Journal of Advanced Medical and Dental Sciences Research

@Society of Scientific Research and Studies

Journal home page: www.jamdsr.com doi: 10.21276/jamdsr ICV 2018= 82.06

(e) ISSN Online: 2321-9599; (p) ISSN Print: 2348-6805

Original Research

Success of monolithic zirconia restorations for posterior teeth: A systematic review

[1]P. Subramanian, [2]Lakshmi Senkumar, [3]Dandu Manohar Varma, [4]Hemanth Kumar PMV, [5]Anmol Singh Boparai, [6]Damarasingu Rajesh

[1]MDS, Consultant, Oral & Maxillofacial Surgeon, Frontline Hospital, Trichy, Tamil Nadu, India;
[2]BDS(Maharashtra University of Health Sciences), DPP (University of Michigan), India;
[3]BDS, Consultant & Chief Dental Surgeon, Smile Care Dental Hospital, Sethammadhara, Visakhapatnam, AP, India;
[4]Assistant Professor, SJM Dental College and Hospital, Karnataka, India;
[5]Bachelors in Health Sciences (Public Health), Cape Breton University, Sydney, Nova Scotia, Canada;
[6]PG Student, Department of Oral and Maxillofacial Surgery, St. Joseph Dental College, Eluru, Andhra Pradesh, India

ABSTRACT:
Aim: The purpose of this systematic review was to evaluate the survival rate, biological complications, technical complications, and clinical behaviour of single crowns supported by teeth made up in monolithic zirconia. **Methodology:** An extensive electronic search was conducted through Medline/PubMed, Embase, and Cochrane Library databases. Additional manual search was performed on the references of included articles to identify relevant publications. Two reviewers independently performed the selection and electronic and manual search. **Results:** From nine articles included, there was a total of 594 participants and 1657 single-tooth restorations with a mean exposure time of 1.07 years, and follow-up period between 0.3 and 2.1 years. All studies showed a moderate level of quality, with a consequent moderate possibility of associated bias, using the Newcastle-Ottawa Scale (NOS), with survival rate (SR) ranging between 91% to 100%. Bleeding on probing (BOP) were reported with an average value of 29.12%. Marginal integrity showed high success rate values for the observation periods, except for one that included patients with bruxism which obtained a SR of 31.60%. Failures and/or fractures, mostly total and requiring replacement, were observed in three studies. Linear regression showed that there was no statistical correlation between survival rate and type of cementation and the average years of follow-up (p=0.730 e p=0.454). There was high heterogeneity between studies (I2 = 93.74% and Q = 79.672). **Conclusion:** Within the limitation of this study, monolithic zirconia might be considered as a possible option for restoring single crowns, especially in the posterior zone.
Keywords: Zirconium oxide, Yttria-stabilized tetragonal zirconia, Tooth crown, Fixed partial Denture.

Received: September 24, 2019 **Accepted:** October 29, 2019

Corresponding author: Hemanth Kumar PMV, Assistant Professor, SJM Dental College and Hospital, Karnataka, India

This article may be cited as: Subramanian P, Senkumar L, Varma DM, PMV Hemanth K, Boparai AS, Rajesh D. Success of monolithic zirconia restorations for posterior teeth: A systematic review. J Adv Med Dent Scie Res 2019;7(11):266-270.

