Title/Abstract] OR 3D print[Title/Abstract] OR 3D printing[Title/Abstract] OR DMLS[Title/Abstract] OR "direct metal laser sintering"[Title/Abstract]
#3
Chromium Alloys[MeSH Terms] OR Cobalt Chromium[Title/Abstract] OR Chromium Cobalt[Title/Abstract] OR Co-Cr*[Title/Abstract] OR Cr-Co*[Title/Abstract] OR Zirconia*[Title/Abstract] OR Titanium[Title/Abstract] OR Titanium[MeSH Terms]
Web of Science
#1
TS=(Crowns) OR TS=(“Denture, Partial, Fixed”) OR TS=(“Denture, Complete”) OR TS=(“Denture, Overlay”) OR TS=(“Dental Prosthesis”) OR TS=(Crown*) OR TS=(Fixed) OR TS=(Complete) OR TS=(denture*) OR TS=(Overdenture*) OR TS=(dental) OR TS=(Removable) OR TS=(Overlay*) OR TS=(Removable)
#2
TS=(“Computer-Aided Design”) OR TS=(“Printing, Three-Dimensional”) OR TS=(“Computer Aided”) OR TS=(“CAD/CAM”) OR TS=(“Computer Assisted Design”) OR TS=(Subtractive*) OR TS=(Additive*) OR TS=(“Metal block”) OR TS=(Milling) OR TS=(“EBM”) OR TS=(“electron beam melting”) OR TS=(SLM) OR TS=(“selective laser melting”) OR TS=(“3D print”) OR TS=(“3D printing”) OR TS=(DMLS) OR TS=(“direct metal laser sintering”)
#3
TS=(“Chromium Alloys”) OR TS=(“Cobalt Chromium”) OR TS=(“Chromium Cobalt”) OR TS=(Co-Cr*) OR TS=(Cr-Co*) OR TS=(Zirconia*) OR TS=(Titanium)
Embase
#1
Crowns:ab,ti OR ‘Denture, Partial, Fixed’:ab,ti OR ‘Denture, Complete’:ab,ti OR ‘Denture, Overlay’:ab,ti OR ‘Dental Prosthesis’:ab,ti OR Crown*:ab,ti OR Fixed:ab,ti OR Complete:ab,ti OR denture*:ab,ti OR Overdenture*:ab,ti OR dental:ab,ti OR Removable:ab,ti OR Overlay*:ab,ti OR Removable:ab,ti
#2
‘Computer-Aided Design’:ab,ti OR ‘Printing, Three-Dimensional’:ab,ti OR ‘Computer Aided’:ab,ti OR ‘CAD/CAM’:ab,ti OR ‘Computer Assisted Design’:ab,ti OR Subtractive*:ab,ti OR Additive*:ab,ti OR ‘Metal block’:ab,ti OR Milling:ab,ti OR ‘EBM’:ab,ti OR ‘electron beam melting’:ab,ti OR SLM:ab,ti OR ‘selective laser melting’:ab,ti OR ‘3D print’:ab,ti OR ‘3D printing’:ab,ti OR DMLS:ab,ti OR ‘direct metal laser sintering’:ab,ti
#3
‘Chromium Alloys’:ab,ti OR ‘Cobalt Chromium’:ab,ti OR ‘Chromium Cobalt’:ab,ti OR Co-Cr*:ab,ti OR Cr-Co*:ab,ti OR Zirconia*:ab,ti OR Titanium:ab,ti
Cochrane
#1
MeSH descriptor: [Crowns] explode all trees OR MeSH descriptor: [Denture, Partial, Fixed] explode all trees OR MeSH descriptor: [Denture, Complete] explode all trees OR MeSH descriptor: [Denture, Overlay] explode all trees OR MeSH descriptor: [Dental Prosthesis] explode all trees OR (Crown*):ti,ab,kw OR (Fixed):ti,ab,kw OR Complete[Title/Abstract] OR (denture*):ti,ab,kw OR (Overdenture*):ti,ab,kw OR (dental):ti,ab,kw OR (Removable):ti,ab,kw OR (Overlay*):ti,ab,kw
#2
MeSH descriptor: [Computer-Aided Design] explode all trees OR MeSH descriptor: [Printing, Three-Dimensional] explode all trees OR (Computer Aided):ti,ab,kw OR (CAD/CAM):ti,ab,kw OR (Computer Assisted Design):ti,ab,kw OR (Subtractive*):ti,ab,kw OR (Additive*):ti,ab,kw OR (Metal block):ti,ab,kw OR (Milling):ti,ab,kw OR (EBM):ti,ab,kw OR (electron beam melting):ti,ab,kw OR (SLM):ti,ab,kw OR (selective laser melting):ti,ab,kw OR (3D print):ti,ab,kw OR (3D printing):ti,ab,kw OR (DMLS):ti,ab,kw OR (direct metal laser sintering):ti,ab,kw
#3
MeSH descriptor: [Chromium Alloys] explode all trees OR (Cobalt Chromium):ti,ab,kw OR (Chromium Cobalt):ti,ab,kw OR (Co-Cr*):ti,ab,kw OR (Cr-Co*):ti,ab,kw OR (Zirconia*):ti,ab,kw OR (Titanium):ti,ab,kw OR MeSH descriptor: [Titanium] explode all trees

