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SYSTEMATIC REVIEW

Are monolithic zirconia complete arch implant-supported prostheses reliable? A systematic review and meta-analysis

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ABSTRACT

Statement of problem. Despite the increasing use of monolithic zirconia for complete arch implant-supported prostheses, evidence regarding their long-term survival, complication rates, and clinical predictability remains limited and heterogeneous.

Purpose. The purpose of this systematic review was to evaluate the survival and overall performance of monolithic zirconia complete arch implant-supported prostheses.

Material and methods. An electronic search was conducted in 9 databases following Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines and registered on PROSPERO (CRD: 42025640173). Meta-analyses were performed using random-effects models (α=.05). Subgroup analyses evaluated the pooled proportion of prosthetic failures, implant longevity, and technical complications. The risk of bias was assessed using the Risk of Bias in Non-randomized Studies of Interventions (ROBINS-I) tool, and the certainty of evidence was graded according to the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) approach.

Results. Thirteen studies comprising 2841 prostheses and 3940 implants were included in this systematic review. The pooled proportion rate of monolithic zirconia complete arch prostheses in function at the last follow-up (12 to 62 months) was 99% (95% confidence interval [CI]): 97% to 100%; I^2=72%, while implant longevity reached 100% (95% CI: 99% to 100%; I^2=75%). The pooled technical complication rate was 14% (95% CI: 4% to 27%; I^2=96%). Subgroup analyses revealed higher complication rates in veneered designs (up to 27%) compared with monolithic configurations (1% to 3%). Most studies presented a moderate to serious risk of bias according to ROBINS-I, mainly due to retrospective designs and confounding. The certainty of evidence was rated as low by GRADE, primarily because of methodological limitations and heterogeneity.

Conclusions. Monolithic zirconia complete arch implant-supported prostheses demonstrated high cumulative proportions of prostheses remaining in function and low rates of technical and biological complications within the reported follow-up periods. (J Prosthet Dent 2026;136:40-51)

Complete arch implant-supported prostheses have become a popular solution for completely edentulous patients, restoring oral function, esthetics, and quality of life.[1] These prostheses distribute occlusal forces, reducing the risks of implant overload and bone loss with appropriate adjustments.[2] High survival rates (up to 100%) have been reported, making complete arch implant-supported prostheses a reliable and long-term option for complete tooth loss, with few biological and mechanical complications.[3–5] The adoption of computer-aided design and computer-aided manufacturing (CAD-CAM) technology has further enhanced the design and production of prostheses, facilitating accurate digital planning and milling for improved fit and

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Clinical Implications

This systematic review and meta-analysis found that monolithic zirconia complete arch prostheses present high cumulative proportions of prostheses remaining in function and relatively low complication rates over short- to medium-term follow-up. These findings may help clinicians better understand the expected clinical performance of monolithic zirconia for complete arch prostheses.

fewer manual errors.[5] CAD-CAM methods enhance structural integrity, streamline workflows, and increase treatment speed, supporting the use of complete arch restorations with predictability and clinical efficiency.[2,4] Zirconia has become a popular material for these prostheses because of its mechanical strength, biocompatibility, and esthetics.[4] Factors such as durability and similarity to natural enamel make zirconia an excellent choice for complete arch restorations, especially as recent advancements in 5 mol% yttria-stabilized tetragonal zirconia polycrystal and multilayer zirconia have enhanced the esthetic appeal for use in anterior applications.[2,3]

Systematic reviews with meta-analyses provide a high level of scientific evidence to guide clinical practice, particularly when conducted according to established methodological guidelines.[6–10] In this context, the existing clinical studies on monolithic zirconia complete arch prostheses allow a comprehensive assessment of the indications and clinical performance of this material.[11–23] Consequently, this systematic review and meta-analysis aimed to evaluate monolithic zirconia complete arch implant-supported prostheses, focusing on survival rates, complications, and patient satisfaction. The null hypothesis was that no differences would be observed in prosthesis survival or complication rates between monolithic zirconia complete arch implant-supported prostheses and other implant-supported complete arch prosthetic designs.

MATERIAL AND METHODS

This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines and the Cochrane Handbook for Systematic Reviews of Interventions (version 5.1.0).[6,7] The protocol was registered on the PROSPERO database (CRD: 42025640173).

The structured research question followed the population, intervention, outcome, time (PIOT) framework: Population: participants rehabilitated with complete arch implant-supported fixed prostheses. Intervention: complete arch fixed prostheses manufactured from monolithic zirconia. Outcome: evaluation of prosthesis survival rates, patient quality of life after rehabilitation, esthetic satisfaction after treatment, and biological and prosthetic complications in individuals who received the proposed treatments. Time: retrospective and prospective clinical studies, published up to January 2025, with a minimum follow-up of 6 months. Only studies with 10 or more participants were considered for analysis.

The primary objective was to quantify the survival rates of implant-supported monolithic zirconia complete arch prostheses. The secondary objectives included assessing the rates of mechanical and biological complications associated with implant-supported prostheses placed under these conditions, as well as evaluating patient satisfaction with this rehabilitation method.

An electronic search was performed in the Medline (PubMed), Cochrane Library, EMBASE, SciELO, Scopus, EBSCO, LILACS, VHL, Google Scholar, and Web of Science databases. The keywords used for this research were "Full-arch implant-supported fixed prostheses" and "Zirconia." The inclusion criteria consisted of prospective or retrospective clinical studies with a follow-up of at least 6 months, a minimum of 10 participants, and reporting on complete arch prostheses entirely made of monolithic zirconia. Studies were included regardless of language.

