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SYSTEMATIC REVIEW

Evaluating the clinical behavior of veneered zirconia in comparison with monolithic zirconia complete arch implant-supported prostheses: A systematic review and meta-analysis

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ABSTRACT

Statement of problem. Since the use of zirconia in dentistry is relatively new, the number of published studies on the subject is scarce, even though material selection is an important factor in clinical performance. Therefore, a systematic assessment of the impact of the prosthetic material, framework design, veneering material, and manufacturing process is required.

Purpose. The purpose of this systematic review and meta-analysis was to investigate the survival and success rates of feldspathic porcelain veneered zirconia (VZir) in comparison with monolithic zirconia (MZir) complete arch implant-supported prostheses (CAISPs). A secondary objective was to assess the influence of the type of loading, the presence or absence of a cantilever, the type of zirconia used, the location, and the opposing arch on complications rates and patient satisfaction.

Material and methods. An electronic search of the MEDLINE database (via PubMed), Scopus, Science Direct, Cochrane Library, and OpenGrey was carried out. The criteria described in the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement were used. The search was restricted from January 2000 to January 2022.

Results. The systematic search resulted in 20 articles that met the established criteria. In total, 751 patients (VZir=302; MZir=449) with 3038 CAISPs (VZir=368; MZir=2670) were analyzed. Higher prosthetic survival and success rates were found in MZir compared with VZir CAISPs (100% and 95.45%, respectively). The meta-analysis found significantly fewer complications related to MZir (9.4% [4.8%-14.1%]) compared with VZir (33.7% [17.5%-49.9%]).

Conclusions. Based on the findings of this systematic review, MZir CAISPs had higher survival and success rates than VZir CAISPs, with significantly fewer prosthetic complications. The influence of factors such as the type of functional loading, the presence of a cantilever, the material used in the prosthodontic workflow, the location of the CAISP, and the type of antagonist arch in the performance of Zir CAISPs remains unclear.

CLINICAL IMPLICATIONS

Complete arch rehabilitation with MZir CAISPs has a more predictable outcome than with VZir CAISPs and should be considered especially for patients with parafunctional habits. The use of another CAISP of the same material as in the antagonist arch is not advised to reduce prosthetic complications.

Keywords:
Monolithic zirconia; veneered zirconia; Dental Prosthesis, Implant-Supported; Dental implants; full arch.

Oral rehabilitation with dental implants in patients with edentulism or with a terminal dentition has been considered an effective treatment.[1,2] Among the materials available for a complete arch implant-supported prosthesis (CAISPs), metal-resin has classically been considered the "criterion standard." However, zirconia, typically stabilized with 3 mol% yttria,

has gained popularity in recent years because of its excellent biocompatibility, low bacterial adhesion, high flexural strength, durability, and esthetics.[3-6]

The esthetics of monolithic zirconia (MZir) can be improved by veneering with feldspathic porcelain (VZir). However, internal stresses resulting from differences in the coefficients of thermal expansion of the zirconia framework and the veneering material and their geometric structure, delamination or minor fractures of the veneering feldspathic porcelain have been reported.[7] Additionally, the zirconia framework itself may undergo chipping.[7-9] From a systematic review, Bidra et al[10] reported a low prevalence of framework fracture of the prosthesis (1.4%), but that chipping of the veneered feldspathic porcelain was as high as 14.7%.

The design of the zirconia framework has been reported to affect the incidence of chipping, making the material harder and reducing the risk of delamination.[7] According to the literature, this complication occurs more frequently in this type of restoration than in metal-ceramic restorations (50% and 11.6%, respectively, in 5-year follow-up periods).[11,12] To avoid these complications, MZir from monochromatic or multichromatic disks has been developed as an alternative. Recently introduced MZir with 5 mol% yttria has similar optical properties as some glass ceramics, although they are less resistant to fracture than 3 mol% yttria-stabilized zirconia.[7] The advantages of MZir prostheses is that the polished occlusal surface is associated with the low enamel wear in the antagonist arch,[13-15] and its computer-aided design and computer-aided manufacturing (CAD-CAM) processing is faster and less costly than metal-ceramic prostheses.[16,17]

However, the long-term survival of zirconia restorations, as well as the occurrence of complications, remains unclear. Therefore, the primary objective of this

systematic review was to compare the prosthesis survival and success of VZir CAISPs and MZir CAISPs and to evaluate the influence of different prosthetic factors on the occurrence of complications. The null hypothesis of the present study is that MZir CAISPs present higher survival and success rates compared with VZir CAISPs.

MATERIAL AND METHODS

This systematic review was structured according to the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement.[18] The protocol was registered at the international prospective register of systematic reviews (PROSPERO) under the registration number CRD42022302756. The study aimed to answer the following population, intervention, comparison, outcome (PICO question: "In patients with edentulism of one or both arches, does their rehabilitation using MZir CAISP, in comparison with rehabilitation using VZir, lead to higher survival and prosthetic success?"

CAISP survival was defined as those that remain in situ, with or without modification, throughout the follow-up period, and prosthetic success as those CAISPs that remain without complications throughout the observation period. Secondarily, the influence of different prosthetic factors on the occurrence of complications was studied, including the type of functional loading, the presence or absence of a cantilever, the material used in the prosthodontic workflow, the location of the CAISP (maxillary or mandibular), the type of antagonist arch, and the patient's satisfaction with the CAISP.

A meta-analysis was carried out to determine the success, survival, and complications variables with a software program (Stata Release 15; Stata-Corp LLC). To obtain the meta-

analysis of the survival data, the fixed effects method was used due to the homogeneity obtained between the studies through the Cochran Q statistic.

The inclusion criteria were randomized clinical trials (RCTs), controlled clinical trials (CCTs), cohort studies (prospective or retrospective), comparative studies, case series or case-control studies with a sample size with at least 10 participants. These studies had to have been conducted in humans, assessed the influence of these materials in the survival and prosthetic success of CAISPs, with at least 12 months of follow-up, and published in English. The exclusion criteria were animal studies, laboratory studies, systematic reviews and meta-analyses, case reports, studies on zirconia dental implants, studies which assessed fixed implant- and tooth-supported prostheses, books or book chapters, letters to the editor, and commentaries.

A comprehensive search of the literature between January 2000 and January 2022 was conducted in the MEDLINE (via PubMed), Science Direct, Scopus, and Cochrane Library databases. A search for nonpeer-reviewed studies was conducted on the OpenGrey database. In addition, the references of the selected articles were examined for publications that did not appear in the initial search and might have been relevant.

The search was performed by 2 independent researchers (S.M.-S., A.-O.S.-P.). Medical subject headings (MeSH) terms, keywords, and other free terms were used with Boolean operators to combine searches: (zirconia OR monolithic zirconia OR veneered zirconia) AND (implant prostheses OR implant rehabilitation OR full contour implant prostheses OR full arch OR fixed implant rehabilitation). The same keywords were used for all search platforms following the syntax rules of each database.

Two researchers (S.M.-S., A.-O.S.-P.) independently compared results to improve completeness and removed duplicates. Then, the full title and abstracts of the remaining papers were screened individually. Finally, full-text articles to be included in this systematic review were selected according to the described criteria. Disagreements were discussed with a third reviewer (N.K.), and a consensus was reached. Agreement between reviewers was measured with the Kappa coefficient. The results were also expressed as the concordance between reviewers (%). If necessary, study authors were contacted for clarification or missing information.

The quality and risk for bias of the included studies were assessed by the authors (S.M.-S., J.-F.P.-C.). A 9-question checklist developed by Kwon et al[19] was completed for each study. Any disagreement between the examiners was resolved by discussion until an agreement was reached.

RESULTS

The search strategy resulted in 4936 results, of which 4166 remained after removing duplicates. After the titles and abstracts had been reviewed, 4132 papers outside the scope of the review were excluded. After reading the full text of the 34 remaining papers, 14 were discarded because they were case reports (n=6),[20-25] in vitro studies (n=2),[26,27] included partial implant-supported prostheses (n=3),[28-30] metal-acrylic CASIP (n=1),[31] full and partial zirconia implant-supported prostheses without specifying the survival rates of each group (n=1),[32] and had a sample size of fewer than 10 (n=1).[33] Therefore, 20 studies[2,3,6,34-50] were included in this systematic review (Fig. 1).

A 90.8% concordance was found between the 2 authors, with a Kappa coefficient of 0.600 (SE 0.09, 95%CI [0.419, 0.781]) for titles and abstracts and a 95% concordance with a Kappa coefficient of 0.898 (SE 0.099, 95%CI [0.703, 1.093]) for full-text articles. The concordance strength was "good" for titles and abstracts and "very good" for full-text articles.