To the best of the authors' knowledge, no bibliometric review has specifically investigated the materials, manufacturing methods, and clinical features involved in the rehabilitation of single prostheses on teeth and implants while simultaneously providing an overview of current achievements and offering perspectives for future research. Therefore, this stud aimed to assess the research progress of single prostheses applying bibliometric parameters (year, framework material, technology, connection, and impression). The null hypothesis tested was that the number of publications on CAD/CAM single-unit prostheses (dependent variable) would not vary across the different bibliometric parameters selected as independent variables (year, framework material, technology, retention, substrate, and impression).

2. Materials and methods

To achieve a bibliometric overview on CAD/CAM single prostheses, a broad search was carried out in the databases Cochrane, Embase, Pubmed, and Web of Science. The research field involved CAD/CAM prostheses, regardless of whether they were single, partial or complete. The search strategy used was described in Table 1. The articles were screened and were included if their contents topics focused in dental or implant supported prostheses and subtractive or additive manufacturing technologies in Dentistry. After removing duplicates, two independent investigators (L.D.R.S. and D.V.V.) screened a total of 2654 articles by evaluating their titles and abstracts. Then, a manual revision was accomplished by reading the papers in full. After careful analysis, the included papers were obtained (Fig. 1). To properly start the data extraction a calibration was performed priorly by the same reviewers with 200 articles randomly selected in online website (https://www.randomizer.org). The Cohen kappa coefficient (κ) showed a inter reliability of $k = 0.813$. Any inconsistency selecting the articles were solved by open discussion to achieve a consensus prior to the analysis. Only articles written in English were included. The papers classified as case reports, case series, systematic reviews, randomized controlled clinical trials (RCTs), nonrandomized controlled clinical trials (N-RCTs), retrospective, cross-sectional, or in vitro studies were included. If the articles were literature review, letter to editor, dental technique, and in silico they were removed. At least one of the groups in the article should include CAD/CAM technology. The research comprised all types of prosthesis and was separated into two categories: the dependent variable, CAD/CAM single prostheses, which included inlay, onlay, laminate veneers, copings, and single crown; whereas the other types of prosthesis (fixed partial dentures, removable partial dentures, overdenture bars, complete-arch fixed frameworks, baseplates, and combinations of rehabilitation types) were the other rehabilitations found. For those included articles, five

