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CLINICAL RESEARCH

Comparison of clinical outcomes between single metal-ceramic and zirconia crowns

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ABSTRACT

Statement of problem. Evidence comparing the survival of zirconia crowns with metal-ceramic crowns is sparse. Knowledge of their survival and a comparison of their clinical outcomes would improve clinical decision making.

Purpose. The purpose of this university-based study was to compare the survival, failures, biological and technical complications encountered with zirconia and metal-ceramic crowns restored and followed up over a similar period.

Material and methods. This retrospective chart review consisted of 403 patients treated at the University of Toronto, Faculty of Dentistry, predoctoral dental clinic in whom zirconia (n=209) and metal-ceramic (n=306) crowns were inserted between September 2015 and July 2016 and followed for up to 7 years. Outcome measures included failure, causes for failure, and complications associated with survival. Inferential statistical analysis included the chi-squared test, *t* test, Mann-Whitney test, Bonferroni-adjusted z-test, Kaplan-Meier survival test, and logistic regression to examine differences between crown types and explore crown failures (α=.05).

Results. The mean follow-up period was 3.00 years (median 2.58 years). Forty-one (8.0%) crowns had no follow-up, with no difference in follow-up between crown type: metal-ceramic n=23(7.5%), zirconia n=18(8.6%), $\chi^2(1)=0.20$, $P=.652$). Excluding those with no follow-up, the follow-up time between metal-ceramic (mean=3.07, median=2.58) and zirconia (mean=3.54, median=3.32) crowns was statistically similar ($P=.052$). There were 62 anterior crowns (12.0%) and 453 posterior crowns (88.0%), $\chi^2(1)=22.40$, $P<.001$, with no difference between groups. Overall, 44 crowns (8.5%) failed, 30 (9.8%) metal-ceramic and 14 (6.7%) zirconia, with no statistical difference in proportion of failed crowns between groups ($\chi^2(1)=1.53$, $P=.216$). There were 35 crowns with biological failures (6.8%), 26 (8.5%) in the metal-ceramic and 9 (4.4%) in the zirconia group, with no statistical difference between groups ($\chi^2(1)=3.33$, $P=.068$). Nine crowns had technical failures (1.7%), 4 (1.4%) in the metal-ceramic group and 5 (2.5%) in the zirconia group, with no statistical difference between groups ($\chi^2(1)=0.73$, $P=.394$). Biological (79.5%) rather than technical complications were found to be the most frequent cause of failure, goodness-of-fit $\chi^2(1)=15.36$, $P<.001$. Tooth fracture (50.0%) specifically was found to be the most frequent cause of failure, $\chi^2(3)=21.27$, $P<.001$. The total number of crowns that survived was 471 (91.5%); 276 (90.1%) were metal-ceramic and 195(93.3%) zirconia. The survival time (years) for metal-ceramic was mean=6.26, 95% CI [6.01–6.51] and for zirconia crowns mean=6.54, 95% CI [6.31–6.77]. Of the crowns that survived, 370 (78.6%) had no clinical complications, and 101 (21.4%) crowns demonstrated similar clinical complications, with no statistical differences between groups.

Conclusions. Within the study follow-up time, the survival of monolithic zirconia and metal-ceramic crowns was 91.5%, with similar clinical complications between groups. Biological complications, especially tooth fracture, were a significantly more frequent complication with both types of crowns. (J Prosthet Dent 2025;133:464-471)

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Clinical Implications

Both zirconia and metal-ceramic crowns had a similar success rate and similar clinical complications, demonstrating that zirconia is a suitable single tooth restoration and alternative to metal-ceramic. Tooth fracture was responsible for the majority of failures with both types of crowns in anterior teeth.

Metal-ceramic crowns have been accepted as the criterion standard for single tooth restorations where strength and esthetics are required.[1] However the use of cast metal has been decreasing over the past decade and has given way to tooth-colored restorations because of esthetic demands and the rising costs of precious metals.[2] With improvement in digital technology, single teeth requiring complete coverage are now being restored with zirconia crowns.[3] Zirconia demonstrates excellent mechanical properties, biocompatibility, and esthetics[4] and a cumulative survival of single unit zirconia crowns of up to 90% at 3 years and an estimated success of 68% at 5 years have been reported.[5] In comparison, the long-term survival of metal-ceramic restorations has been estimated to be approximately 92% at 10 years and 75% at 15 years.[6–8] Studies on the survival of zirconia crowns is limited to a maximum of 5 years,[3] and systematic reviews based on randomized control clinical trials (RCTs) reporting on the clinical performance of zirconia crowns determined that the included studies showed risk of bias and poor quality of evidence.[9,10] In addition, many studies have jointly reported on single crowns and fixed partial dentures or implant-supported crowns.[11] Advances in technology lead many studies to be redundant in their reported results; for example, data on pressed ceramic to zirconia,[12] are limited in their usefulness because of the current low popularity of this technique. Veneered zirconia restorations have been shown to demonstrate more technical failures such as chipping of veneered porcelain and including these complicates the overall evaluation of survival and success.[11,13]