The selection process was performed using a software program (Rayyan). Duplicate entries were removed. Three independent reviewers (A.C.M., F.L.V., J.R.M.) screened the titles and abstracts according to the eligibility criteria. Disagreements were resolved through consensus meetings, which included a fourth reviewer (J.F.S.Jr). The risk of bias in the included studies was assessed using the Risk of Bias in Non-randomized Studies of Interventions (ROBINS-I). The responses for the 7 ROBINS-I domains were organized using the online Robins tool.[8] Quantitative data were pooled through meta-analysis for multiple outcomes, including the survival rate of monolithic zirconia complete arch implant-supported prostheses, dental implant survival, overall complication rate, and complication rates stratified by veneering design of monolithic zirconia prostheses. The outcomes were reported as event proportions accompanied by their corresponding 95% confidence intervals (95% CI). Accordingly, the meta-analyses were conducted as pooled proportions using random-effects models, and the resulting estimates represent cumulative event proportions at the study-specific follow-up times (α=.05).[9] The relative weight contributed by each study was also assessed in the pooled analysis. Meta-analyses were performed using an online tool for quantitative data synthesis.[10] A Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) assessment was performed to evaluate the certainty of evidence across the main outcomes included in this systematic review (https://www.gradepro.org/).

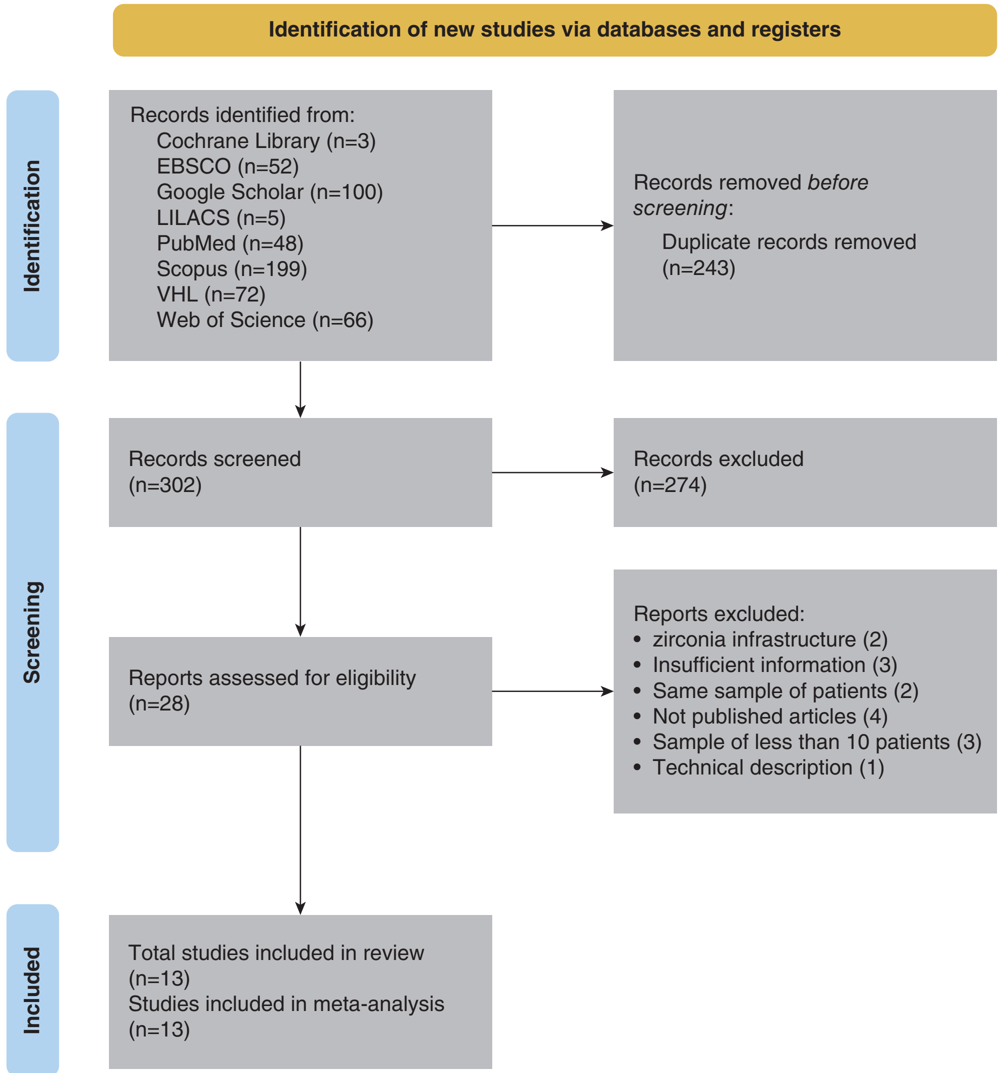

Figure 1. Flow diagram of article selection process based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

RESULTS

The search strategy yielded a total of 545 records, from which 243 duplicates were removed. After screening titles and abstracts, 28 studies were initially selected for full-text review based on inclusion and exclusion criteria (Fig. 1). Among these, 2 articles evaluated prostheses in which only the infrastructure was from monolithic zirconia, 3 articles did not detail the number of complications observed in the different types of prostheses and materials used, 3 articles consisted of the same sample of participants in different observation periods, but only the most recent article was incorporated into the sample of this systematic review, 4 studies were excluded because they were theses and not published articles, 3 articles presented a sample of fewer than 10 participants with complete arch prostheses in monolithic zirconia, and 1 article presented a technical description.

As a result, 13 studies met all inclusion and exclusion criteria and were included in this systematic review.[11–23] The number of participants per study ranged from 10 to 129.[11,23] The average age across the studies was approximately 60 years,[11,13–17,19,21,23] and the follow-up periods ranged from 12 to 62 months (Table 1).[17,18]

In terms of types of zirconia, the studies not only investigated monolithic zirconia but also compared it with veneered zirconia and combinations such as zirconia–ceramic (Table 2). Twelve studies reported that all prostheses were screw-retained,[11,12,14–23] and 1 study used both screw and cement retention.[13]

As shown in Table 3, the number of implants per prosthesis varied among the studies. A few studies reported using between 4 and 6 implants, but this varied depending on the study and clinical situation. Implants were placed in both the maxillary and mandibular regions. When explicitly reported, the total number of

Table 1. Characteristics included studies (patient data)