INTRODUCTION

The all-ceramic crown is a common restoration method for a broken or cracked tooth.[1] Compared with the metal crown and the metal-ceramic crown, it has excellent biocompatibility and esthetic appearance, compatibility with magnetic resonance imaging, and superior refractive index and transparency.[1,2] At present, the materials used in all-ceramic crowns mainly include glass-infiltrated alumina-based ceramics, glass ceramics by injection molding, and yttria-stabilized tetragonal zirconia polycrystals (Y-TZP).[1] Among these, Y-TZP has a flexural strength of 900 to 1200 MPa and a fracture toughness of 7 to 9 MPa $m_{1/2}$,[3-5] which are 2 to 3 times those of the alumina-based all-ceramic materials.[6] Its advantageous mechanical properties make it the most popular all-ceramic restoration material. Although Y-TZP ceramics exhibit low-temperature degradation when exposed to low temperature or hydrothermal environment for a long time, resulting in increased surface roughness and a decreased failure load, its flexural strength is still enough to withstand chewing forces applied to the posterior region.[7] The addition of a stabilizer with Y2O3 as the main component in the zirconia preparation can significantly improve its antiaging properties and enhance its biological and mechanical properties.[8] Clinically, the veneering porcelain has been found to chip or even delaminate after long-term wear of the crown, resulting in restoration failures.[9] This problem was resolved by gradually introducing the monolithic zirconia crown into clinical practice. The monolithic zirconia crown restoration is fabricated with computer-aided design and computer-aided manufacturing (CAD/CAM) technique with the removal of veneering porcelain. It is made from a single piece of monolithic zirconium oxide ceramic ingot by computer numerical controlled cutting and sintering. The fabricated crowns have high flexural strength and high fracture toughness, both of which are remarkably better than those of the alumina-based ceramic crowns.[10] The mechanical properties of monolithic zirconia restorative material are notably superior to those of other all-ceramic restorative materials, as the risk of chipping of porcelain veneers caused by chewing hard foods can be avoided. Besides, the monolithic zirconia crown restoration requires a less amount of tooth structure trimming compared with the all-ceramic crown,[11] retaining a more natural tooth structure. With the rapid development of material science and manufacturing techniques, high-translucent Y-TZP ceramics with high purity and nearly zero porosity can be prepared nowadays, overcoming the shortcomings of poor translucency and single-layer appearance of earlier zirconia ceramics.[12] The Zenostar zirconia system from Wieland Dental has outstanding optical and mechanical properties, as well as high translucency and profound resistance to hydrothermal aging; it also provides a broad range of vital shades for esthetic restorations.[13] Only a few clinical studies have reported on the periodontal conditions and the therapeutic effects of the restorations on the abutment and the antagonist teeth after the monolithic zirconia crowns were placed in patients.[14-16]