Posterior monolithic zirconia crowns without the inherent complications associated with veneered porcelain are reported to have a 3-year cumulative survival rate of 89.8%, with a confidence interval (CI) of 80.0–95.1%.[14] The knowledge of survival and clinical complications of zirconia crowns would be valuable if it is to be considered as an alternative restorative material to metal-ceramic. Direct comparisons of the survival outcomes of zirconia and metal-ceramic crowns are sparse. In an RCT comparing outcomes of complete coverage zirconia crowns to precious metal crowns, no significant differences were reported between groups.[15] The study reported a high risk of performance and detection bias due to lack of blinding and a high risk of attrition bias because of the loss to follow-up.[9] An RCT comparing the 5-year outcomes of 90 endodontically treated posterior teeth with zirconia or metal-ceramic crowns demonstrated a survival rate of 97.7% and 97.4%, respectively.[16] However, the research was considered biased because of the number lost to follow-up in the metal-ceramic group.[17] Overall, the chipping rate for monolithic zirconia crowns was 0% compared with 7.61% for metal-ceramic restorations over a 1-year period.[3] Despite the lack of long-term evidence, monolithic zirconia appears to be a promising alternative to metal-ceramic as a complete coverage restorative material.

The University of Toronto, Faculty of Dentistry predoctoral clinic has provided monolithic zirconia crowns on anterior and posterior single teeth since 2015. At the same time, metal-ceramic crowns continued to be used for complete coverage restorations, thus providing an opportunity for a direct comparison of outcomes. The null hypothesis was that no difference in survival and clinical complications would be found between zirconia and metal-ceramic crowns cemented on single teeth and followed up for the same time period.

MATERIAL AND METHODS

The study was designed as a retrospective chart review from the electronic health record (EHR) system (axiUm Academic Dental Software; Exan Software) of all single monolithic (3–4Y) zirconia crowns and metal-ceramic crowns that were inserted between September 2015 and July 2016 and followed up until May 2023. Ethics approval was obtained from the University Research Oversight and Compliance office (REB protocol # 00044441). All zirconia crowns were made by a single laboratory (Shaw Labs North York) manufactured from zirconia stabilized with 6.1% to 8.2% yttrium dioxide (IdentCeram; Argen Corp), milled with the 5-axis dental milling machine (DWX-50; Roland DGA Corp), and then stained and glazed (IPS e.max porcelain; Ivoclar AG). The metal-ceramic crowns were made from a noble metal alloy (IdentAlloy; AuriDent Inc) containing Au 2.5%, Pd 70.3%, and Pt 0.1%. The copings were veneered with porcelain (IPS Inline; Ivoclar AG, Initial; GC America Inc). The researchers relied on clinical notes and records for accuracy. The patient demographic data collected included age, sex, and smoking status. Preinsertion variables included abutment tooth, reasons for crown including endodontic treatment, extensive restoration, replacement crown, embrasure clasp, tooth

sensitivity, and other nonspecified reasons. Other variables collected included pulp vitality, details of endodontic treatment if any, whether the tooth was restored with a post-and-core, and type of core material. In addition, the status of the opposing tooth, present or missing, whether opposed by a removable, fixed, or implant-supported prosthesis, presence or absence of proximal contacts, and type of cement used at insertion were recorded (Table 1). The insertion date, follow-up dates, complaints, and procedures performed at follow-up were recorded.

Outcomes were reported as survival when the tooth with the crown was still in function with or without clinical complications, during and up to the end of follow-up. The complications recorded during follow-up included occlusal adjustment, follow-up sensitivity, open margin, recurrent caries, infection, endodontic treatment or retreatment, repair of porcelain, re-cementation, non-healed endodontic lesion, bone loss and associated periodontal problems, and chipped crown. Failures were reported when the tooth was no longer present in the mouth at follow-up because of biological complications such as tooth or core fracture rendering the tooth nonrestorable, tooth extracted because of infection or caries, and technical complications such as crown fracture or crown replaced because of inadequate fit (Table 2). Success was recorded as surviving crowns having no complications.