Author (s) and year	Country	Study type	Number of participants (n)	Mean age (years)	Mean follow-up time months)
Al-Tarawneh et al, 2023	USA	retrospective cohort study	129	≤ 65 vs > 65	22.8
Bidra et al, 2018	USA	retrospective study	NR	NR	60
Box et al, 2018	USA	retrospective study	37	63 (MZ)	20 (MZ)
Cappare et al, 2021	Italy	retrospective clinical study	50	64,8	24
Caramês et al, 2018	Portugal	prospective study	150 total, 67 in MZ group	62	18
Gonzalez and Triplett 2017	USA	retrospective case series study	40	60.05	33
Limmer et al, 2014	USA	prospective clinical study	17	57.9	12
Papaspyridakos et al, 2024	USA	retrospective multicenter study	71	NR	62
Tirone et al, 2021	Italy	observational retrospective study	140 total; 41 in group 3 (MZ)	63.0	48
Tischler et al, 2018	USA	retrospective clinical study	128	NR	48
Vasques et al, 2021	Portugal	retrospective study	21	32-77	16.7
Venezia et al, 2015	Italy	retrospective evaluation	18	NR	20.9
Vizcaya et al, 2018	Spain	retrospective study	10	59.5	54

MZ, monolithic zirconia; NR, not reported; vs, versus.

Table 2. Characteristics of included studies (prosthesis data)

Author (s) and year	Type of Zirconia Prosthesis	Commercial name of Zirconia Company	Type of Prosthesis: screw-retained (sr) or cemented (c)	Number of elements per Prosthesis (n)	Number of Prosthesis (n)
Al-Tarawneh et al, 2023	Monolithic: 72; minimally Layered with ceramic: 101	monolithic e veneered (name of company NR)	Sr	12 (range 10 to 14)	173
Bidra et al, 2018	monolithic: with veneered porcelain restricted to the gingival region:	Prettau Zirconia (ZirkonZahn)	Sr	NR	2039
Box et al, 2018	monolithic zirconia (MZ) or Porcelain Veneered Zirconia (PVZ), Metal-Acrylic, Retrievable Crown	NR	Sr and c	NR	7(MZ)
Cappare et al, 2021	monolithic with ceramic veneering limited to nonfunctional areas	Prettau Zirconia (ZirkonZahn)	Sr	NR	50 (25MZ)
Caramês et al, 2018	monolithic zirconia with porcelain veneering limited to buccal (MZ) rehabilitations	Prettau Zirconia (ZirkonZahn)	Sr	10 to 14	100(MZ); PVZ (77)
Gonzalez and Triplett 2017	monolithic zirconia with layers of porcelain on nonfunctional and esthetic areas	Prettau Zirconia (ZirkonZahn)	Sr	NR	44
Limmer et al, 2014	monolithic zirconia	ZirkonZahn	Sr	NR	17
Papaspyridakos et al, 2024	monolithic design or a modified monolithic design (minimum of 0,2 mm of facial and gingival stratification)	3Y-TZP monolithic zirconia (Katana ML (Noritake) and Copra Supreme Symphony (Whitepeaks)	Sr	NR	115
Tirone et al, 2021	monolithic zirconia IFCDP veneered in the gingival portion	Group 1: Procera Zirconia (Nobel Biocare, USA), Group 2: Prettau (Zirkonzahn, Germany), Grou 3: Zircodent Multilayer (Amann Girrbach, Austria)	Sr	NR	55
Tischler et al, 2018	monolithic; veneered porcelain restricted to the gingival region; 1-piece	Prettau Zirconia (ZirkonZahn)	Sr	NR	191
Vasques et al, 2021	monolithic zirconia	Noritake Katana ML (Kuraray)	Sr	NR	29
Venezia et al, 2015	monolithic zirconia restoration with facial and/or incisal porcelain veneers were selected	Sagemax Zr (Sagemax Bioceramics Inc.)	Sr	NR	26
Vizcaya et al, 2018	monolithic zirconia	Prettau Zirconia (ZirkonZahn)	Sr	10 to12units	20

C, cemented; MZ, monolithic zirconia; NR, not reported; PVZ, porcelain-veneered zirconia; SR, screw-retained.

implants placed in the maxilla[11,14,15,18,20–23] was 1788, and 1325 in the mandible.[11,14–23]

Prosthetic failure was rare throughout the studies. While some studies reported no failures,[11,13,14,16,22,23] others noted a small number of prosthesis losses.[12,15,17–20] Technical complications were more common, with the most frequent issues being chipping, decementation of titanium cylinders, and screw loosening (Table 4). Implant failure was also not frequent, with 19 reported implant losses.[11,15,19,20] Among the biological complications documented, mucositis, and peri-implantitis were the most common, and 1 study reported 2 participants with sinusitis.[11,12]

Marginal bone loss (MBL) was not consistently reported. However, among the few studies[14,22] that measured it, 1 reported an average MBL of less than 1.52 ±0.63 after 1 year of function.[22] Prosthetic survival rates were consistently high across all included studies varying from 88.2% to 100%.[11–23] When success rates were reported, they were also high, varying between 99.8% and 41%.[15,17,21–23] Patient satisfaction was

Table 3. Characteristics of included studies (implant information)