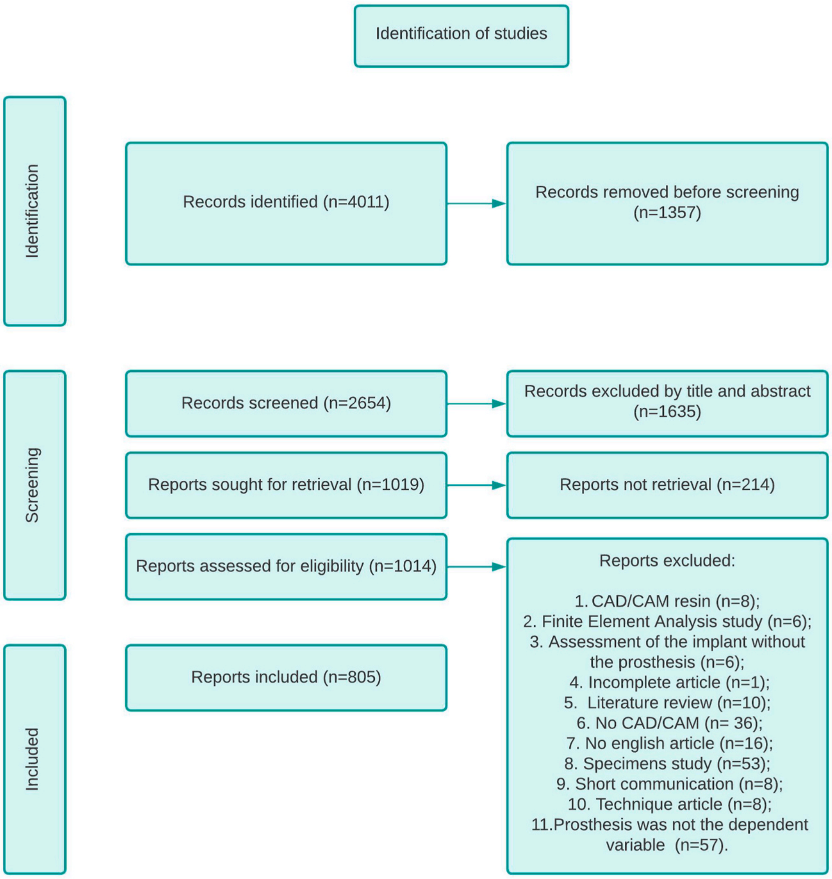

Fig. 1. Flow chart showing procedure for selection and inclusion of studies.

bibliometric parameters were collected and selected as independent variables: a) year; b) framework material [studies with combination of materials, Co-Cr; Zirconia, aesthetic materials (lithium disilicate, felspathic ceramic, and leucite-reinforced glass-ceramic), and titanium]; c) technology (milling, additive manufacturing, and both); d) retention (cemented, both, and screwed); e) substrate: implant, tooth, master model, implant and tooth; f) impression (scanned, hybrid: conventional impression followed by cast scanning). Meanwhile, the dependent variable was CAD/CAM single prostheses, which included: inlay, onlay, laminate veneers, copings, and single crown. Statistical analysis was performed by means of a software program (IBM SPSS Statistics, v20.0; IBM Corp). A multiple Poisson regressions analysis was used to assess the association of the dependent variable (CAD/CAM single prosthesis) with each independent variable (year, technology, framework material, retention, substrate, and impression). Thereafter, crude and adjusted models, incidence rate ratio (IRR) values, and 95 % confidence interval (CI) values were plotted. Backward-Wald procedure was applied to obtain the adjusted model. The independent variable withdrawn ($P > .2$) was 'rehabilitation substrate' (tooth, implant, master model, and tooth and implant) to achieve the adjusted model. Therefore, all results with $P < .05$ in the adjusted model were considered statistically significant.

3. Results

A 25-year bibliometric research was carried out, which resulted in a total of 4041 articles on CAD/CAM prosthesis. The papers were retrieved, of which 1019 proceed for title and abstract evaluation after copies removal. Afterwards, 805 articles fulfilled the inclusion criteria (Fig. 1). Afterwards, the majority number of studies were related to single crowns (54.2 %). The other categories were fixed partial denture, removable partial denture, overdenture bar, complete-arch fixed frameworks, baseplate, and combination of types of rehabilitation. This categorization aimed to provide an overview of the study populations involving CAD/CAM prostheses. While the statistical analysis focused exclusively on single prostheses, additional details were included to highlight the study profiles and the eligibility process. The independent variable with continuous data (year) was based solely on single prostheses. The data (mean ± standard deviation) for year was 2016 ± 4. Of the 437 single prosthesis papers, most 380 (55.2 %) were produced by milling, 20 (41.1 %) used 3D printing exclusively, and 37 (53.6 %) had both technologies in the study. Regarding the framework material 152 (65.8 %) compared different materials, 178 (52 %) had zirconia as its main focus, followed by aesthetic materials 52 (78.8 %), Co-Cr 44 (49.5

Table 2
Bibliometric parameters associated with CAD/CAM single prostheses, during 25 years. Crude and adjusted Poisson regression models.