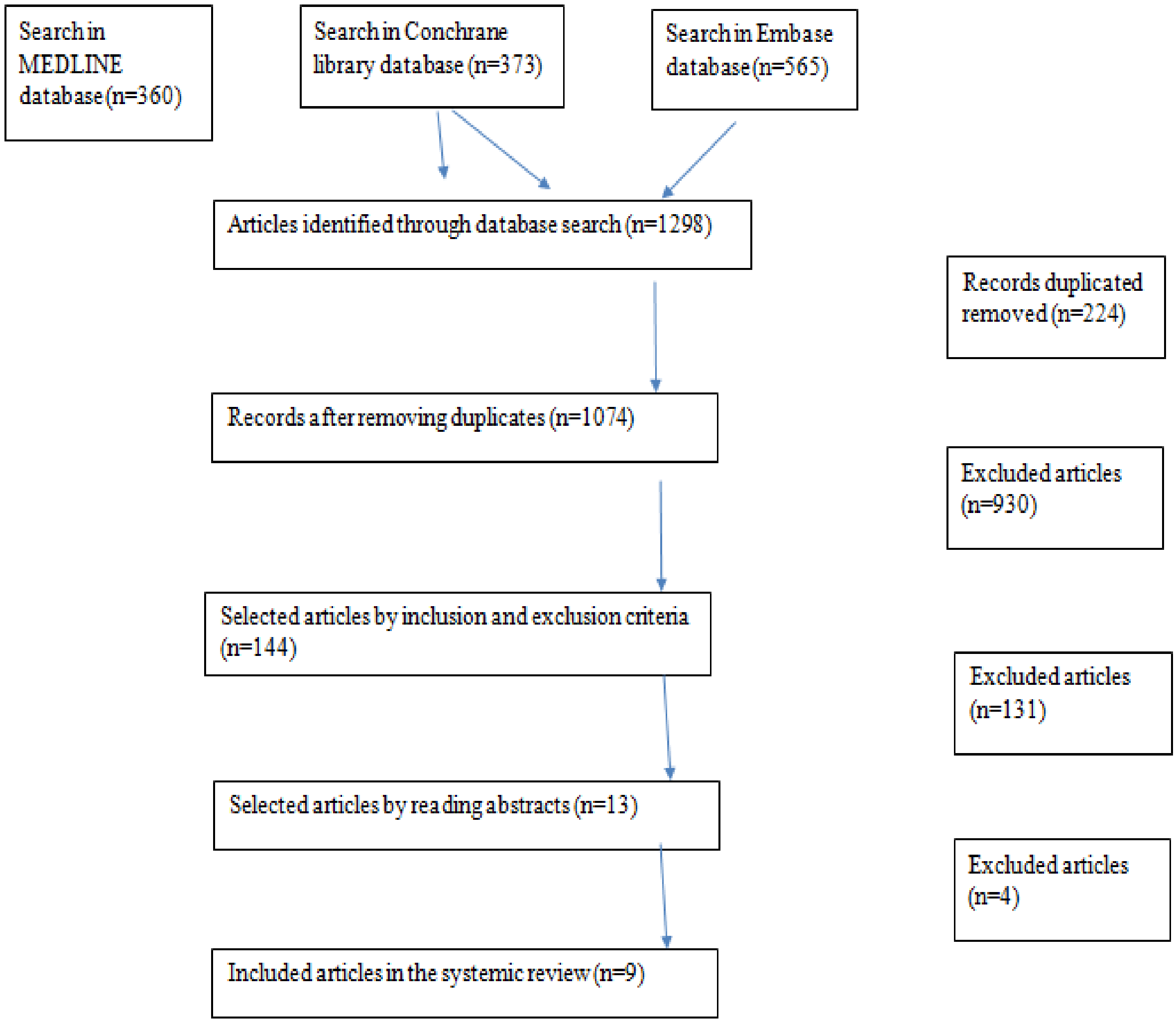
AIM OF THE PRESENT STUDY

The purpose of this systematic review and meta-analysis was to assess the survival rate, biological complications, technical complications, and clinical behavior of single teeth-supported monolithic zirconia crowns, developed with the CAD/CAM system, to help clinicians in the decision process.

METHODOLOGY

This systematic review and meta-analysis was conducted following the PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-analysis)[17,18] and the research question was defined through the PICOT format (population, intervention, comparison, outcomes, and time).[19]This electronic survey was initiated in three different databases, applying theEnglish-language limitation: Medline/PubMed (National Library ofMedicine), Embase, and Cochrane Library. At Medline/PubMed andCochrane Library, different MeSH (medical subject headings) termswere combined by using Boolean operators AND, OR, and NOT. A search was also carried out in the form of free text, using the search terms: “Monolithic zirconia”; “Monolithic dental crown”; “Zirconia dental crown”. Combining research in controlled English-language at Embase, a total of 565 articles was obtained. For the selection of the studies, inclusion, and exclusion criteria were defined such as only abstracts published in congress, e-posters, content non-published, grey literature, and letter to editor. After eliminating duplicates, the titles and abstracts of all identified articles were systematically evaluated. Subsequently, the articles were read in full and the reasons for their exclusion were recorded. (Table 1) Data extraction for descriptive and quantitative synthesis was performed using a standardized form and recorded in an Excel table. The information extracted included: study (Authors/Year of publication), type of study, country, age, restorations (n), drop-outs (n), CAD/CAM system, monolithic zirconia type/brand, glaze/stain (yes or no), dental preparation, impression (digital/conventional), CAD/CAM system, cement/cementation process, follow-up period (years), evaluation system, location (anterior/ posterior), dental group, whether in the maxilla or mandible, occlusal adjustments (yes or no), wear antagonist, absence or presence of plaque, surface treatment, marginal integrity, bleeding on probing (BOP), color stability (yes or no), dental vitality (n), number of failure (considered only facture in which the material cannot be replaced or adjusted), and survival rate. This meta-analysis compared data obtained on success/survival rates after a minimum of three months in function. All analysis were performed using Excel software. Where the random effect model at a 5% significance level was used. To assessthe quality of the cohort studies, the Newcastle-Ottawa Scale(NOS) for Quality Assessment was used. Heterogeneity among thestudies was quantified using the Cochran test (Test Q) and the inconsistencytest ($I2 \geq 50\%$). Values above 75% (in both tests) wereconsidered an indication of substantial heterogeneity, not allowing afixed-effect analysis method to be applied (i.e., the effect of interestis not the same in all studies and therefore it is not possible to considerthat the studies are homogeneous and derived from the samepopulation).[20]Since the confidence interval (CI) was not provided, the standarddeviation (SD) value was used to calculate it. Linear regression (therelationship between survival rate, cementation, and average follow-upperiod) was also performed.