All included studies were observational, 4 prospective[35,40,46,48] and 16 retrospective,[2,3,6,34,36-39,41-45,47,49,50] published between 2012 and 2021. The locations of the studies were university (n=8),[3,6,36,38,41,46-48] private practice (n=10),[34,35,37,39,40,42,43,45,49,50] a prosthetic laboratory with follow-up by clinicians at a private practice,[2] and a multicenter study.[43]

Quantitative data were extracted and analyzed by classifying the studies into 2 groups: VZir CAISP (n=8),[6,39-42,47-50] and MZir CAISP group, which includes monolithic zirconia with different variables: completely monolithic, with porcelain veneering in the gingival area, or extending to labial areas of anterior teeth but not to functional areas (as occlusal or incisal surfaces) (n=9 studies).[2,3,37,38,43-46,49] Three studies[34-36] compared both types of CAISPs, so data were separated for each group.

A total of 751 participants were included in total (VZir=302; MZir=449). In 2 studies,[2,36] the number of participants could not be determined. A total of 3037 CAISPs were analyzed (VZir=368; MZir=2670). Most were screw-retained (n=2831), with only 12 cement-retained. All CAISPs were supported by between 3 and 15 dental implants in the MZir group and 4 and 10 in the VZir group. The follow-up periods were heterogeneous, ranging from 0.1 to 13 years (mean=10 years) (Tables 1, 2).

The data for prosthesis survival were analyzed in a heterogeneous way in the different studies. In the MZir group, the overall survival rate ranged from 88% (n=27 CAISPs) to 100% (n=170 CAISPs).[3,36,38,43-45,49] Information about follow-up periods is described in Table 2.

In the VZir group, the authors referred to the survival rate in different ways. The overall survival rate was described as between 66.7% (n=6 CAISPs)[36] and 100% (n=119 CAISPs).[6,34,41,47-48] One author did not report sufficient data to extrapolate overall survival but describes a cumulative survival rate at 10 years of 87% (n=15 CAISPs).[40] Information about follow-up is described in Table 1.

In the MZir group, the overall prosthetic success ranged between 29.4% (n=17 CAISPs)[46] and 100% (n=25 CAISPs).[45] Three authors did not analyze this parameter (n=2199 CAISPs).[2,34,36]

In the VZir group, overall success ranged between 20% (n=10 CAISPs)[48] and 88.5% (n=26 CAISPs).[47] One study, which only specified prosthetic success based on the follow-up period, showed a rate of 29% at 10 years (n=15 CAISPs).[40] Four studies did not specify success rate (n=59 CAISP).[34,36,40,50]

The prosthetic complication rates were analyzed, as well as those factors that may have influenced their occurrence. Minor complications were considered to be those that could have been resolved chairside, such as minor chipping, corrected by polishing, loosening or fracture of prosthetic screws, debonding of abutments, and loss of the access channel restoration. Major complications required correction by a dental laboratory technician and might require remaking the prosthesis. These included major chipping and framework fracture.

In the VZir group, there were 30 major (8.2%) and 78 minor (21.2) complications out of a total of 368 CAISPs. Specifically, chipping was observed in 26.1% (n=96 of 368 CAISPs). These data were not provided in 2 studies[34,40] (Table 3).

In the MZir group, 25 major (1.0%) and 49 minor (1.8%) complications occurred out of a total of 2670 CAISPs. Chipping affected 27 of 2560 CAISPs (1.1%). These data should be considered with caution, as minor complications were not recorded in 2 studies. One with a sample of 2039 CAISPs[2] reported only major complications, and one with 153 CAISPs[34] only reported framework fracture associated with cantilever length (Table 4).

When analyzing the data globally, complications were more frequent in the VZir group (29.3%) than in the MZir group (2.8%), even though the MZir group had a much larger sample size (368 compared with 2670 CAISPs). An almost 3-fold higher risk of porcelain delamination was found in VZir CAISPs.

Regarding immediate or delayed loading, in the VZir group, immediate loading with the placement of an acrylic resin interim prosthesis was performed in 81.8% of the prostheses (n=301of 368 CAISPs), while delayed loading was performed in 3.3% (n=12 of 368 CAISPs). Three articles did not provide or did not specify these data (14.9%; n=55 of 368 CAISPs).[34,36,50]

In the MZir group, 2 authors performed immediate loading with interim prostheses,[35,44] 1 performed delayed loading,[3] and 3 performed both types of loading.[37,46,49] In summary, 7.53% performed immediate loading (n=201 of 2670 CAISPs), and 5.84% performed delayed loading (n=156 of 2670 CAISPs). Six articles did not provide or did not specify these data (86.63%; n=2313 CAISPs).[2,34,36,38,43,45]

Concerning cantilever, in the VZir group, 70.38% of the CAISPs had cantilevers (n=259 of 368 CAISPs), and 26.90% did not (n=99 of 3688 CAISPs).[2,6,34-36,39,41,47,50] One author did not provide these data (2.72%; n=10 of 368 CAISPs).[48] Regarding cantilever length, 3 studies reported the measurement of the cantilevers used (≤10.7 mm).[36,41,47]

In the MZir group, 17.15% of the CAISPs had a cantilever (n=458 of 2670 CAISPs), while 2.96% did not (n=79 of 2670 CAISPs).[34-37,44,46,49] Four authors did not report it (79.89%; n=2133 of 2670 CAISPs).[2,3,38,45] In this group, only 3 studies reported cantilever length: 7.2 mm in the maxilla and 13.2 in the mandible in one of the studies,[43] 10.7 mm in another study,[36] and ≤12 mm in another,[37] without the location in the arch being specified in any.[36,37,43]

Regarding the prosthetic material and prosthetic workflow, even though the acquisition and design processes were heterogeneous, they followed a similar process that consisted of making the definitive casts from conventional impressions with the open tray technique and splinting the impression transfers, making records (vertical dimension, prosthetic volume, esthetic tests, and occlusion) using different techniques, digitizing the casts, CAD, milling the frameworks, sintering, ceramic application (when applicable), and firing. Most studies[3,6,38-40,44,48-50] used polyether and, to a lesser extent, polyvinyl siloxane[34,35,41,42,45,47] as impression materials. The remaining studies[2,36,37,43,46] did not specify.

Regarding the commercial system used as the framework for zirconia prostheses, 9 studies used Zirconia Prettau; Zirkonzahn,[2,3,35,37,38,42,43,45,46] 4 Procera; Nobel Biocare and,[6,41,47,50] less popular, Sagemax Zr; Sagemax Bioceramics (n=1),[44] Zirite; Keramo (n=2),[39,40] Cercom; Degudent (n=1),[48] and Oral Iceberg; Ceracrown (n=1).[49] One of the studies[34] used 3 different systems: fully veneered with feldspathic ceramic (Procera; Nobel Biocare), only veneered in the

vestibular region (ICE Zircon Ceramics; Zirkonzahn), and monolithic with ceramic only at the gingival level (Amann Girrbach; Vorarberg). One study[36] did not specify the material used.

The location of the CAISP (maxillary or mandibular) and type of antagonist arch were analyzed. In the MZir group 9.74% of the CAISPs were maxillary (n=260 of 2670 CAISPs), and 7.23% were mandibular (n=193 of 2670 CAISPs). These data could not be extracted from 83.03% of the MZir CAISPs (n=2217 CAISPs).[2,34,45] In the VZir group, 47.3% were maxillary (n=174 of 368 CAISPs), and 28.3% were mandibular (n=104 of 368 CAISPs). These data could not be extracted from 24.2% of the CAISPs (n=90 CAISPs).[34,39,40]

Two studies analyzed the occurrence of complications in zirconia arches concerning the type of antagonist arch. One[35] stated that, in the VZir group, the occurrence of complications was more frequent when the antagonist arch was another VZir CAISP and that no complications were found in this group when the antagonist arch was an MZir CAISP or natural dentition. In the MZir group, complications were observed when the antagonist arch was of the same material (15.9%), but not when it was the natural dentition, VZir CAISP, mixed dentition tooth-dental implants, or metal-acrylic resin CAISP. The second study[38] showed that maxillary zirconia CAISPs with zirconia opposites and those with antagonist natural dentition have the same probability of complications.

Patient satisfaction with the prosthetic material was only analyzed in 5 of the 20 studies. It is difficult to conclude from the results found because of the heterogeneity of the different scales used. Two of them used a visual analog scale (VAS), which ranged

from "0"-minimum satisfaction to "100"-maximum satisfaction. The first[47] reported that all patients were satisfied with the esthetics and function of the VZir CAISP, with a score of 98.10±2.99 and 99.2±2.10, respectively. The second study[41] similarly reflected that all patients were esthetically and functionally satisfied with their VZir CAISP, with a mean score of 99.50 ±2.20. Another study[36] analyzed patient satisfaction with both types of materials using the Oral Health-Related Quality-of-Life (OHQoL) measure, consisting of 16 questions and considering both the effect and impact of oral health on life quality The measure incorporated dimensions and an individualized weighting system, with a score of "7" for the MZir prosthesis and "29" for the VZir prosthesis. Other authors[46] used the Oral Health Impact Profile (OHIP) questionnaire, a 49-item questionnaire with scores ranging from "0" meaning no impact of oral health on quality of life to "196" points, equivalent to a very negative impact. The MZir CAISP obtained a mean score of 16.3 on this questionnaire. One author[48] used a nonstandardized questionnaire with values from 0 to 10, obtaining scores of 10 (n=7 patients), 9 (n=1 patient), and 8 (n=1 patient). An Odds Ratio study could not be carried out to study the probability effect in each group (success or survival or complications).