Variables	Single prostheses[b] n (%)	Crude model				Adjusted model[a]			
	Mean ± SD	P	PR	95 % CI		P	PR	95 % CI	
				Lower	Upper			Lower	Upper
I. Year									
	2016 ± 4	<.001	1.019	1.01	1.029	**<.001**	1.020	1.010	1.030
II. Technology									
Milling	380 (55.2)	.349	1.118	.885	1.411	.356	1.116	.884	1.480
Additive Manufacturing	20 (41.7)	.014	1.290	1.052	1.582	**.016**	1.286	1.048	1.577
Both[c]	37 (53.6)	–	Ref.	–	–	–	Ref.	–	–
III. Framework material									
Combination[d]	152 (65.8)	.163	1.126	0.953	1.331	.169	1.120	.953	1.317
Co-Cr	44 (49.4)	.320	1.112	0.902	1.371	.334	1.106	.902	1.357
Zirconia	178 (52)	.815	.982	.840	1.147	.716	.971	.831	1.136
Aesthetic materials[e]	52 (78.8)	.012	1.257	1.052	1.502	**.012**	1.258	1.052	1.504
Titanium	11 (14.3)	–	Ref.	–	–	–	Ref.	–	–
IV. Connection									
Cemented	304 (67.4)	<.001	2.312	2.027	2.637	**<.001**	2.272	2.002	2.572
Both[f]	9 (33.3)	.002	1.545	1.175	2.033	**.005**	1.426	1.007	1.836
Screwed	8 (6.1)	–	Ref.	–	–	–	Ref.	–	–
V. Substrate									
Implant	30 (24.6)	.155	1.264	.915	1.746	–	–	–	–
Tooth	77 (56.2)	.236	1.218	.879	1.687	–	–	–	–
Master model	320 (62.7)	.210	1.235	.888	1.719	–	–	–	–
Implant and tooth	5 (21.7)	–	Ref.	–	–				
VI. Impression									
Scanned	323 (60.6)	.109	1.093	.980	1.219	**.036**	1.107	1.007	1.218
Impression and scanning	77 (38.1)	–	Ref.	–	–	–	Ref.	–	–

SD, standard deviation; PR, prevalence ratio; 95 % CI, 95 % confidence interval; Ref., reference category used.

[a] Included variables with $P < 0.2$ in the crude model. Bold values in adjusted model inform statistically significant difference.

[b] Single prosthesis (inlay, onlay, laminate veneers, copings, and single crowns) was the reference for the dependent variable in a population of studies that also included other types of prostheses (fixed partial dentures, removable partial dentures, overdenture bars, complete-arch fixed frameworks, baseplates, and combinations of rehabilitation types).

[c] Both, studies with milling and additive manufacturing groups.

[d] Combination, studies with more than one type of material in comparative groups.

[e] Esthetic materials, lithium disilicate, felspathic ceramic, and leucite-reinforced glass-ceramic.

[f] Both, studies with comparative groups between cemented and screw-retained prostheses.

%), and Titanium 11 (14.3 %). Most studies 304 (67.4 %) used luting agents to retain prostheses while 8 (6.1 %) used screws and 9 (33.3 %) applied both retention systems. The prostheses manufacturing through scanning was reported in 323 (60.6 %) studies, although conventional impression was also used as an initial step (hybrid) in 77 (38.1 %) studies.

The multiple Poison regression (Table 2) demonstrated that CAD/CAM single prosthesis, regarding the technology applied, had a higher incidence rate ratio (IRR = 1.286) of studies using only additive manufacturing than papers that used both technologies (P = .016, 95 % CI = 1.048, 1.577). Respecting to framework materials, aesthetic materials showed a higher incidence rate ratio (IRR = 1.258) compared with studies that used only titanium material (P = .012, 95 % CI = 1.052, 1.504). Concerning retention, a higher incidence rate ratio (IRR = 2.272) was observed for cemented prostheses ($P < .001$, 95 % CI = 2.002, 2.572) and both connections (IRR = 1.436) compared to screwed design (P = .005, 95 % CI = 1.007, 1.836). Evaluating impression, scanning had a higher incidence rate ratio (IRR = 1.107) than hybrid method (P = .036, 95 % CI = 1.007, 1.218).