Table 1- Article selection strategy according to the PRISMA Flowchart (Preferred Reporting Items for Systematic Reviews and Meta-Analysis).



RESULTS

Through the search strategy, 1298 references were initially identified (360 from Medline/PubMed, 373 from the Cochrane Library, and 565 from Embase). Of these, 224 duplicate articles were removed, resulting in a total of 1074 articles. Subsequently, through the selection by the inclusion and exclusion criteria (reading the title), 930 articles were eliminated, leaving a total of 144 articles. Of these, 13 articles were selected by abstract and four articles were eliminated after full read. In this quantitative analysis, 1657 monolithiczirconia unitary restorations were included. Most studies reportedposterior mandibular restorations (premolars and molars),the majority of which (n=423) were maxillary restorations (n=380).The evaluated studies had an observation period between 0.3 and2.1 years, with an average follow-up of 1.07 years. Thus, nine articles(1 randomized controlled trial; 3 prospective cohort clinical trial; 1 prospective observational case-series; 2 retrospectives clinical trial; 1 retrospective observational clinical trial; 1 retrospective observational case-series) published between2018 and 2022 were included in this systematic review. Cohen’s kappa value was calculated to measure the inter-rater agreement in the study selection process. The standard deviation calculation was 0.98 (±0.14) for the first selection stage and 0.78 (±0.23) for the second stage. In this systematic review, a total of 594 individuals were reported, with an estimated average age of 49.1 years. Most of the dental preparations were made with the monolithic ceramic crowns’ standard reductions (i.e., a minimum wall thickness of 1mm, occlusal reduction of 1.5 to 2.0mm, axial reduction of 1.0 to 1.5mm). The analysis of biological complications was performed usingthe following parameters: presence/absence of bacterial plaque,bleeding on probing, and dental vitality. When evaluating the studies,it can be seen that the presence of plaque was mentioned infour of them, with only one study reporting that the bacterialplaque was absent. Bleeding on probing was reported in four studies with an average value of 29.12%. Failures/fractures, mostly total and requiring replacement, were observed in three out of nine studies. In the retrospective study by Gunge et al., with a survival rate of 91.5% after 3.5 years in clinical function, six monolithic zirconia crowns for natural teeth were lost, such as by hyperesthesia (1), root fracture of an abutment tooth (1), restoration fracture (1), pulpitis (2), and one restoration was removed because the tooth was used as an abutment tooth for a fixed partial denture after root fracture of an adjacent tooth, with other technical problems related to marginal discoloration, loss of retention and compromised esthetics being occasionally reported. Then, only 1 failure was really considered in this study due to a direct failure/fracture of the restauration. In the prospective study by Hansen et al., visible plaque was found in two patients, and bleeding on probing was present in one or more teeth in all patients. According to Tang et al., there was no incidence of secondary caries. However, at the end of the total follow-up period (96 weeks), 45 crowns had no plaque, three crowns had visible plaque and only one crown had a moderate plaque index at the level of the gingival margin. (Table 2)

Table 2- Quality assessment of studies included at risk of bias using the Newcastle-Ottawa Scale.