Author (s) and year	Number of implants (n)	length × diameter (mm:n)	Commercial name of Implants Company	Number of implants (impl) /Prostheses	Region of implants
Al-Tarawneh et al, 2023	849	NR	NR	4 impl: 78; 5-8 impl: 95	maxilla n=101; mandible n=71
Bidra et al, 2018	NR	NR	NR	NR	maxilla and mandible
Box et al, 2018	mean: 5.7	NR	NR	MZ: 5.7 impl/Prosthesis; PVZ: 5.3 impl/Prosthesis	MZ: maxilla 71%; mandible 29%; PVZ: maxilla/mandible: 50/50%
Cappare et al, 2021	222 (116MZ)	11×3.8: 20; 11×3.3: 2; 13×3.8: 92; 13×3.3: 14; 15×3.8: 48; 15×3.3:14	NR	4 impl: 156; 6 impl: 66	Patients: maxilla n=22; mandible n=28
Caramês et al, 2018	581	NR	Osseotite, Zimmer Biomet, Warsaw, IN, USA	4 impl: 20; 5 impl: 7; 6 impl: 55; 7 impl: 8; 8 impl: 10	maxilla n=354; mandible n=227
Gonzalez and Triplett 2017	NR	NR	Nobel Biocare (Temporary Coping Multi-unit)	NR	maxilla and mandible
Limmer et al, 2014	68	NR	Astra Tech Osseospeed TX implants, (Dentsply Sirona)	4 impl	Patients: mandible n=17
Papaspyridakos et al, 2024	784	NR	Straumann e Nobel Biocare	4 impl: 12; 5 impl: 3; 6 impl: 44; 7 impl: 7; 8 impl: 36; 9 impl: 10; 10 impl:3	maxilla n=456 e mandible n=328
Tirone et al, 2021	794	NR	Nobel Biocare	4-6 impl per arch (majority: 4 implant-supported)	Patients: mandible n=70; bimaxilla n=43
Tischler et al, 2018	1072	3.8 mm: 795; 4.6 mm: 249; 5.8 mm: 28	BioHorizons – Tapered Internal (internal hexagonal connection)	5 mandible; 6 maxilla	maxilla n=618; Mandible n=454
Vasques et al, 2021	4-6 per arcade	3.30 mm: 10; 3.75 mm: 47; 4.10 mm: 28; 4.20 mm:49	MIS C1 (69% of the cases), Straumann BLT (31%)	4 impl: 20; 6 impl: 9	maxilla: 15 Prostheses, Mandible: 14 Prostheses
Venezia et al, 2015	154	NR	SLActive, Institut Straumann AG; Osseotite; Biomet 3i or Ti-Unite, Nobel Biocare	4 impl: 1; 5 impl: 4; 6 impl: 17; 7 impl: 4	maxilla (n=99); mandible (n=55)
Vizcaya et al, 2018	101	NR	NR	4impl: 9; 5impl: 3; 6impl:7; 8:1	maxilla (n=56); mandible (n=45)

MZ, monolithic zirconia; NR, not reported; IMPL, implant; PVZ, porcelain-veneered zirconia.

Table 4. Characteristics of included studies (quantitative variables analyzed)

Author (s) and year	Type of loading	Prostheses failure (n)	Technical complications- Prosthesis	Implant failure	Biological complications	Prostheses survival rates	Success rates	Marginal bone loss
Al-Tarawneh et al, 2023	NR	0	Chipping of prostheses (n=9/173); Chipping of opposing (n=6); Screw loosening (n=3); Screw fracture (n=5); Clicking sounds (n=4), debonding of titanium cylinder (n=8);	Fractured implant n=1; Implant failure n=2	Mucositis (n=3); Peri-implantitis (n=8); Sinusitis (related to zygomatic implant) (n=2)	MZ (100%: 72/72); MLZ (100%:101/101)	NR	NR
Bidra et al, 2018	NR	6	fracture of titanium cylinder (n=3), debonding of titanium cylinder (n=6);	NR	NR	0.993 (2033/2039)	NR	NR
Box et al, 2018	NR	0	MZ: Access cap replacement: 1 case; Marked wear in the posterior region: 2 cases; PVZ: Access cap replacement: 3 prostheses; Marked wear in anterior or posterior region: 1 prosthesis, 2 prostheses; Tooth fracture: 3 prostheses; esthetic problem: 1 prosthesis.	0	NR	100% (7/7)	NR	No participants lost implants or displayed radiographic pathology other than marginal bone loss
Cappare et al, 2021	immediate	0	NR	0	Complete mouth bleeding score (33% MA; 13% Zir); complete mouth plaque score (n=76% MA; 53% Zr)	100% (50/50); 100% MZ (25/25)	NR	1.52 ±0.63 mm (zirconia); 1.74 ±0.89 mm (metal-acrylic)
Caramês et al, 2018	NR	5/100 (MZ); 5/77 (PVZ)	Chipping of prostheses: n=4. Loss of composite resin from screw access chamber. Prosthetic screw loosening n=5	MZ: 0,17%; PVZ: 0,47%	NR	PVZ: 85% (71/83); MZ: 89% (98/110)	99.83% (MZ)	NR
Gonzalez and Triplett 2017	NR	0	8 prostheses; 6: incisal chipping of prostheses, 2: debonding of metallic cylinder	NR	NR	100% (44/44)	NR	NR
Limmer et al, 2014	delayed	n=2 (fractured n=1; implant failure n=1)	Chipped denture tooth: 6; Fractured abutment:2; Loose abutment: 1; Fractured MZ-FDP: 1; Debonded component: 1;	1	NR	88.2% (15/17)	41% of the participants without any complication (7/17)	NR
Papaspyridakos et al, 2024	delayed	n=2 (115)	Chipping of prostheses: 4; Decementation of titanium base: 2; Fracture of opposing complete denture: 1; Screw access filling lost: 32	0	NR	98.26% (113/115 Prosthesis)	NR	NR
Tirone et al, 2021	Mix: immediate if torque ≥ 35 Ncm; otherwise delayed (after 2 months)	4/55 (MZ)	Failures: type 1 fracture: 1; type 2 fracture: 3	5	NR	92.7% (4/55) MZ	NR	NR
Tischler et al, 2018	immediate or delayed	Prostheses fracture n=1; remade Prosthesis because of implant failure n=3; absence of passivity n=1	inadequate passive fit; debonding of titanium cylinders: 1; screws fractured: 2	18	NR	0.994 (1 fracture)	NR	NR
Vasques et al, 2021	Mix: 41.4% immediate; 58.6% delayed	1	multi-unit screw loosening: 3 (10.3%); prosthetic screw loosening: 1 (3.4%), antagonist arch wear (6.9%)	0	Complete mouth plaque score: 20.7%	96.6% (28/29)	76% without any complication	NR
Venezia et al, 2015	delayed	0	Chipping of prostheses (11,5%: 3/26).	0	bleeding on probing (19%), 8 implants with bone loss >2 mm, depth >5 mm → implant success: 94.8%	100% (26/26)	High: only 3/26 Prosthesis with small chipping (11.5%)	0.66 ±0.59 mm
Vizcaya et al, 2018	delayed	0	chipping of pink ceramic: 1; screw loosening: 2	0	NR	100% (20/20)	8 Prostheses of 10 participants without complications	NR

MA, metal-acrylic prostheses; MZ, monolithic zirconia; NR, not reported; IMPL, implant; PVZ, porcelain-veneered zirconia.