Regarding success, a rate of 68.2% (95% confidence interval [CI]=52.3-84.1%) was found in the VZir group and a rate of 87.6% (95%CI=79.9-95.3%) in the MZir group, without significant differences between each other (Fig. 2). In addition, no significative differences were found between the groups when survival rates were assessed, VZir=95.5% [95%CI=91.1-99.8%)] (Fig. 3); MZir=99.6% [95%CI=99.4-99.9%] (Fig. 4)). Significantly higher complication rates were found in VZir CAISP (33.7% [95%CI=17.5-49.9%]) compared with MZir CAISP (9.4% [95%CI=4.8-14.1%]) (Fig. 5).

Based on the strength of evidence[51] all the included studies were classified as "fair" or "average." Assessments of quality and risk bias for the included studies are shown in Table 5.

DISCUSSION

The hypothesis that survival and success rates were higher in MZir CAISP than in VZir CAISP and that lower prosthetic complications were present in MZir CAISP compared with VZir CAISP was confirmed. This study was based on the clinical results of MZir CAISPs compared with their VZir counterparts. In the absence of a precise and agreed definition of what is considered a conventional VZir or MZir CAISP, the authors have considered VZir CAISPs as those milled at a reduced thickness and completely covered by feldspathic porcelain and MZir CAISPs as those milled in 1 piece, even if they present a partial cut-back in nonfunctional esthetic areas, as long as the veneering porcelain did not extend to occlusal areas or incisal edges. Thus, 2 major groups were created, VZir and MZir. A recent systematic review[52] made a distinction between MZir and VZir CAISP, but without separating the data by groups, and considered VZir CAISP as all those with feldspathic porcelain, even if only in esthetic regions. Following this scheme, only MZir prostheses belonging to one study[46] are considered as MZir CAISPs, since a great difference in the behavior of the restorations was found when they had porcelain veneers in functional areas and when they did not.[10]

The hypothesis that higher survival and prosthetic success rates in MZir CAISPs, as well as significantly lower prosthetic complication rates compared with VZir CAISPs was accepted. A precise comparison between the different studies was difficult, but overall survival rates of 88% to 100% were observed in the MZir group compared with

66.7% to 100% in the VZir group. The influence of various factors on the risk of prosthetic complications was evaluated with the most frequent complication being chipping of the veneering ceramic, which occurred almost 3 times more frequently in fully VZir CAISPs than in partially or fully MZir CAISPs, even though the sample of the latter was much larger, with a total of 77 chipped prostheses (20.9%) in VZir CAISPs and 27 (1.0%) in the MZir CAISPs. Bidra et al[2] specified that complications in partially MZir prostheses could be minimized by using high quality zirconia, with careful adherence to laboratory protocols: slow heating and cooling of the material can provide a minimum prosthetic gap of 12 mm to give adequate support and strength to the zirconia, using titanium cylinders from the same manufacturer can create a metal-to-metal interface on the abutments of the dental implants, providing a milled acrylic resin prototype, where possible, to allow for adjustments in occlusion and esthetics before fabrication of the definitive zirconia prosthesis, and quality should be controlled at each stage of fabrication. In another study,[37] the importance of providing a minimum prosthetic space of 11 to 12 mm to give the zirconia prosthesis adequate strength was highlighted. If this space is insufficient, an osteotomy of the alveolar ridge would be required to achieve it. Despite the heterogeneity of the analysis of these data in the different studies, the survival rate in the short term was high. However, the success of a CAISP that remains in the mouth free of complications decreases in the long term and especially in the VZir group.

In addition to the material, many factors could affect the success and survival of a CAISP, such as the type of implants, their length and diameter, the presence or not of an intermediate abutment, the location of the implants in the arch, whether bone regeneration procedures have been carried out, the type of loading (immediate or delayed), the number of implants per CAISP, the presence or not of a cantilever, the design of the framework and how it

was manufactured, the type of antagonist arch, and the use or not of an occlusal splint.[53-55] In the present review, these parameters were evaluated, specifically, the type of loading, the presence or absence of a cantilever, the material used in the CAISP, the location in the arch, and the type of antagonist arch.

Concerning the antagonist arch, Cârames et al[35] stated that whether the CAISPs were MZir or VZir, the occurrence of complications was greater when the opposing arch was another CAISP of the same material. Gonzalez and Triplett[38] reported that maxillary zirconia CAISP with opposing zirconia and those patients with antagonistic natural dentition had a similar complication probability.

An association between parafunctional habits (bruxism) and the development of complications has been suggested, although several of the articles included did not consider this factor.[3,34-38,42-46] In the VZir group, Papaspyridakos et al[6] reported a relationship with the development of chipping between the presence of parafunction, the presence of another CAISP in the antagonist arch, and the absence of an occlusal splint. Tartaglia et al[39,40] suggested that parafunctional habits were relevant when considering prosthetic rehabilitation but did not record these data in the diagnostic phase, leaving the choice of CAISP material to the clinician. Also, in their study with a longer follow-up,[40] they reported 14 mechanical complications between the sixth and tenth year of follow-up in a patient with bruxism. Another study[50] also related major complications to bruxism.

Limitations of the present systematic review included the difficulty of obtaining studies that evaluate the behavior of these types of complete arch rehabilitations in the long term and with reliable evidence to support such treatment options. For these reasons, the external validity of the results obtained in the present study needs to be confirmed in

future studies. Although the terms prosthetic success and survival have been often used in dental implant studies,[56,57] precise definitions for these terms are lacking. The authors defined these concepts by modifying those provided by different authors, with all authors agreeing on this definition.

Future research should enroll larger samples with long-term follow-ups. Standardized criteria should be incorporated in the design of the studies to facilitate comparison.

CONCLUSIONS

Based on the findings of this systematic review, the following conclusions were drawn:

1. MZir CAISPs and VZir CAISPs had statistically similar survival and success rates.
2. MZir CAISPs showed fewer complications than VZir CAISPs (33.7% and 9.4%, respectively).
3. The influence of different factors such as the type of functional loading, the presence or absence of a cantilever, the material used, the location of the CAISP, and the type of antagonist arch in the performance of zirconia CAISP remains controversial.
4. All these factors create the need for more long-term studies with reliable evidence to achieve a better understanding of the behavior of the zirconia CAISP.

REFERENCES

1. Astrand P, Ahlqvist J, Gunne J, Nilson H. Implant treatment of patients with edentulous jaws: a 20-year follow-up. Clin Implant Dent Relat Res 2008;10:207–17.

2. Bidra AS, Tischler M, Patch C. Survival of 2039 complete arch fixed implant-supported zirconia prostheses: A retrospective study. J Prosthet Dent 2018;119:220–24.

3. Carames J, Suinaga LT, Yu YCP, Pérez A, Kang M. Clinical advantages and limitations of monolithic zirconia restorations full arch implant supported reconstruction: Case series. Int J Dent 2015;2015:392496.

4. Guess PC, Att W, Strub JR. Zirconia in fixed implant prosthodontics. Clin Implant Dent Relat Res 2012;14:633–45.

5. Heintze SD, Rousson V. Survival of zirconia- and metal-supported fixed dental prostheses: a systematic review. Int J Prosthodont 2010;23:493–502.

6. Papaspyridakos P, Lal K. Computer-assisted design/computer-assisted manufacturing zirconia implant fixed complete prostheses: clinical results and technical complications up to 4 years of function. Clin Oral Implants Res 2013;24:659–65.

7. Stawarczyk B, Keul C, Eichberger M, Figge D, Edelhoff D, Lümkemann N. Three generations of zirconia: From veneered to monolithic. Part I. Quintessence Int 2017;48:369–80.

8. Sailer I, Balmer M, Hüsler J, Hämmerle CHF, Känel S, Thoma DS. Comparison of fixed dental prostheses with zirconia and metal frameworks: Five-year results of a randomized controlled clinical trial. Int J Prosthodont 2017;30:426–8.

9. Nicolaisen MH, Bahrami G, Schropp L, Isidor F. Comparison of metal-ceramic and all-ceramic three-unit posterior fixed dental prostheses: A 3-year randomized clinical trial. Int J Prosthodont 2016;29:259–64.

10. Bidra AS, Rungruanganunt P, Gauthier M. Clinical outcomes of full arch fixed implant-supported zirconia prostheses: A systematic review. Eur J Oral Implantol 2017;10:35–5.

11. Sailer I, Pjetursson BE, Zwahlen M, Hämmerle CHF. A systematic review of the survival and complication rates of all-ceramic and metal-ceramic reconstructions after an observation period of at least 3 years. Part II: Fixed dental prostheses. Clin Oral Implants Res 2007;18:86–96.

12. Sailer I, Strasding M, Valente NA, Zwahlen M, Liu S, Pjetursson BE. A systematic review of the survival and complication rates of zirconia-ceramic and metal-ceramic multiple-unit fixed dental prostheses. Clin Oral Implants Res 2018;29:184–98.