4. Discussion

This study observed a notable increase in the number of publications related to the rehabilitation of CAD/CAM single prostheses, predominantly produced through milling. Therefore, the null hypothesis—that the number of publications on CAD/CAM single prostheses (dependent variable) remains unchanged across the various bibliometric parameters selected as independent variables—was rejected. Despite the rapid development of additive manufacturing in engineering, it will take a while for this technology to be standardized for use in everyday dental practice [16]. Probable explanations for this fact are the initial cost of equipment and mainly the lack of standardized parameters for 3D printers [16]. Regardless this technology presenting progressively promising results and within the minimum adaptation required [25], the oral rehabilitation involves pieces with complex geometries which requires precision for long-lasting results. Our results demonstrated that studies focused on evaluating solely additive manufacturing are more prevalent than studies comparing both technologies. This might be associated with milling being a well-established technique, and therefore it is not justified to carry out studies only evaluating its reproducibility. Our data currently reinforces the hypothesis that milling remains in high clinical and research demand, likely due to its close alignment with the clinical scenario [16,27].

The increasing demand for highly aesthetic rehabilitations substantially stimulates the development of new materials that can accomplish this requirement, either in the field of dental or implant-supported rehabilitations [14]. In the present study, a higher number of papers focused on evaluating frameworks manufactured in aesthetic materials than in titanium were observed. Feldspathic ceramic, leucite-reinforced glass-ceramic, and the widespread lithium disilicate were the most found materials in the studies compared with titanium. It means that there is a tendency to research more purely ceramic materials than metal-ceramic ones due to the technical advantages, clinical aspects, and patient reported outcome measures [9,10]. From a technical perspective, factors such as sensitivity to bonding techniques, high translucency, natural dental appearance, and adequate flexural strength are benefits of aesthetic materials when compared to metallic ones [11]. Indeed, monolithic crowns have high fracture resistance, which is related to minimally invasive preparations and might explain why this material is becoming increasingly popular [12]. Moreover, a previous publication [9] retrospectively verified a six-year of clinical performance of single dental crowns rehabilitated with lithium disilicate or metal-ceramic crowns. Regarding the clinical assessment, survival (96 % lithium disilicate; 90.8 % metal-ceramic) and success rates (96 % lithium disilicate; 83.4 % metal-ceramic) were higher for all-ceramic crowns when compared to metal-ceramic ones. This study also reported, by means of Visual Analogue Scale, patients' preference for lithium disilicate crowns in the following areas: color, chewing ability, and overall rating. Finally, a systematic review concluded that resin-bonded fixed partial dentures have a higher success rate than metal-ceramic ones, and the authors emphasize that the evolution of adhesive dentistry in last years could explain this finding [28].

Concerning the use of aesthetic materials in implant-supported single crowns, Wolfard and cols [3] compared cemented and screw-retained lithium disilicate posterior single crowns from biological and technical aspects. The measurements of bleeding on probing, gingival and plaque index, marginal bone loss, as well as technical complications, were similar for both groups. In our study, cemented prostheses and the comparison between cemented and screwed prostheses had a higher prevalence than the screwed design. Indeed, the preference for cemented prostheses in the field of implant dentistry might be explained by the benefits: compensation for inaccurately implant inclination mainly in the aesthetic area, the ease of reaching passivity by the cement layer, and the similarity with the techniques and protocols used in dental prosthesis [6]. In addition, the literature also reports a lower rate of prosthetic complications with cemented implant-supported single prostheses when compared to screw-retained ones [4]. A randomized controlled clinical trial [8] reported the rates related to the absence of complications, being 54.5 % for screw-retained and 91.3 % for cement-retained implant-supported single crowns. Although screw-retained prostheses offer the advantage of reversibility, the access opening in the ceramic for the screw can compromise the material's integrity, potentially increasing the risk of fracture [29]. The fact that cemented crowns have fewer technical complications might be associated with the stress relieve performed by the cement layer that distributes occlusal forces, helps to dissipate tension, and equalize possible misfits in the supported implant system [5,29]; however, these issues are sensitive to the technical skills of the operator [5].