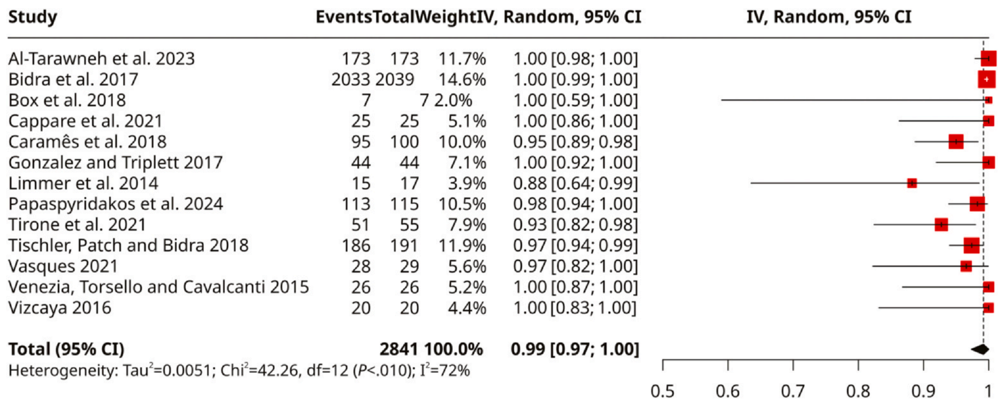

Figure 2. Meta-analysis of pooled proportion of monolithic zirconia complete arch prostheses supported by dental implants (prostheses in function).

evaluated in 2 studies.[11,13] However, the use of different questionnaires made it impossible to conduct quantitative analysis.

Five different meta-analyses were conducted, considering various degrees of monolithic zirconia complete arch prosthesis and subgroups for prosthesis survival. The number of studies included in each meta-analysis ranges from 5 to 13 (all studies). Prosthesis survival refers to any prosthesis that remained functional despite any complications that did not require remaking the restoration.[24]

A meta-analysis included 13 studies that assessed the proportion of prostheses in function at the last follow-up of 2841 monolithic zirconia complete arch prostheses with follow-up periods ranging from 12 to 62 months.[11–23] Using a random-effects model with the inverse variance method, the pooled proportion of prostheses remaining was estimated at 99% (95% CI: 97 to 100%). Statistically significant heterogeneity was evaluated ($P<.010$, I^2 =72%) (Fig. 2).

A total of 8 studies with 3725 dental implants were included to investigate the longevity of implants in monolithic zirconia complete arch restorations with follow-up periods ranging from 12 to 62 months.[11,14,15,17,20,22,23] The pooled proportion of implants remaining in situ was estimated at 100% (95% CI: 99 to 100%). Significant heterogeneity was observed ($P<.010$, I^2=75%) (Fig. 3).

The glossary of prosthodontic terms defines a prosthetic failure as "the inability of a prosthesis to produce the expected desired outcome."[25] To acknowledge the prosthetic failure in complete arch zirconia restorations, a total of 13 studies comprising 2841 monolithic zirconia complete arch prostheses with follow-up periods ranging from 12 to 62 months were included.[11–23] The pooled prosthetic failures proportion during the reported follow-up was estimated to be 1% (95% CI: 0 to 3%). Significant heterogeneity was detected ($P<.010$, I^2=72%) (Fig. 4).

A total of 12 studies encompassing 2685 monolithic zirconia complete arch implant-supported prostheses were included[11–18,20–23] to investigate the incidence of technical complications in monolithic zirconia prostheses (follow-up: 12 to 62 months). This analysis considered a broad range of technical complications, including chipping, screw loosening, screw fracture, debonding or fracture of the titanium cylinder, inadequate passive fit, loss of screw access filling, and fracture or wear of the opposing dentition or prosthesis. The pooled technical complication proportion was estimated to be 14% (95% CI: 4% to 27%). Substantial heterogeneity was detected ($P<.010$, I^2=96%) (Fig. 5). A total of 8 studies with about 2641 monolithic zirconia complete arch prostheses stratified according to veneering type (follow-up: 18 to 62 months) were included. The overall pooled complication rate was

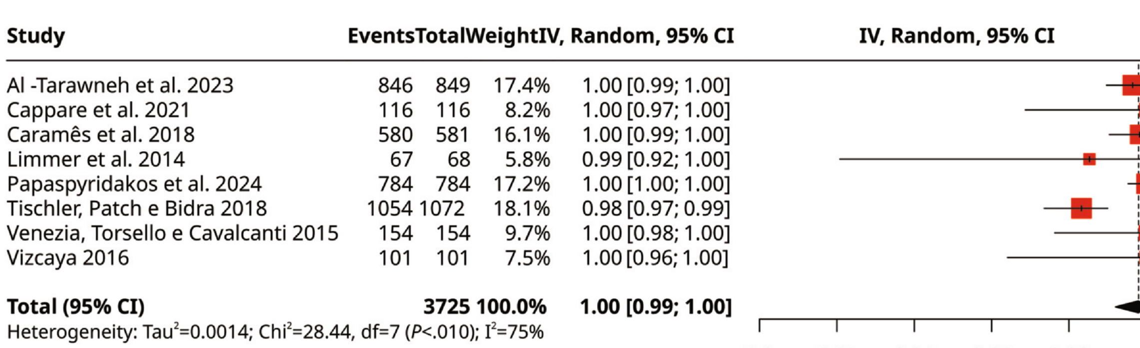

Figure 3. Meta-analysis of pooled proportion of implant survival rate in participants rehabilitated with monolithic zirconia complete arch prostheses.