13. Cardelli P, Manobianco FP, Serafini N, Murmura G, Beuer F. Full-arch, implant-supported monolithic zirconia rehabilitations: pilot clinical evaluation of wear against natural or composite teeth. J Prosthodont 2016;25;8:629–33.

14. Gou M, Chen H, Kang J, Wang H. Antagonist enamel wear of tooth-supported monolithic zirconia posterior crowns in vivo: A systematic review. J Prosthet Dent 2019;121:598–603.

15. Mörmann WH, Stawarczyk B, Ender A, Sener B, Attin T, Mehl A. Wear characteristics of current aesthetic dental restorative CAD/CAM materials: Two-body wear, gloss retention, roughness and Martens hardness. J Mech Behav Biomed Mater 2013;20:113–25.

16. Benic GI, Mühlemann S, Fehmer V, Hämmerle CHF, Sailer I. Randomized controlled within-subject evaluation of digital and conventional workflows for the fabrication of lithium disilicate single crowns. Part I: Digital versus conventional unilateral impressions. J Prosthet Dent 2016;116:777–82.

17. Joda T, Zarone F, Ferrari M. The complete digital workflow in fixed prosthodontics: A systematic review. BMC Oral Health 2017;17;124:1–9.

18. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Reprint-preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Phys Ther 2009;89:873–80.

19. Kwon T, Bain PA, Levin L. Systematic review of short- (5-10 years) and long-term (10 years or more) survival and success of full-arch fixed dental hybrid prostheses and supporting implants. J Dent 2014;42:1228–41.

20. Altarawneh S, Limmer B, Reside GJ, Cooper L. Dual jaw treatment of edentulism using implant-supported monolithic zirconia fixed prostheses. J Esthet Restor Dent 2015;27:63–70.

21. Cheng CW, Chien CH, Chen CJ, Papaspyridakos P. Complete-mouth implant rehabilitation with modified monolithic zirconia implant-supported fixed dental prostheses and an immediate-loading protocol: A clinical report. J Prosthet Dent 2013;109:347–52.

22. Mehra M, Vahidi F. Complete mouth implant rehabilitation with a zirconia ceramic system: A clinical report. J Prosthet Dent 2014;112:1–4.

23. Papaspyridakos P, Chochlidakis K, Kang K, Chen YW, Alghfeli A, Kudara Y, et al. Digital workflow for implant rehabilitation with double full-arch monolithic zirconia prostheses. J Prosthodont 2020;29:460–5.

24. Rojas-Vizcaya F. Full zirconia fixed detachable implant-retained restorations manufactured from monolithic zirconia: clinical report after two years in service. J Prosthodont 2011;20:570–6.

25. Thalji GN, Cooper LF. Implant-supported fixed dental rehabilitation with monolithic zirconia: a clinical case report. J Esthet Restor Dent 2014;26:88–96.

26. Durkan R, Oyar P, Deste G. Effects of cantilever length and implant inclination on the stress distribution of mandibular prosthetic restorations constructed from monolithic zirconia ceramic. Int J Oral Maxillofac Implants 2020;35:121–9.

27. Shetty R, Singh I, Sumayli HA, Jafer MA, Abdul-Feroz SM, Bhandi S, et al. Effect of prosthetic framework material, cantilever length and opposing arch on peri-implant strain in an all-on-four implant prostheses. Niger J Clin Pract 2021;24:866–73.

28. Esquivel-Upshaw JF, Mecholsky JJ Jr, Clark AE, Jenkins R, Hsu SM, Neal D, et al. Factors influencing the survival of implant-supported ceramic-ceramic prostheses: A randomized, controlled clinical trial. J Dent 2020;103S:100017.

29. Gintaute A, Weber K, Zitzmann NU, Brägger U, Ferrari M, Joda T. A double-blind crossover RCT analyzing technical and clinical performance of monolithic ZrO_2 implant fixed dental prostheses (iFDP) in three different digital workflows. J Clin Med 2021;10:2661.

30. Larsson C, Vult von Steyern P. Ten-year follow-up of implant-supported all-ceramic fixed dental prostheses: A randomized, prospective clinical trial. Int J Prosthodont 2016;29:31–4.

31. Chrcanovic BR, Kisch J, Larsson C. Retrospective evaluation of implant-supported full-arch fixed dental prostheses after a mean follow-up of 10 years. Clin Oral Implants Res 2020;31:634–45.

32. Pozzi A, Arcuri L, Fabbri G, Singer G, Londono J. Long-term survival and success of zirconia screw-retained implant-supported prostheses for up to 12 years: A retrospective multicenter study. J Prosthet Dent 2023;129:96–108.

33. Diéguez-Pereira M, Chávarri-Prado D, Estrada-Martínez A, Pérez-Pevida E, Brizuela-Velasco A. Monolithic and minimally veneered zirconia complications as implant-supported restorative material: a retrospective clinical study up to 5 years. Biomed Res Int 2020;2020:8821068.

34. Tirone F, Salzano S, Rolando E, Pozzatti L, Rodi D. Framework fracture of zirconia supported full arch implant rehabilitation: a retrospective evaluation of cantilever length and

distal cross-sectional connection area in 140 patients over an up-to-7-year follow-up period. J Prosthodont 2022;31:121–9.

35. Caramês J, Marques D, Malta Barbosa J. Full-arch implant-supported rehabilitations: A prospective study comparing porcelain-veneered zirconia frameworks to monolithic zirconia. Clin Oral Implants Res 2019;30:68–78.

36. Box VH, Sukotjo C, Knoernschild KL, Campbell SD, Afshari FS. Patient-reported and clinical outcomes of implant-supported fixed complete dental prostheses: A comparison of metal-acrylic, milled zirconia, and retrievable crown prostheses. J Oral Implantol 2018; 44:51–61.

37. Tischler M, Patch C, Bidra AS. Rehabilitation of edentulous jaws with zirconia complete-arch fixed implant-supported prostheses: An up to 4-year retrospective clinical study. J Prosthet Dent 2018;120:204–9.

38. Gonzalez J, Triplett RG. Complications and clinical considerations of the implant-retained zirconia complete-arch prosthesis with various opposing dentitions. Int J Oral Maxillofac Implants 2017;32:864–9.

39. Tartaglia GM, Maiorana C, Gallo M, Codari M, Sforza C. Implant-supported immediately loaded full-arch rehabilitations: Comparison of resin and zirconia clinical outcomes in a 5-year retrospective follow-up study. Implant Dent 2016;25:74–82.

40. Tartaglia GM, Farronato M, Sforza C, Bidra AS. Implant-supported immediately loaded complete arch rehabilitations with a mean follow-up of 10 years: A prospective clinical study. J Prosthodont 2019;28:951–7.

41. Sannino G, Barlattani A. Straight versus angulated abutments on tilted implants in immediate fixed rehabilitation of the edentulous mandible: A 3-year retrospective comparative study. Int J Prosthodont 2016;29:219–26.

42. Caramês JMM, Sola Pereira da Mata AD, da Silva Marques DN, de Oliveira Francisco HC. Ceramic-veneered zirconia frameworks in full-arch implant rehabilitations: A 6-month to 5-year retrospective cohort study. Int J Oral Maxillofac Implants 2016;31:1407–14.

43. Rojas Vizcaya F. Retrospective 2- to 7-year follow-up study of 20 double full-arch implant-supported monolithic zirconia fixed prostheses: measurements and recommendations for optimal design. J Prosthodont 2018;27:501–8.

44. Venezia P, Torsello F, Cavalcanti R, D´Amato S. Retrospective analysis of 26 complete-arch implant-supported monolithic zirconia prostheses with feldspathic porcelain veneering limited to the facial surface. J Prosthet Dent 2015;11:506–12.

45. Moscovitch M. Consecutive case series of monolithic and minimally veneered zirconia restorations on teeth and implants: Up to 68 months. Int J Periodontics Restorative Dent 2015;35:315–23.

46. Limmer B, Sanders AE, Reside G, Cooper LF. Complications and patient-centered outcomes with an implant-supported monolithic zirconia fixed dental prosthesis: 1-year results. J Prosthodont 2014;23:267–75.

47. Pozzi A, Holst S, Fabbri G, Tallarico M. Clinical reliability of CAD/CAM cross-arch zirconia bridges on immediately loaded implants placed with computer-assisted/template-guided surgery: A retrospective study with a follow-up between 3 and 5 years. Clin Implant Dent Relat Res 2015;17:e86–96.

48. Larsson C, Vult von Steyern P. Implant-supported full-arch zirconia-based mandibular fixed dental prostheses. Eight-year results from a clinical pilot study. Acta Odontol Scand 2013;71:1118–22.

49. Oliva J, Oliva X, Oliva JD. All-on-three delayed implant loading concept for the completely edentulous maxilla and mandible: A retrospective 5-year follow-up study. Int J Oral Maxillofac Implants 2012;27:1584–92.

50. Worni A, Kolgeci L, Rentsch-Kollar A, Katsoulis J, Mericske-Stern R. Zirconia-based screw-retained prostheses supported by implants: A retrospective study on technical complications and failures. Clin Implant Dent Relat Res 2015;17:1073–81.