Digital dentistry is an upward tendency that can be assessed by our data, and it has been frequently present in clinical practice [20]. The present study demonstrated a higher prevalence of papers that used only digital workflow compared to those that performed at least one conventional impression followed by scanning the cast for single prostheses manufacturing. In addition to the advantages associated with the use of intraoral scanners such as improved patient acceptance [24], visualization of errors seen on the screen in real time [22], and reducing the distortion of impression materials [21,24], accomplish part of the process conventionally and another digitally might result in discrepancies adding "error factors" [20]. In vitro study [18], randomized clinical trials [17,21], and systematic reviews [19,23] have already demonstrated the absence of difference for adaptation [17,21] and accuracy [18], meanwhile the superiority of intraoral scanner in terms of patient convenience [17,19,21], marginal and internal fit [23]. In addition to the aforementioned advantages, several studies also report the greater speed [17,19,21], better occlusal contacts [21], and lower gag reflex [17] of digital impressions when compared to the use of elastomeric materials.

The results found in this study are similar to cross-sectional studies and, therefore, are valid for the moment in which they were analyzed. This perspective might change depending on the development of technologies and the clinical scenario. The inclusion of systematic reviews duplicates data from clinical trials as they were included in the systematic reviews and meet the inclusion criteria of this study, and for this reason this can also be considered as a limitation of this study. In addition, not having separated the data for single prostheses on teeth and on implants can overestimated the results related to cemented prostheses since prostheses on teeth can only be cemented. The option for a 25-year time frame was performed due to the volume of information collected. Therefore, future bibliometric studies with CAD/CAM single crowns might focus on more recent years, rehabilitation region, whether anterior or posterior, and its association with frameworks and types of aesthetic coverage due to the aesthetic demand.

5. Conclusions

Based on the findings of this bibliometric study, the following conclusions were drawn:

1. Over the years there has been an increase in the publication of studies on CAD/CAM single prostheses;
2. Studies that used only additive manufacturing were more common than those that compared milling and additive technologies;
3. Aesthetic materials had an increase in scientific demand over the years compared to titanium;
4. The cemented retained prostheses and both connections were more reported than the screwed retained;
5. Digital impression was a more widely used approach than the hybrid technique (conventional impression followed by cast scanning).

CRediT authorship contribution statement

Letícia Del Rio Silva: Writing – review & editing, Writing – original draft, Visualization, Methodology, Data curation. **Daniele Valente Velôso:** Visualization, Methodology, Data curation. **Valentim A. R. Barão:** Writing – review & editing, Supervision, Formal analysis. **Marcelo Ferraz Mesquita:** Writing – review & editing, Supervision, Project administration. **Guilherme Almeida Borges:** Writing – review & editing, Supervision, Formal analysis, Conceptualization.

Data availability statement

Data will be made available on request.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Guilherme Almeida Borges reports financial support was provided by Universidade Estadual de Campinas. The co-author Valentim Adelino Ricardo Barão is an Associate Editor for *Heliyon* and was not involved in the editorial review or the decision to publish this article. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] M. Hosseini, N. Worsaae, K. Gotfredsen, A 5-year randomized controlled trial comparing zirconia-based versus metal-based implant-supported single-tooth restorations in the premolar region, Clin. Oral Implants Res. 33 (2022) 792–803, https://doi.org/10.1111/clr.13960.

[2] S. Al-Saleh, F. Vohra, S.M. Albogami, N.M. Alkhammash, M.A. Alnashwan, N.S. Almutairi, et al., Marginal misfit of 3D-printed (selective laser sintered), CAD-CAM and lost wax technique cobalt chromium copings with shoulder and chamfer finish lines: an in-vitro study, Medicina 58 (2022) 1313, https://doi.org/10.3390/medicina58101313.

[3] S. Wolfart, A. Rittich, K. Groß, O. Hartkamp, A. von der Stück, S. Raith, et al., Cemented versus screw-retained posterior implant-supported single crowns: a 24-month randomized controlled clinical trial, Clin. Oral Implants Res. 32 (2021) 1484–1495, https://doi.org/10.1111/clr.13849.