Authors/Year	Konstantinidis et al. 2018	Batson et al. 2014	Tang et al. 2019	Kitaoka et al. 2018	Gunge et al. 2017
Selection (up to 4*)	****	**	**	**	**
Comparability (up to 2*)					**
Outcome/Exposure (up to 3*)	**	**	***	**	**
TOTAL	6/9	4/9	5/9	4/9	6/9
INTERPRETATION	Moderate	Moderate	Moderate	Moderate	Moderate

***** *1 to 3 – Low quality; 4 to 6 – Moderate quality; 7 to 9 – High quality of assessment.*

DISCUSSION

Systematic reviews and meta-analysis are usually assessed as high-quality scientific evidence, systematically identifying the relevant published information. The introduction of new technologies, manufacturing processes, and materials in dental clinical practice should ideally be supported by scientific evidence. However, there is a lack of evidence on the clinical performance of monolithic ceramic (zirconia) crowns, which becomes necessary for more scientific studies with longer follow-up periods.[21]The main biological complications reported were increasedBOP in the abutment teeth, secondary caries, bacterial plaque, lossof vitality, and fracture of the abutment tooth. However, it is worthyof note that the evidence is scarce in this regard since not all studiesprovided information and/or used different evaluation systems(USPHS or CDA).After statistical analysis, it was also found that there was highheterogeneity, for survival rate (I2=92.49% and Q=81.518) and the relationshipbetween survival rate and BOP (I2=93,74% and Q=79.672). Regarding the reported technical complications, significant differences occurred in three studies [22], all with the occurrence of one fracture of MZ restoration - a total of three failures (0.18%). The lowest SR, according to statistical analysis, was found in two of these studies. However, when analyzed Gunge et al.'s study, it was noticeable that, in addition to being the only work with an observation period greater than two years, it is also one of the studies with the largest number of samples (n=148).[23] This may be a justification for the lowest survival found (91.5%). Extreme tightening or defects in the crown margins may be possibly associated causes of fractures. The manufacturing process may introduce defects in pre-cementation restoration, reducing the crown's resistance. Also, the phenomenon of low temperature degradation may be associated with this type of failure (since it spreads into the material). According to Nakamura et al. [24], this phenomenon, when associated with wear, can influence the quality of the surface, leading to an increase in the roughness. However, the clinical relevance of this phenomenon is still uncertain. Masticatory forces can also induce this phase transformation around surface microcracks; however, this is not likely to be the associated cause since, in most cases, time in function was relatively low. Monolithic crowns have a high fracture resistance, allowing preparation without excessive tooth reduction, which is one of the reasons by which have become a treatment alternative to metal ceramic or ceramic crowns. Previous studies have shown that the design of the preparation influences significantly and is associated with fracture resistance of metal-ceramic crowns. According to Miyazaki et al.[25], although the range of available ceramics has considerably improved its characteristics, zirconia is arguably the best all-ceramic material. Thus, due to the quick development of materials and processing technologies, the application of zirconia is promising. However, further studies and clinical evaluations are needed. This is also an affirmation of a systematic review [26], implying zirconia as a clinical material of choice for molar zones (zone of increased occlusal forces).

CONCLUSION

High heterogeneity, the reduced follow-up period, and the overall survival rate of zirconia monolithic restorations manufactured with CAD/CAM technology, this material might be a feasible option for restoration of single crowns, particularly in the posterior sector.