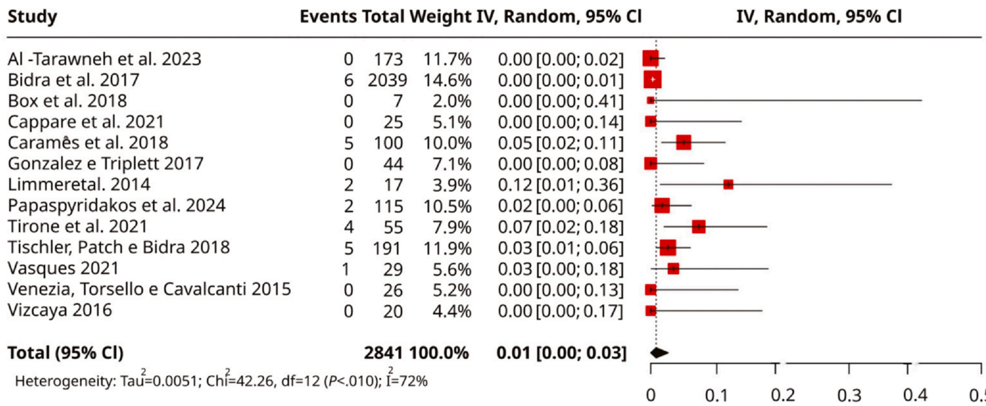

Figure 4. Meta-analysis of pooled proportion of prosthetic failures of monolithic zirconia complete arch prostheses.

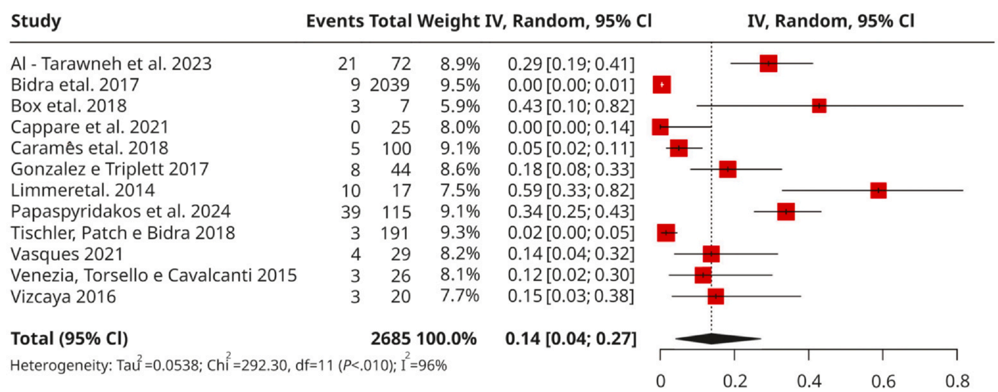

Figure 5. Meta-analysis of technical complications associated with monolithic zirconia complete arch implant-supported prostheses.

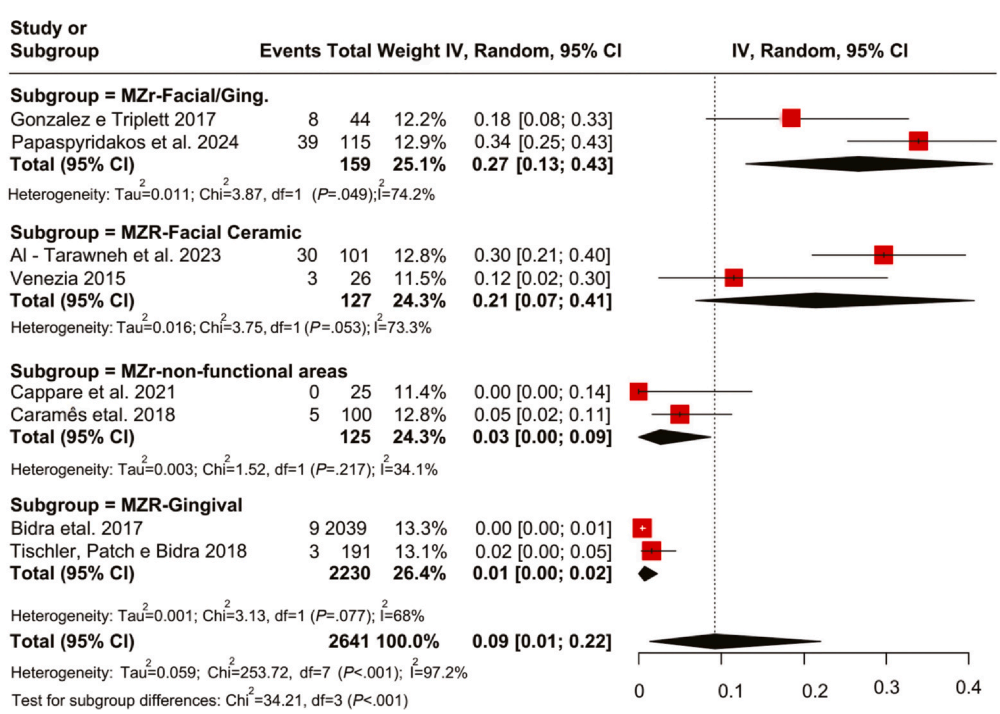

Figure 6. Meta-analysis of monolithic zirconia complete arch prostheses stratified by veneering type (pooled technical complication proportion).