51. Proskin HM, Jeffcoat RL, Catlin A, Campbell J, Jeffcoat MK. A meta-analytic approach to determine the state of the science on implant dentistry. Int J Oral Maxillofac Implants 2007;22:11–8.

52. Abdulmajeed AA, Lim KG, Närhi TO, Cooper LF. Complete-arch implant-supported monolithic zirconia fixed dental prostheses: A systematic review. J Prosthet Dent 2016;115:672–7.e1.

53. Pjetursson BE, Brägger U, Lang NP, Zwahlen M. Comparison of survival and complication rates of tooth-supported fixed dental prostheses (FDPs) and implant-supported FDPs and single crowns (SCs). Clin Oral Implants Res 2007;18:97–113.

54. Vehemente VA, Chuang SK, Daher S, Muftu A, Dodson TB. Risk factors affecting dental implant survival. J Oral Implantol 2002;28:74–81.

55. Teichmann M, Göckler F, Weber V, Yildirim M, Wolfart S, Edelhoff D. Ten-year survival and complication rates of lithium-disilicate (Empress 2) tooth-supported crowns, implant-supported crowns, and fixed dental prostheses. J Dent 2017; 56:65–77.

56. Smith DE, Zarb GA. Criteria for success of osseointegrated endosseous implants. J Prosthet Dent 1989;62:567–72.

57. Albrektsson T, Brånemark PI, Hansson HA, Lindström J. Osseointegrated titanium implants. Requirements for ensuring a long-lasting, direct bone-to-implant anchorage in man. Acta Orthop Scand 1981;52:155–70.

CRediT authorship contribution statement

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TABLES

Table 1. Results of included observational studies for VZir group

Author(s) / Year	**Tirone et al[34] (2022)**	**Cârames et al[35] (2019)**	**Tartaglia et al[40] (2019)**	**Box et al[36] (2018)**	**Cârames et al[42] (2016)**	**Tartaglia et al[39] (2016)**	**Sanino and Barlattani[41] (2016)**	**Worni et al[50] (2014)**	**Pozzi et al[47] (2013)**	**Larsson and von Steyern[48] (2013)**	**Papaspyridakos and Lal[6] (2012)**
Type of study	Retrospective	Prospective	Retrospective	Retrospective	Retrospective	Retrospective	Retrospective	Retrospective	Retrospective	Retrospective	Retrospective
Follow-up (years)	1–7.3	1.70±0.50	8–13	0.10–5.80	0.50–5	0.16–5	3	2–7	3–5	8	2–4
Sample size	21	77	UNS	UNS	75	32	40	11	22	10	14

(patients)											
Age (years)	63.01	UNS	65	62.50	59.62	62.70–66.50	56.50	59.10±11.70	68.30	52–76	58
No. DIs	UNS	428	UNS	UNS	528	UNS	UNS	UNS	170	36	103
No. DIs per prosthesis	4–6	4–8	4–6	UNS	4–10	4–6	4	UNS	4–10	4	5–8
No. CAISP/ Retention System	27/UNS	77/SR	15/SR	6/UNS	92/SR	48/SR	40/SR	11/SR	26/SR	10/CR	16/ SR
Material of the CAISP	Structure[3]/Coating: UNS	Structure[1]/Coating[2]	Structure: UNS/ Coating[5]	UNS	Structure[1]/Coating[2]	Structure[4]/Coating: UNS	Structure[3]/Coating[6]	Structure[3]/Coating: UNS	Structure[3]/Coating[6]	Structure[7]/Coating[8]	Structure[3]/Coating: UNS.
Type of loading	UNS	Delayed	Immediate interim prosthesis	UNS	Immediate interim prosthesis	Immediate interim prosthesis	Immediate interim prosthesis	UNS	Immediate interim prosthesis	Delayed	Delayed (11); immediate interim prosthesis (3)
Arch (Mx/ Mnd)	UNS	69/8	UNS	3/3	73/19	UNS	0/40	11/0	12/14	0/10	6/10
Opposite arch	UNS	Natural dentition (7); VZir (12), MZir (1); MC (27); mixed (30)	UNS	CAISP, natural dentition or RCD	Natural dentition (9); VZir (31); MA (25); mixed (23); MC (3); ZirA (1)	Zir (32)	UNS	UNS	MC or VZir (14); RPD (2); natural dentition (9); MA (1)	MC (9); RPD (1)	CAISP of VZir or MC (9); RPD (2); overdenture (1); RCD (2)
Cantilever (No. CAISPs) / length	Yes (27) /UNS	Yes (35)/UNS	UNS/ UNS	Yes (6)/10.70 mm	Yes (57)/UNS	Yes (48)/UNS	Yes (40)/≤10 mm	Yes (11)/UNS	Yes (7)/<10 mm	UNS/UNS	Yes (13)/UNS
Prosthetic survival	100%	93.50%	UNS/ 87%-10 years	66.67 %	80.43%	95.8%	100%	81.8%	100%	100%	100%

Prosthetic success	UNS	87.01%	UNS/ 29%-10 years	UNS	50%	60.41%	90%	UNS	88.5%	20%	68.75%
Patient Satisfaction	UNS	UNS	VAS= 99.5± 2.2	OHQoL=29	UNS	UNS	UNS	UNS	VAS=99.2±2.1 for function, and 98.1±2.9 for esthetics	Questionnaire from 0 (not at all satisfied) to 10 (fully satisfied)=10 (7), 9 (1), 8 (1)	Dichotomous yes/no questionnaire.

CAISP, complete arch implant-supported; CR, cement-retained; DIs, dental implants; MA, metal-acrylic; Mx, maxilla; Mnd, mandibular; MC, metal-ceramic; OHQoL, Oral Health-Related Quality-of-Life Measure; RCD, removable complete denture; RPD, removable partial denture; SR, screw-retained; UNS, unspecified; VAS, visual analog scale.VZir, zirconia complete arch porcelain veneered prosthesis; ZirA, zirconia-acrylic

Zirconia brands used: [1]Zirconia Prettau; Zirkonzahn, [2]ICE Zirkon Ceramics; Zirkonzahn, [3]Procera; Nobel Biocare, [4]Zirite; Keramo, [5]CZR; Noritake, [6]Cerabien; Kuraray, [7]Cercom; Degudent), [8]Cercom Ceram S; Degudent.

Table 2. Results of included observational studies for MZir group

Author(s) / Year	**Tirone et al[34] (2022)**	**Cârames et al[35] (2019)**	**Box et al[36] (2018)**	**Tischler et al[37] (2018)**	**González and Triplett[38] (2017)**	**Bidra et al[2] (2017)**	**Rojas-Vizcaya F[43] (2016)**	**Cârames et al[3] (2015)**	**Venezia et al[44] (2015)**	**Moscovitch M[45] (2015)**	**Limmer et al[46] (2014)**	**Oliva et al[49] (2012)**
Type of Study	Retrospective	Prospective	Retrospective	Retrospective	Retrospective	Retrospective	Retrospective	Retrospective	Retrospective	Retrospective	Retrospective	Retrospective
Follow--up (years)	1–7.3	1.5±0.5	0.1–5.8	4	0.25–2.5	0-5	2–7	0.25–3.5	0.8–3	0.5–5.6	1	5

Sample size (patients)	119	67	UNS	128	40 (21/19)	UNS	10 (5/5)	14	18	21	17	15
Age (years)	63.01	62.06	62.50	UNS	60.50	UNS	60	56	UNS	62	57.90	52.80
No. DIs	UNS	581	UNS	1,072	UNS	UNS	UNS	156	154	UNS	68	66
No. DIs per prosthesis	4–6	4–8	UNS	5–6	UNS	UNS	4–8	4–9	5–7	5–15	4	3
No. CAISP/ Retention System	153/UNS	100/SR	7/UNS	191/SR	44/SR	2039/SR	20/SR	24/SR;2/CR	26/SR	25/SR	17/SR	22/SR
Material of the CAISP	CAISP with B load[1]/ CAISP with gingival load[3]	CAISP with B load Structure[1]/Coating[2]	UNS	CAISP with gingival load[1]	CAISP with B and gingival load[1]	CAISP with gingival load[1]	Monolithic CAISP (10), with gingival load (10), or B load (UNS). Structure[1]/ Coating[2]	CAISP with B and gingival load (17), and monolithic (9). Structure[1]/Gingival Porcelain[2]	CAISP with B load (15), and with load in B and incisal axes (11). Structure[4]/Coating[5]	CAISP with B and gingival load. Structure[1]/Coating[5]	Monolithic CAISP (1)	Monolithic CAISP (7)
Type of loading	UNS	Delayed	UNS	Immediate interim prosthesis (74), delayed (119)	UNS	UNS	UNS	Delayed	Immediate interim prosthesis	UNS	UNS	Immediate interim prosthesis (1), delayed (11)
Arch (Mx/ Mnd)	UNS	61/39	5/2	102/89	40/4	UNS	10/10	14/12	17/9	UNS	0/17	11/11
Opposite arch	UNS	Natural dentition (3), VZir (5), MZir	CAISP, natural dentition or	Natural dentition, mixed or	MZir (4). Natural dentition	UNS	MZir (10)	MZir (4). Natural dentition (24), MA (12)	Natural dentition (6), natural dentition+FDP	UNS	UNS	MZir (18), natural dentition