[4] I. Sailer, S. Mühlemann, M. Zwahlen, C.H.F. Hämmerle, D. Schneider, Cemented and screw-retained implant reconstructions: a systematic review of the survival and complication rates, Clin. Oral Implants Res. 23 (2012) 163–201, https://doi.org/10.1111/j.1600-0501.2012.02538.x.

[5] C. Dini, G.A. Borges, R.C. Costa, M.B. Magno, L.C. Maia, Barão VAR. Peri-implant and esthetic outcomes of cemented and screw-retained crowns using zirconia abutments in single implant-supported restorations—a systematic review and meta-analysis, Clin. Oral Implants Res. 32 (2021) 1143–1158, https://doi.org/10.1111/clr.13824.

[6] J.G. Wittneben, T. Joda, H.P. Weber, U. Brägger, Screw retained vs. cement retained implant-supported fixed dental prosthesis, Periodontol 73 (2000 2017) 141–151, https://doi.org/10.1111/prd.12168.

[7] B.E. Pjetursson, N.A. Valente, M. Strasding, M. Zwahlen, S. Liu, I. Sailer, A systematic review of the survival and complication rates of zirconia-ceramic and metal-ceramic single crowns, Clin. Oral Implants Res. 29 (2018) 199–214, https://doi.org/10.1111/clr.13306.

[8] C.W. Cheng, C.H. Chien, C.J. Chen, P. Papaspyridakos, Randomized controlled clinical trial to compare posterior implant-supported modified monolithic zirconia and metal-ceramic single crowns: one-year results, J. Prosthodont. 28 (2019) 15–21, https://doi.org/10.1111/jopr.12767.

[9] A. Aziz, O. El-Mowafy, Six-year clinical performance of lithium disilicate glass-ceramic CAD-CAM versus metal-ceramic crowns, J. Adv. Prosthodont. 15 (2023) 44–54, https://doi.org/10.4047/jap.2023.15.1.44.

[10] E.R. Batson, L.F. Cooper, I. Duqum, G. Mendonça, Clinical outcomes of three different crown systems with CAD/CAM technology, J. Prosthet. Dent 112 (2014) 770–777, https://doi.org/10.1016/j.prosdent.2014.05.002.