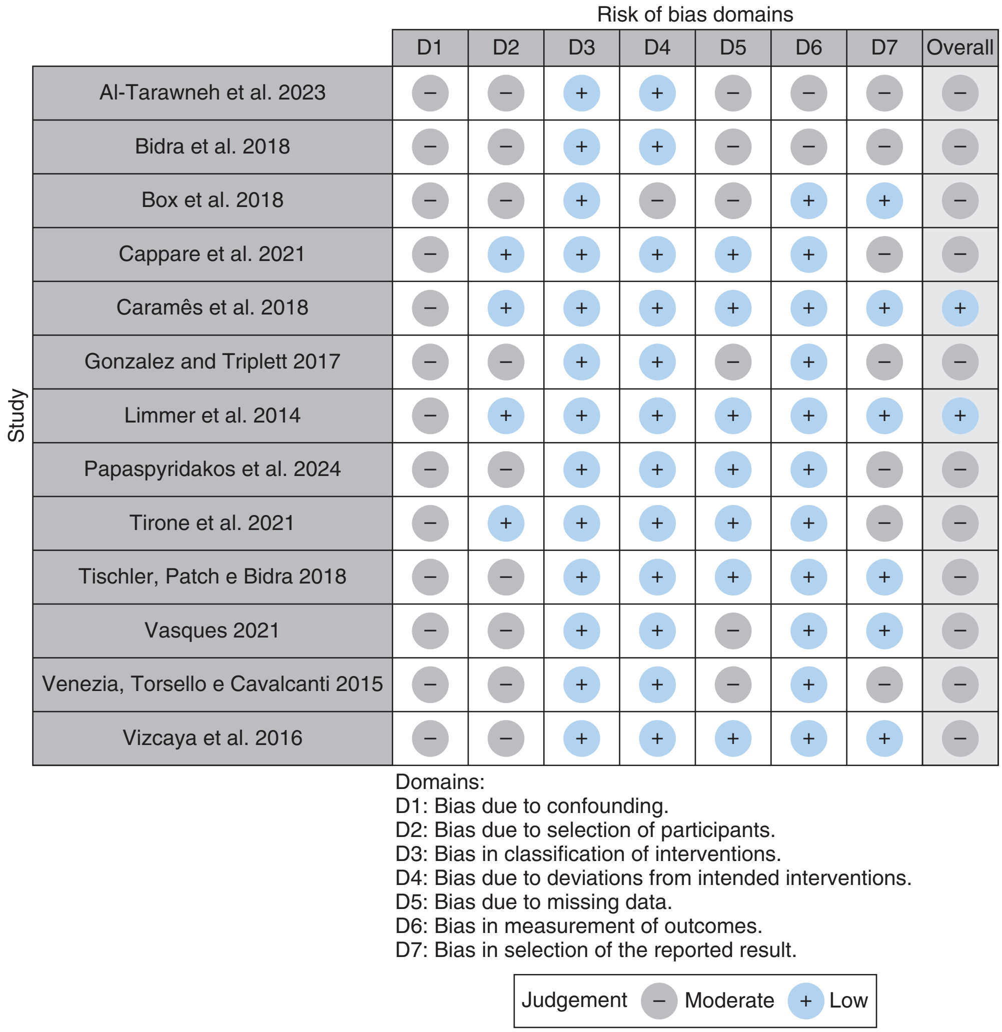

Figure 7. Risk of bias assessment of included studies using ROBINS-I tool.

estimated at 9% (95% CI: 1 to 22%). Among the subgroups, monolithic zirconia prostheses with both facial and gingival veneering exhibited the highest estimated complication rate at 27% (95% CI: 13% to 43%) and facial-only veneering at 21% (95% CI: 7% to 41%). Lower pooled technical complication proportions were observed for monolithic zirconia restorations with porcelain layering restricted to nonfunctional and esthetic areas, at 3% (95% CI: 0% to 9%) and for prostheses with gingival veneering only at 1% (95% CI: 0% to 2%). Significant heterogeneity was detected (P<.001), with an I^2 value of 97.2% (Fig. 6).

Figures 7 and 8 display the main findings for each domain assessed using the ROBINS-I tool. Most studies used a retrospective design and lacked control groups, resulting in a moderate risk of bias due to confounding,

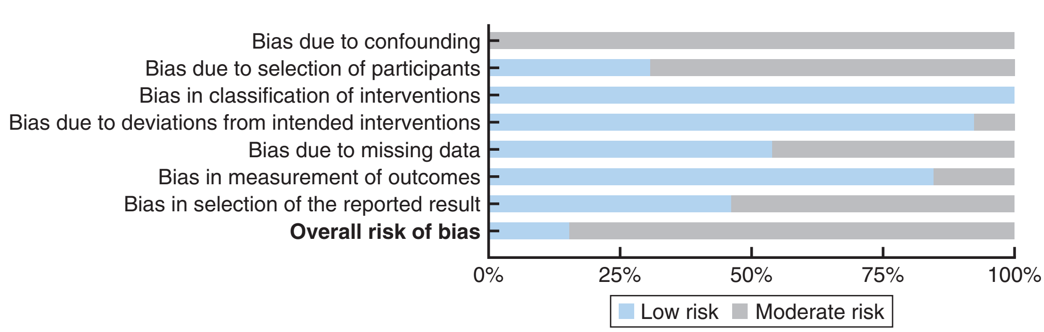

Figure 8. Summary of risk of bias assessment of included studies using the ROBINS-I tool.

Table 5. Summary of Evidence (GRADE) for monolithic zirconia complete arch implant-supported prostheses

Outcome	No. of Studies	Study Design	Units.	Effect (RR, 95% CI)	Certainty of Evidence (GRADE)
Prosthesis Survival	13	Nonrandomized	2841	0.99 (0.97–1.00)	⨁◯◯◯ Very low
Implant Longevity	8	Nonrandomized	3725	1.00 (0.99–1.00)	⨁◯◯◯ Very low
Prosthetic Failure	13	Nonrandomized	2841	0.01 (0.00–0.03)	⨁◯◯◯ Very low
Technical Complications	12	Nonrandomized	2685	0.14 (0.04–0.27)	⨁◯◯◯ Very low

particularly given the absence of statistical control for potentially relevant clinical variables.[14–23] In several studies, participant selection bias was also identified, as samples were chosen by convenience or based on available clinical records, without confirmation of consecutive inclusion or reporting of follow-up losses.[12,14,18,21] Only 2 studies reported sample size calculations,[15,19] and some had small sample sizes.[13,22] Although the classification of interventions and outcome measurements were generally adequate and well-standardized, some studies reported incomplete data or potential underreporting of adverse events, particularly when based on laboratory returns or retrospective clinical records.[12,13,18,20,22,23] Only a limited number of studies demonstrated a low overall risk of bias, typically those with a prospective design.[15,17]

The certainty of the evidence was rated as very low, primarily associated with methodological limitations in the included studies, such as the lack of randomization and proper allocation methods. The meta-analyses also revealed high heterogeneity (I^2 >40%), reflecting variability in study designs, small sample sizes, imprecise estimates, and nonoverlapping confidence intervals. Another limitation was that failure estimates were based on cumulative proportions rather than formal survival analyses. In addition, the heterogeneity in follow-up periods across studies represents an important limitation for interpreting the results, as shown in Table 5 and Supplemental Tables 1, 2 (available online).