		(63), mixed (20), MC (9)	RPD on DIs	RPD (61), MZir (65)	(24), MA (12)				Zir (2), natural dentition+FDP (1), MC (1)			(2), mixed (2)
Cantilever (No. CAISP / length	Yes (153)/ UNS	Yes (43)/UNS	Yes (7)/10 mm	Yes (191)/ ≤12 mm	UNS/ UNS	UNS/ UNS	Yes (19)/7.2-13.72 mm	UNS/UNS	Yes (6)/UNS	UNS/UNS	Yes (17)/ UNS	Yes (22)/ UNS
Prosthetic survival	94.77 %	95%	100%	97.38 %	100%	99.7 %	100%	100%	100%	100%	88%	100%
Prosthetic success	UNS	90%	UNS	95.81 %	81.8 %	UNS	90%	96.2%	88.4%	100%	29.4 %	95.45 %
Patient satisfaction	UNS	UNS	OHQoL (7)	UNS	UNS	UNS	UNS	UNS	UNS	UNS	OHIP (16.3)	UNS

B, Buccal; CAISP, complete arch implant-supported; CR, cement-retained; DIs, dental implants; MA, metal-acrylic; MC, metal-ceramic; Mnd, mandibular; Mx, maxilla; OHIP, Oral Health Impact Profile; OHQoL, Oral Health-Related Quality-of-Life Measure; RPD, removable partial denture; SR, screw-retained; UNS, unspecified; VZir, zirconia complete arch porcelain veneered prosthesis.

Zirconia brands used: [1]Zirconia Prettau; Zirkonzahn, [2]ICE Zirkon Ceramics; Zirkonzahn, [3]Amann Girrbach; Vorarberg, [4]Sagemax Zr; Sagemax Bioceramics, [5]Vita VM9; VITA Zahnfabrik.

Table 3. Prosthetic complications in VZir CAISP

Author(s)/ Year	**No. CAISP**	**Complications**			**Chipping**		
		Major	**Minor**	**Total**	**Major**	**Minor**	**Total**

Tirone et al[34] (2022)	27	0 (0%)	UNS	0 (0%)	0 (0%)	UNS	0 (0%)
Cârames et al[35] (2019)	77	5 (6.49%)	5 (6.49%)	10 (12.99%)	4 (5.19%)	5 (6.49%)	9 (11.69%)
Tartaglia et al[40] (2019)	15	UNS	UNS	UNS	UNS	UNS	UNS
Box et al[36] (2018)	6	2 (33.33%)	10 (100%)	12 (100%)	2 (33.33%)	1 (16.67%)	3 (50%)
Cârames et al[42] (2016)	92	18 (19.57%)	28 (30.43%)	46 (50%)	16 (17.39%)	28 (30.43%)	44 (47.83%)
Tartaglia et al[39] (2016)	48	2 (4.17%)	17 (35.42%)	19 (39.58%)	UNS	UNS	UNS
Sannino and Barlattani[41] (2016)	40	0 (0%)	4	4(10%)	0 (0%)	4 (10%)	4(10%)
Worni et al[50] (2014)	11	2 (18.18%)	0	2 (18.18%)	1 (9.09%)	0 (0%)	1 (9.09%)
Pozzi et al[47] (2013)	26	0 (0%)	3 (11.54%)	3 (11.54%)	0 (0%)	3 (11.54%)	3 (11.54%)
Larsson and von Steyern[48] (2013)	10	0 (0%)	8 (80%)	8 (80%)	0 (0%)	8 (80%)	8 (80%)
Papaspyridakos and Lal[6] (2012)	16	2 (12.50%)	3 (18.75%)	5 (31.25%)	2 (12.50%)	3 (18.75%)	5 (31.25%)
Total	368	30 (8.15%)	78 (21.19%)	108 (29.34%)	25 (6.79%)	52 (14.13%)	77 (20.92%)

CAISP, complete arch implant-supported; UNS, unspecified.

Table 4. Prosthetic complications in MZir CAISP

Author(s)/		**Complications**	**Chipping**

Year	No. CAISP	Major	Minor	Total	Major	Minor	Total
Tirone et al[34] (2022)	153	8 (5.23%)	UNS	8 (5.23%)	UNS	UNS	UNS
Câmames et al[35] (2019)	100	5 (5%)	5 (5%)	10 (10%)	4 (4%)	5 (5%)	9 (9%)
Box et al[36] (2018)	7	0 (0%)	2 (28.57%)	2 (28.57%)	0 (0%)	0 (0%)	0 (0%)
Tischler et al[37] (2018)	191	5 (2.62%)	3 (1.57%)	8 (4.19%)	0 (0%)	0 (0%)	0 (0%)
Gonzalez and Triplett[38] (2017)	44	0 (0%)	8 (18.18%)	8 (18.18%)	0 (0%)	6 (13.64%)	6 (13.64%)
Bidra et al[2] (2017)	2,039	6 (0.29%)	9 (0.44%)	15 (0.74%)	0 (0%)	0 (0%)	0 (0%)
Rojas-Vizcaya F[43] (2016)	20	0 (0%)	2 (10%)	2(10%)	0 (0%)	1 (5%)	1 (5%)
Câmames et al[3] (2015)	26	0 (0%)	1 (3.85%)	1 (3.85%)	0 (0%)	1 (3.85%)	1 (3.85%)
Venezia et al[44] (2015)	26	0 (0%)	3 (11.54%)	3 (11.54%)	0 (0%)	3 (11.54%)	3 (11.54%)
Moscovitch M[45] (2015)	25	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Limmer et al[46] (2014)	17	2 (11.76%)	10 (58.82%)	12 (70.59%)	0 (0%)	6 (35.29%)	6 (35.29%)
Oliva et al[49] (2012)	22	0 (0%)	2 (9.09%)	2 (9.09%)	0 (0%)	1 (4.55%)	1 (4.55%)
Total	2,670	26 (0.97%)	49 (1.84%)	75 (2.81%)	4 (0.15%)	23 (0.86%)	27 (1.01%)

CAISP, complete arch implant-supported; UNS, unspecified.

Table 5. Risk of bias in individual studies

	Tirone et al[34] (2022)	Cârames et al[35] (2019)	Tartaglia et al[40] (2019)	Box et al[36] (2018)	Tischler et al[37] (2018)	Gonzalez and Triplett[38] (2017)	Bidra et al[2] (2017)	Tartaglia et al[39] (2016)	Sannino and Barlattani[41] (2016)	Cârames et al[42] (2016)	Rojas-Vizcaya F[43] (2016)	Cârames et al[3] (2015)	Worni et al[50] (2015)	Venezia et al[44] (2015)	Moscovitch M[45] (2015)	Limmer et al[46] (2014)	Pozzi et al[47] (2013)	Larsson and von Steyern[48] (2013)	Papaspyridakos and Lal[6] (2012)	Oliva et al[49] (2012)
Where was the study conducted?	PC	PC	PC	U	PC	U	DL	PC	U	PC	U	U	U	2PCs	PC	U	U	U	U	PC
Have patients been included in more than one centre?	No	No	No	No	No	No	Yes	No	No	No	No	No	No	Yes	No	No	No	No	No	No
Is the objective clearly described?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Are the exclusion and inclusi	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes

on criteria described?																				
Is a clear definition of outcomes provided?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Have the data been collected prospectively?	No	Yes	Yes	No	No	No	No	Yes	No	No	No	No	No	No	No	Yes	No	Yes	No	No
Are losses to follow-up described?	Yes	Yes	Yes	NR	Yes	NR	Yes	Yes	Yes	NR	Yes	Yes	Yes	NR	NR	Yes	NR	Yes	NR	Yes
Are the study findings	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

clearly described?																				
Do the authors have any conflicts of interest?	No	No	No	No	No	No	NR	No	No	No	NR	No	NR	NR	No	No	No	No	No	No

DL, dental laboratory; NR, not registered; PC, private center; U, university.