[11] Y. Chen, A.W.K. Yeung, E.H.N. Pow, J.K.H. Tsoi, Current status and research trends of lithium disilicate in dentistry: a bibliometric analysis, J. Prosthet. Dent 126 (2021) 512–522, https://doi.org/10.1016/j.prosdent.2020.08.012.
[12] C.I.M.B. Leitão, G.V.O. Fernandes, L.P.P. Azevedo, F.M. Araújo, H. Donato, A.R.M. Correia, Clinical performance of monolithic CAD/CAM tooth-supported zirconia restorations: systematic review and meta-analysis, J. Prosthodont. Res. 66 (3) (2022 30) 374–384, https://doi.org/10.2186/jpr.JPR_D_21_00081.
[13] W. Höland, V. Rheinberger, E. Apel, C. van 't Hoen, M. Höland, A. Dommann, et al., Clinical applications of glass-ceramics in dentistry, J. Mater. Sci. Mater. Med. 17 (2006) 1037–1042, https://doi.org/10.1007/s10856-006-0441-y.
[14] M. Hosseini, N. Worsaae, M. Schiødt, K. Gotfredsen, A 3-year prospective study of implant-supported, single-tooth restorations of all-ceramic and metal-ceramic materials in patients with tooth agenesis, Clin. Oral Implants Res. 24 (2013) 1078–1087, https://doi.org/10.1111/j.1600-0501.2012.02514.x.
[15] T.F. Alghazzawi, Advancements in CAD/CAM technology: options for practical implementation, J. Prosthodont. Res. 60 (2016) 72–84, https://doi.org/10.1016/j.jpor.2016.01.003.
[16] C. Valenti, M.I. Federici, F. Masciotti, L. Marinucci, I. Xhimitiku, S. Cianetti, et al., Mechanical properties of 3D-printed prosthetic materials compared with milled and conventional processing: a systematic review and meta-analysis of in vitro studies, J. Prosthet. Dent 5 (22) (2022) S0022–S3913, https://doi.org/10.1016/j.prosdent.2022.06.008, 00415-2.
[17] N. Sakornwimon, C. Leevailoj, Clinical marginal fit of zirconia crowns and patients' preferences for impression techniques using intraoral digital scanner versus polyvinyl siloxane material, J. Prosthet. Dent 118 (2017) 386–391, https://doi.org/10.1016/j.prosdent.2016.10.019.
[18] S.J. Lee, R.A. Betensky, G.E. Gianneschi, G.O. Gallucci, Accuracy of digital versus conventional implant impressions, Clin. Oral Implants Res. 26 (2015) 715–719, https://doi.org/10.1111/clr.12375.
[19] R. Siqueira, M. Galli, Z. Chen, G. Mendonça, L. Meirelles, H.L. Wang, et al., Intraoral scanning reduces procedure time and improves patient comfort in fixed prosthodontics and implant dentistry: a systematic review, Clin. Oral Invest. 25 (2021) 6517–6531, https://doi.org/10.1007/s00784-021-04157-3.
[20] K. Sarafidou, M. Chatziparaskeva, D. Chatzikamagiannis, V. Mpotskaris, D. Tortopidis, A. Bakopoulou, et al., Evaluation of marginal/internal fit of fixed dental prostheses after digital, conventional, and combination impression techniques: a systematic review, Eur. J. Oral Sci. 130 (2022) e12902, https://doi.org/10.1111/eos.12902.
[21] B. Gjelvold, B.R. Chrcanovic, E.K. Korduner, I. Collin-Bagewitz, J. Kisch, Intraoral digital impression technique compared to conventional impression technique, A randomized clinical trial, J. Prosthodont. 25 (2016) 282–287, https://doi.org/10.1111/jopr.12410.
[22] M. Boeddinghaus, E.S. Breloer, P. Rehmann, B. Wöstmann, Accuracy of single-tooth restorations based on intraoral digital and conventional impressions in patients, Clin. Oral Invest. 19 (2015) 2027–2034, https://doi.org/10.1007/s00784-015-1430-7.
[23] J. Manisha, G. Srivastava, S. Das, N. Tabarak, G. Choudhury, Accuracy of single-unit ceramic crown fabrication after digital versus conventional impressions: a systematic review and meta-analysis, J. Indian Prosthodont. Soc. 23 (2023) 105–111, https://doi.org/10.4103/jips.jips_534_22.
[24] E. Yuzbasioglu, H. Kurt, R. Turunc, H. Bilir, Comparison of digital and conventional impression techniques: evaluation of patients' perception, treatment comfort, effectiveness and clinical outcomes, BMC Oral Health 14 (2014 30) 10, https://doi.org/10.1186/1472-6831-14-10.
[25] J. Thakur, S. Parlani, S. Shivakumar, K. Jajoo, Accuracy of marginal fit of an implant-supported framework fabricated by 3d printing versus subtractive manufacturing technique: a systematic review and meta-analysis, J. Prosthet. Dent 129 (2023) 301–309, https://doi.org/10.1016/j.prosdent.2021.05.010.
[26] Nassani LM, Bencharit S, Schumacher F, Lu WE, Resende R, Fernandes GVO. The impact of technology teaching in the dental predoctoral curriculum on students' perception of digital dentistry. Dent. J. 202413;12(3):75. doi: 10.3390/dj12030075.
[27] V. Rutkūnas, A. Gedrimienė, L. Auškalnis, O. Admakin, F. Mangano, Accuracy of fixed implant-supported dental prostheses additively manufactured by metal, ceramic, or polymer: a systematic review, J. Prosthodont. 31 (2022) 70–87, https://doi.org/10.1111/jopr.13449.
[28] M.C. Santos, L. Azevedo, P. Fonseca, P.C. Viana, F. Araújo, E. Villarinho, G.V.O. Fernandes, A. Correia, The success rate of the adhesive partial fixed prosthesis after five years: a systematic review, Prosthesis 5 (1) (2023) 282–294, https://doi.org/10.3390/prosthesis5010021.
[29] L.M. Vozzo, L. Azevedo, J.C.H. Fernandes, P. Fonseca, F. Araújo, W. Teixeira, et al., The success and complications of complete-arch implant-supported fixed monolithic zirconia restorations: a systematic review, Prosthesis 5 (2) (2023) 425–436, https://doi.org/10.3390/prosthesis5020029.