DISCUSSION

The null hypothesis that no differences would be observed in prosthesis survival or complication rates between monolithic zirconia complete arch implant-supported prostheses and other implant-supported complete arch prosthetic designs was not rejected, as the findings of this systematic review suggested that monolithic zirconia complete arch implant-supported prostheses exhibited survival and complication rates similar to those reported for other implant-supported complete arch prostheses, within the limitations of indirect comparisons and heterogeneous study designs. The results were consistent with those of previous studies, indicating that such prostheses should be a safe option with survival rates exceeding 98%.[26] Similarly, the survival rate observed in this review was comparable with that reported for traditional prostheses, such as metal-ceramic or metal-acrylic prostheses, which showed a survival rate of 97%, as reported by Bagegni et al.[27]

The low prosthetic failure rate (1%) and moderate technical complication rate (14%) corroborated previous studies and highlighted the mechanical reliability of monolithic zirconia.[17,23] The most frequently reported technical issues included chipping of porcelain, screw loosening, and complications with the titanium cylinder. However, these complications were manageable and did not compromise the overall function or survival of the prostheses.

However, an increase in complications was reported with the use of ceramic veneers, although these have been limited to esthetic areas. Studies comparing purely monolithic prostheses with those featuring esthetic veneers showed that the monolithic prosthesis group presented significantly fewer complications (such as porcelain chipping) than the veneered prosthesis group.[12,19] In the present study, the veneering of more extensive areas (buccal and gingival) represented higher complication rates, ranging from 21% to 37%, while the veneering of remaining nonfunctional or only gingival areas presented lower rates of 3% and 1%, respectively. This finding reinforces that monolithic designs offer better structural stability.[14,16]

Some authors used the term "monolithic zirconia" even when veneering was used for esthetic purposes.[14–16,18,19,22] This inconsistency in terminology could lead to confusion when interpreting results in the clinical community, as data on complications with so-called monolithic zirconia prostheses often involved esthetic veneering, whereas the responses are purely monolithic. This observation reinforces the need for the more rigorous standardization of terminology for monolithic zirconia prostheses to avoid confusion when reporting clinical results and disseminating data. As defined in the Glossary of Prosthodontic Terms,[25] monolithic zirconia is “a full-contour zirconia without any veneering ceramic layering; it often has a thin glaze and coloring added pigments for esthetic purposes.” Two studies included patient questionnaires to assess satisfaction and oral health-related quality of life (OHQoL)[11,13] using a custom satisfaction survey and the validated 49-item Oral Health Impact Profile (OHIP-49). Both articles reported high patient satisfaction with implant-supported fixed complete dental prostheses, regardless of the specific material or design used. Notably, both studies observed that complication rates did not significantly predict patient-reported satisfaction or OHQoL, suggesting that psychosocial and functional outcomes might be more influential than purely technical performance in shaping patient perceptions.

From a clinical perspective, monolithic zirconia prostheses offered advantages not only in terms of durability but also in workflow efficiency. This highlights the importance of precise digital planning and verification throughout the CAD-CAM workflow and clinical stages of prosthesis development to ensure proper alignment and stress-free fit. In the analyzed sample, 1 prosthesis involved an inadequate passive fit leading to reconstruction.[20]

Among the included studies, denture abrasion caused by contact with monolithic zirconia surfaces was reported, raising concerns about their abrasiveness against natural teeth or other prosthetic materials.[13] Furthermore, fracture of an opposing complete denture made of acrylic resin was reported.[18] These findings highlight the need for a thorough clinical evaluation that considers the condition of opposing structures when selecting a complete arch prosthesis in monolithic zirconia.

Other aspects, such as phonetics, esthetics, and hygiene maintenance, were consistently rated as excellent in clinical reports, reinforcing the versatility of monolithic zirconia in complete arch restorations.[2] Additionally, when well polished, zirconia exhibits resistance to bacterial adhesion, making it a suitable material for long-term use in the oral environment.[2,12] Future research should focus on direct comparisons between different formulations of zirconia and on digital protocols for completely monolithic prostheses, including well-defined and patient-reported esthetic outcomes, and should ensure consistent reporting of complications and bone loss data.

Despite the promising results, several meta-analyses have revealed significant heterogeneity between studies (I^2 values ranging from 72% to 97%). This variability can be attributed to differences in sample sizes, follow-up periods, prosthesis designs, and reporting methods. Future research with well-designed randomized controlled trials would strengthen the clinical evidence in this field. The lack of standardized reporting for marginal bone loss (MBL) measurements was also identified as a methodological limitation in this review. All these factors contributed to a moderate risk of bias, as confirmed by the ROBINS-I assessment, and, consequently, lowered the overall certainty of the evidence as rated by the GRADE approach. A limitation of this review was the absence of time-to-event information in the primary studies, which prevented the use of formal survival analyses. Because the analyses relied on cumulative event counts at the end of each follow-up period, the pooled estimates presented here reflect cumulative clinical performance rather than standardized survival rates.

CONCLUSIONS

Based on the findings of this systematic review, the following conclusion was drawn:

1. Monolithic zirconia prostheses supported by dental implants were determined to be a reliable option for complete arch rehabilitation, demonstrating high cumulative proportions of prostheses remaining in function, low frequencies of technical and biological complications during the reported follow-up periods, and strong mechanical properties.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work, the authors used Grammarly (Grammarly Inc.) and ChatGPT (OpenAI) to improve grammar and formatting according to the Journal of Prosthetic Dentistry guidelines. After using these tools, the authors reviewed and edited the content as needed and assume full responsibility for the content of the published article.

APPENDIX A. SUPPORTING INFORMATION

Supplemental data associated with this article can be found in the online version at doi:10.1016/j.prosdent.2026.02.006.

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