FIGURES

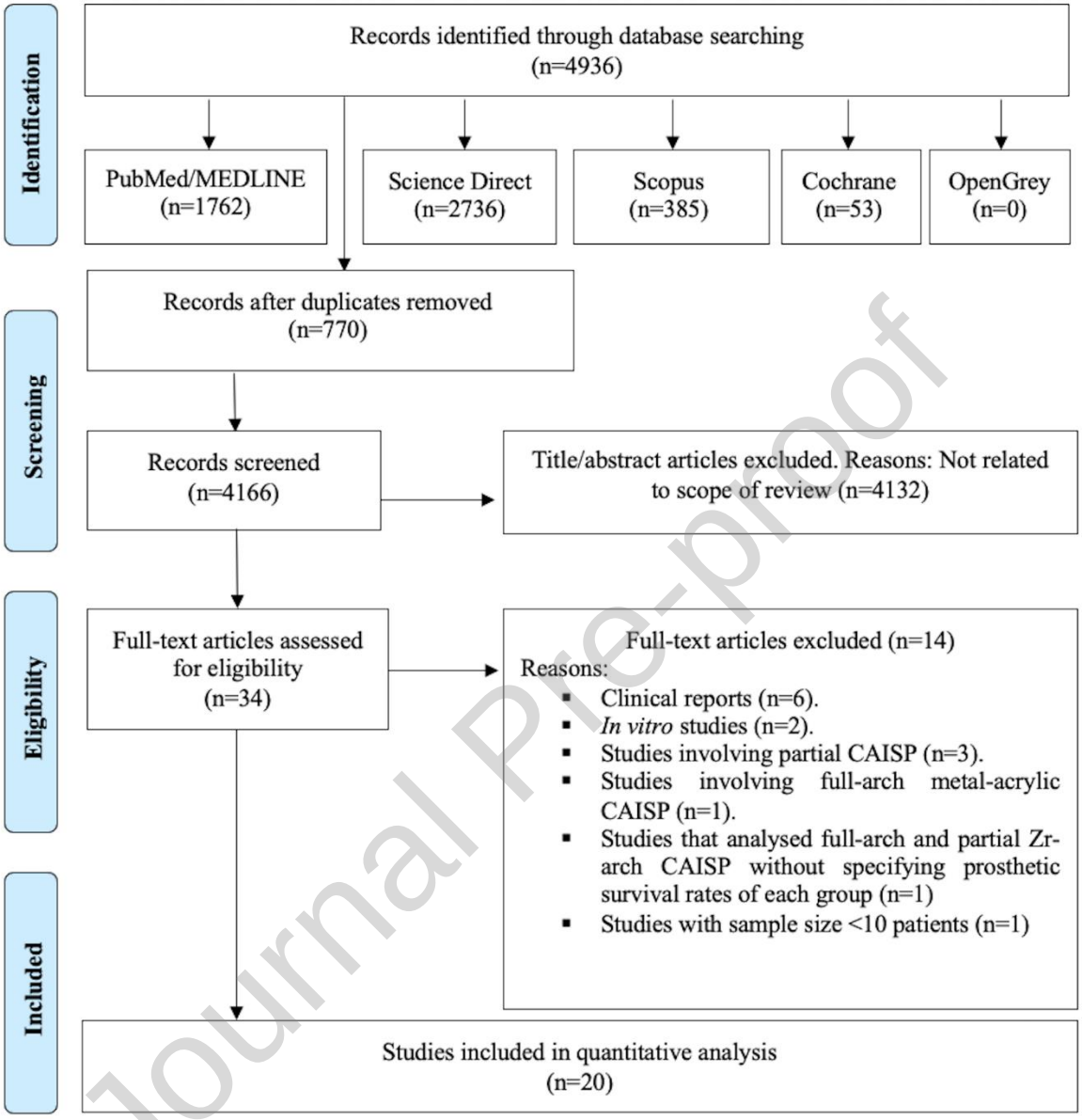

Figure 1. Preferred reporting items for systematic reviews and meta-analyses flow diagram of search processes and results.

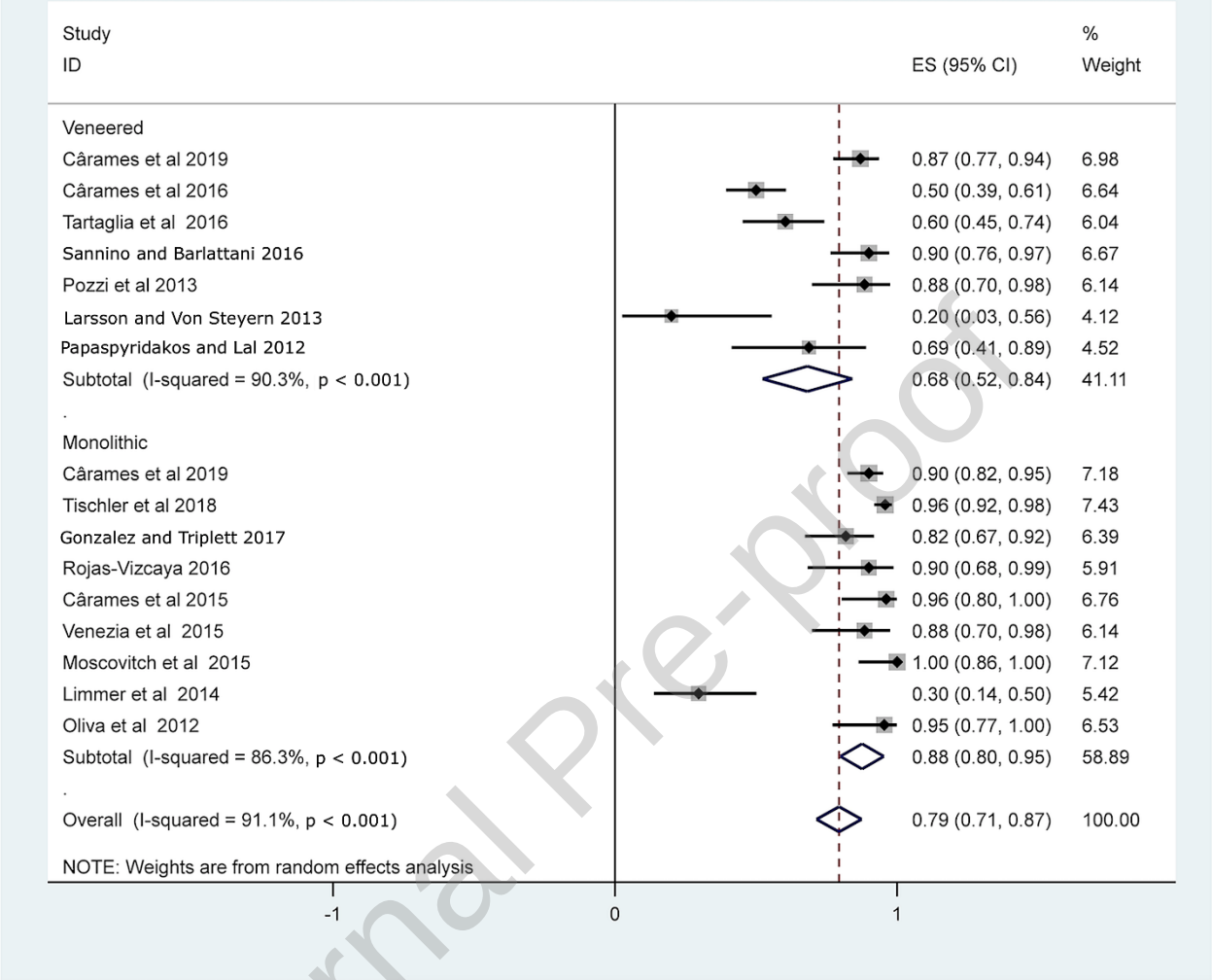

Figure 2. Meta-analysis of success data.