REFERENCES

1. Porcelain-Fused-to-Metal Crowns versus All-Ceramic Crowns: A Review of the Clinical and Cost-

Effectiveness. Ottawa: Canadian Agency for Drugs and Technologies in Health; 2016.
2. BaraoVA,Gennari-FilhoH,GoiatoMC,et al. Factors to achieve aesthetics in all-ceramic restorations. J Craniofac Surg 2010;21:2007–12.
3. Kumagai N, Hirayama H, Finkelman MD, et al. The effect of translucency of Y-TZP based all-ceramic crowns fabricated with difference substructure designs. J Dent 2013;41(suppl 3):e87–92.
4. Harada K, Shinya A, Gomi H, et al. Effect of accelerated aging on the fracture toughness of zirconias. J Prosthet Dent 2016;115:215–23.
5. Harada K, Shinya A, Yokoyama D, et al. Effect of loading conditions on the fracture toughness of zirconia. J Prosthodont Res 2013;57:82–7.
6. de Kok P, Kleverlaan CJ, de Jager N, et al. Mechanical performance of implant-supported posterior crowns. J Prosthet Dent 2015;114:59–66.
7. Pereira GKR, Guilardi LF, Dapieve KS, et al. Mechanical reliability, fatigue strength and survival analysis of new polycrystalline translucent zirconia ceramics for monolithic restorations. J Mech Behav Biomed Mater 2018;85:57–65.
8. Hao Z,Ma Y, Liu W, et al. Influence of low-temperature degradation on the wear characteristics of zirconia against polymer-infiltrated ceramic network material. J Prosthet Dent 2018;120:596–602.
9. Rekow ED, Silva NR, Coelho PG, et al. Performance of dental ceramics: challenges for improvements. J Dent Res 2011;90:937–52.
10. Candido LM, Miotto LN, Fais L, et al. Mechanical and surface properties of monolithic zirconia. Oper Dent 2018;43:E119–28.
11. Stawarczyk B, Keul C, Eichberger M, et al. Three generations of zirconia: from veneered to monolithic. Part II. Quintessence Int 2017;48:441–50.
12. Krell K, Hutzler T, Klimke J. Transmission physics and consequences for materials selection, manufacturing, and applications. J Euro Cera Soci 2009;29:207–21.
13. Stober T, Bermejo JL, Schwindling FS, et al. Clinical assessment of enamel wear caused by monolithic zirconia crowns. J Oral Rehabil 2016;43:621–9.
14. Miura S, Kasahara S, Yamauchi S, et al. Clinical evaluation of zirconiabased all-ceramic single crowns: an up to 12-year retrospective cohort study. Clin Oral Investig 2018;22:697–706.
15. Lohbauer U, Reich S. Antagonist wear of monolithic zirconia crowns after 2 years. Clin Oral Investig 2017;21:1165–72.
16. Kitaoka A, Akatsuka R, Kato H, et al. Clinical evaluation of monolithic zirconia crowns: a short-term pilot report. Int J Prosthodont 2018;31:124–6.
17. Zorzela L, Loke YK, Ioannidis JP, Golder S, Santaguida P, Altman DG, et al.; PRISMAH arms Group. PRISMA harms checklist: improving harms reporting in systematic reviews. BMJ. 2016;352:i157.
18. Wright RW, Brand RA, Dunn W, Spindler KP. How to write a systematic review. Clin Orthop Relat Res. 2007;455:23–9.
19. Donato H, Donato M. [Stages for Undertaking a Systematic Review]. Acta Med Port. 2017;32:227–35.
20. Higgins JPT, Thompson SG. Quantifying heterogeneity in a meta-analysis. Stat Med. 2002;21:1539–58.
21. Cattani-Lorente M, Scherrer SS, Ammann P, Jobin M, Wiskott HWA. Low temperature degradation of a Y-TZP dental ceramic. Acta Biomater. 2011;7:858–65.
22. Chevalier J, Loh J, Gremillard L, Meille S, Adolfson E. Low-temperature degradation in zirconia with a porous surface. Acta Biomater. 2011;7:2986–93.
23. Nakamura K, Harada A, Kanno T, Inagaki R, Niwano Y, Milleding P, et al. The influence of low-temperature degradation and cyclic loading on the fracture resistance of monolithic zirconia molar crowns. J Mech Behav Biomed Mater. 2015;47:49–56.
24. Alves de Carvalho I, Marques T, Araujo F, Azevedo L, Donato H, Correia A. Clinical Performance of CAD/CAM Tooth-Supported Ceramic Restorations: A Systematic Review. The International Journal of Periodontics & Restorative Dentistry. 2018;38:e68–78.
25. Mormann WH, Bindl A, Luthy H, Rathke A. Effects of preparation and luting system on all-ceramic computer-generated crowns. Int J Prosthodont. 1998;11:333–9.
26. Sun T, Zhou S, Lai R, Liu R, Ma S, Zhou Z, et al. Load-bearing capacity and the recommended thickness of dental monolithic zirconia single crowns. J Mech Behav Biomed Mater. 2014;35:93–101.