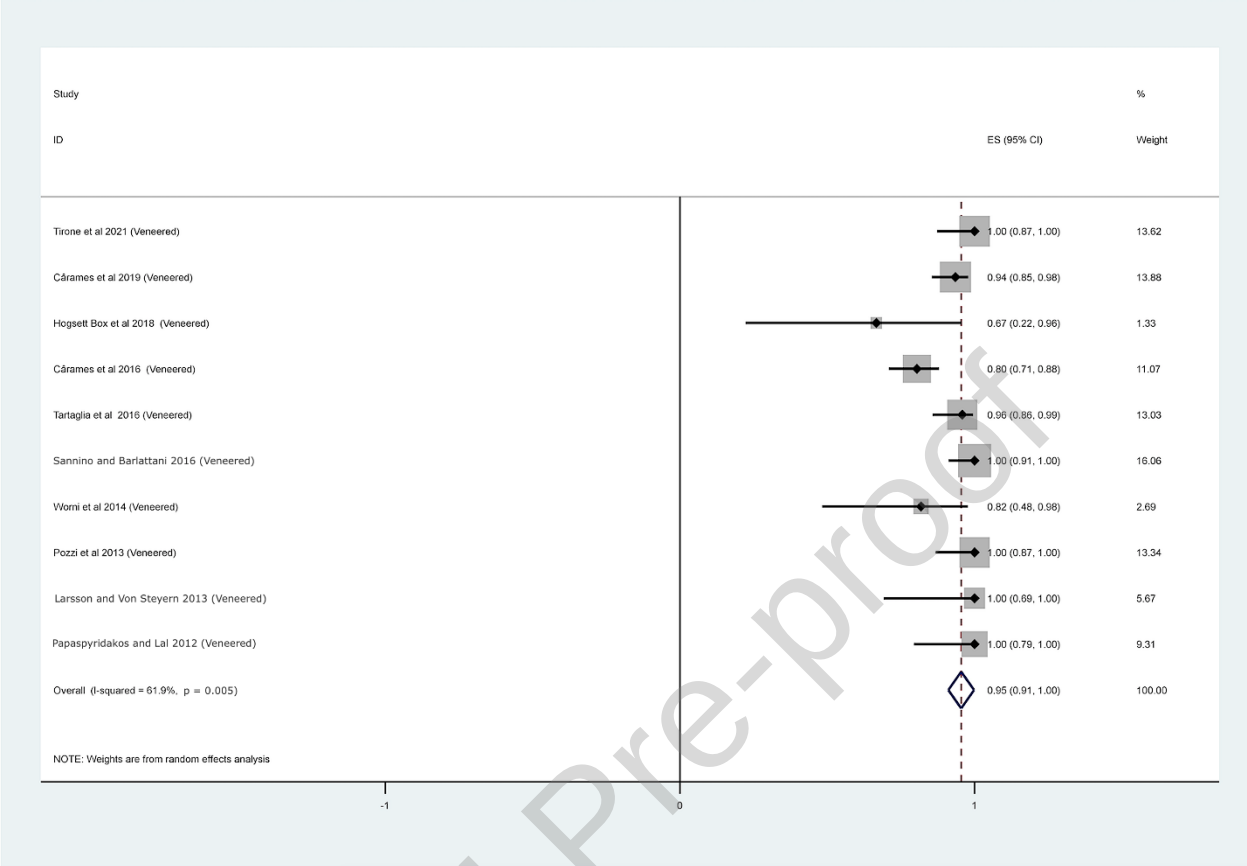

Figure 3. Meta-analysis of survival data of VZir group.

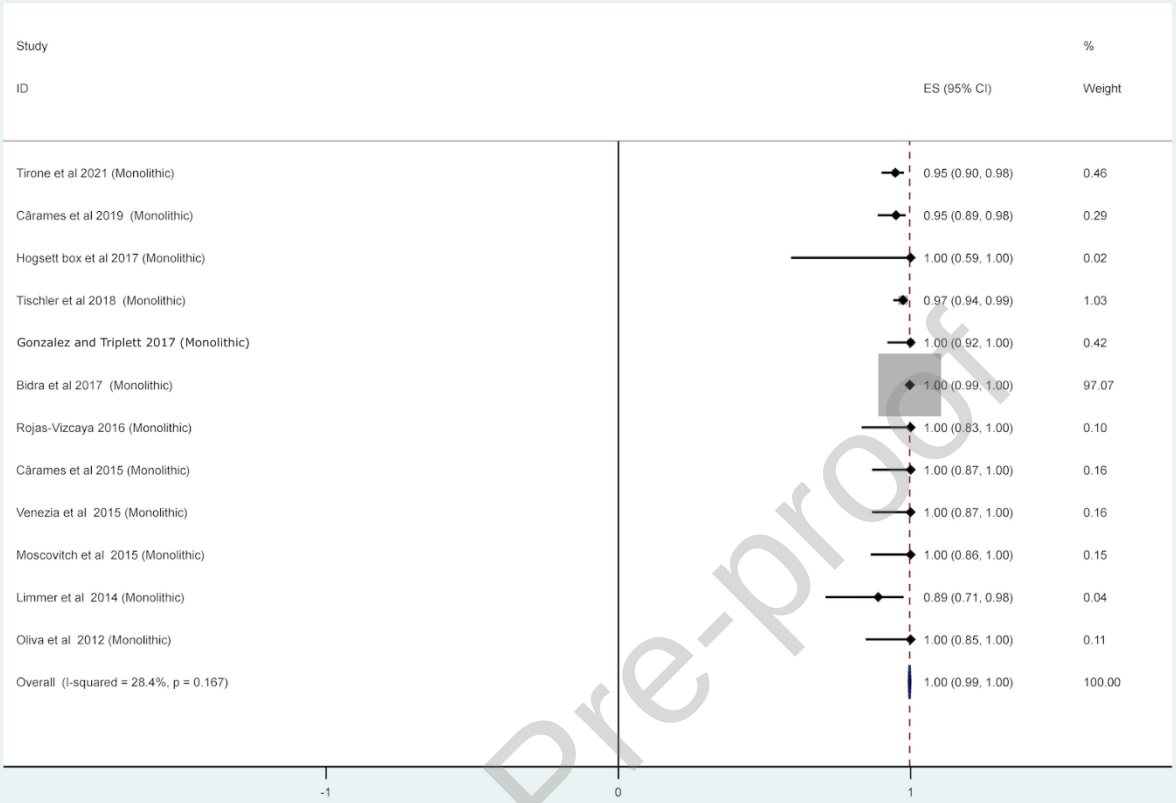

Figure 4. Meta-analysis of MZir group's survival data.

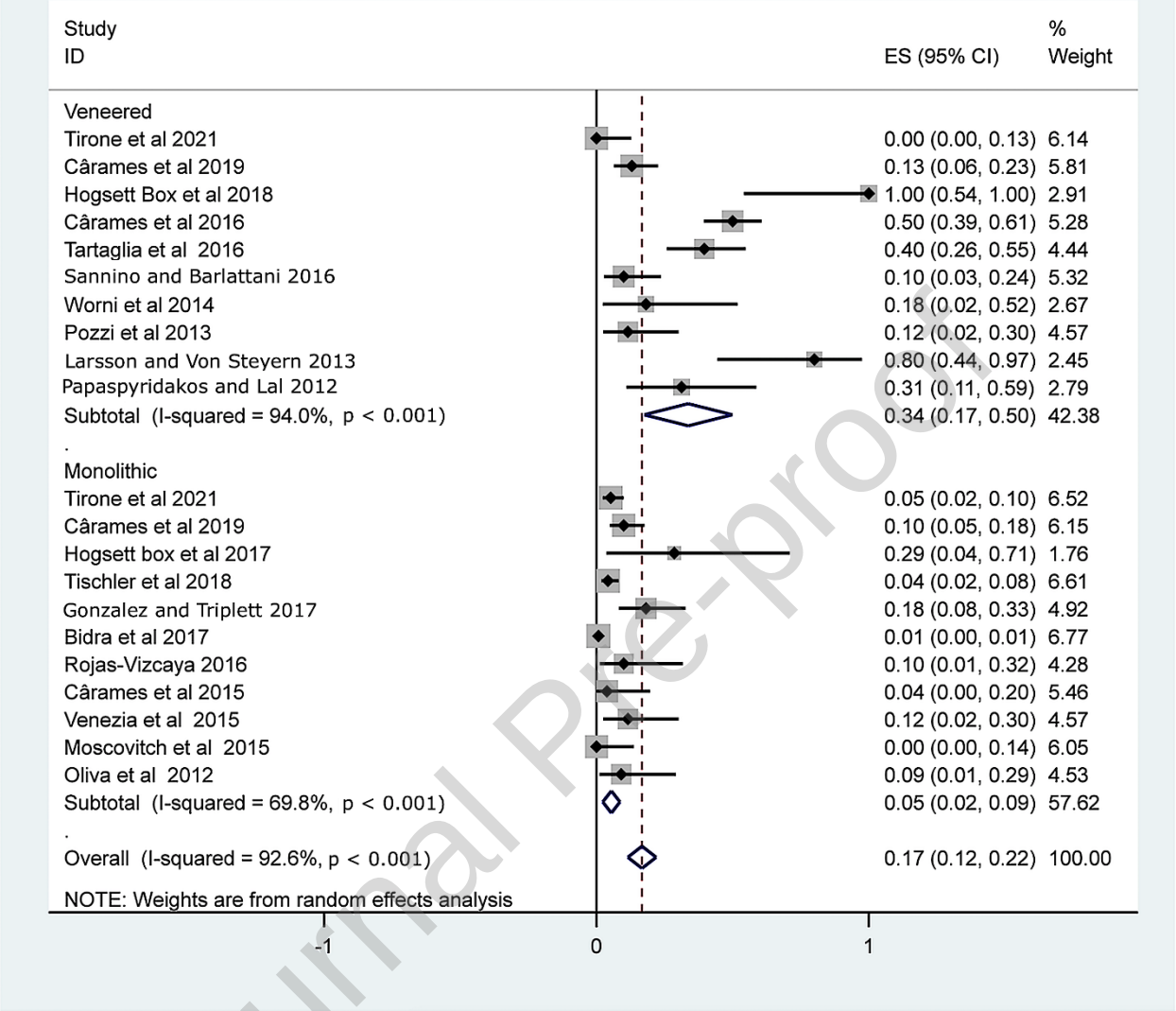

Figure 5. Meta-analysis of complications data.

CRediT authorship contribution statement

Sara Martakoush-Saleh: Conceptualization, Methodology, Data curation, Investigation, Formal analysis, Writing - original draft. **Angel-Orión Salgado-Peralvo:** Visualization, Methodology, Supervision, Writing - review & editing. **Juan-Francisco Peña-Cardelles:** Conceptualization, Methodology, Supervision, Writing-review & editing. **Naresh Kewalramani:** Visualization,

Supervision, Writing - review & editing. **German O. Gallucci:** Supervision, Visualization, Supervision, Writing - review & editing.

Declarations of interest:

none.