The Cohen kappa coefficient was used to assess interrater agreement between 2 independent raters for patient data before and after crown insertion for zirconia and metal-ceramic crowns separately. Descriptive statistics (frequency, percentages, mean, median, standard deviation) were used to summarize the collected data. Comparison between metal-ceramic and zirconia crowns was performed by using the chi-squared test (for categorical variables), the independent samples *t* test for normally distributed numerical variables (age) and the Mann-Whitney test for skewed variables (follow-up duration). Significant differences in variables with multiple categories were further examined within each category by using the Bonferroni-adjusted z test for proportions. Crown failures were explored by using Kaplan-Meier survival analysis including Cox proportional regression to compare metal-ceramic and zirconia crowns. The bivariate association between categorical predictors and crown failure was examined by using the chi-squared test or Fisher exact test for small counts. Binary logistic regression models were used to examine the bivariate relationship between continuous predictors and binary outcomes. All analysis was performed using a statistical software package (IBM SPSS Statistics, v29; IBM Corp) (α=.05 for all tests).

RESULTS

For zirconia crowns, the interrater reliability (kappa) was 0.920 (95% CI 0.865–0.975) for data before insertion and 0.843 (95% CI 0.676–1.000) for data after insertion. For metal-ceramic crowns, the interrater reliability (kappa) was 0.792 (95% CI 0.719–0.865) for data before insertion and kappa=1.00 for data after insertion.[18] The patients were followed for up to 7 years with a mean (M) of 3.00 years and median of 2.58 years. Forty-one crowns (8.0%) had no follow-up, with no significant difference between crown types (metal-ceramic n=23 (7.5%) versus zirconia n=18(8.6%), $\chi^2(1)=0.20$, P=.652). Excluding crowns with no follow-up, the follow-up period was M=3.26 years, median=2.92 years, with no significant difference in follow-up between metal-ceramic (M=3.07, median=2.58) and zirconia (M=3.54, median=3.32), Mann-Whitney P=.052.

There were 515 crowns, 209 zirconia and 306 metal-ceramic. The mean (M) ±standard deviation (SD) ages of the patients in the zirconia group was 54.25 ±13.17 and in the metal-ceramic group was 59.43 ±13.85, t(513)=4.25, P<.001. The proportion of non-smokers was higher in the metal-ceramic group (67.0% versus 54.5%) $\chi^2(2)=8.36$, P=.015. There were 62 anterior crowns (12.0%) and 453 posterior crowns (88.0%). These differences were significant for both groups $\chi^2(1)=22.40$, P<.001, with no difference between groups. The majority of teeth in both groups (63.9%) were endodontically treated, 41.8% of these had posts in the metal-ceramic group compared with 32.5% in the zirconia group $\chi^2(1)=4.46$, P=.035, and the majority of crowns were placed in the maxillary (n=224,43.5%) and mandibular posterior (n=229, 44.5%) regions. The remaining crowns were distributed between the maxillary (n=45,8.7%) and mandibular anterior (n=17,3.3%) regions. Significant differences were found in the number of crowns in the maxillary anterior and maxillary posterior regions between groups, metal-ceramic (13.1% and 39.9%) and zirconia (2.4% and 48.8%) respectively $\chi^2(3)=22.86$, P<.001. More replacement crowns were needed for the metal-ceramic (18.3%) group compared with the zirconia (9.6%) group, $\chi^2(3)=9.34$, P=.025 (Table 1).

Overall, 44 crowns (8.5%) failed, 30(9.8%) in the metal-ceramic group and 14(6.7%) in the zirconia group, with no significant differences in proportion of failed crowns between groups, $\chi^2(1)=1.53$, P=.216. Thirty-five crowns had biological failures (a 6.8% failure rate), 26(8.5%) in the metal-ceramic group and 9 (4.4%) in the zirconia group, with no significant difference between groups, Fisher exact P=.431. There were 9 crowns with technical failures, representing a 1.7% failure rate, 4(1.4%) in the metal-ceramic group and 5(2.5%) in the

Table 1. Demographic characteristics of study participants

	Overall Sample (n=515)	Metal-Ceramic (n=306)	Zirconia (n=209)	Difference Between Crown Types
Sex				
Male	197 (38.3%)	107 (35.0%)	90 (43.1%)	$\chi^2(1)=2.65$,
Female	305 (59.2%)	188 (61.4%)	117 (56.0%)	$P=.104$
Not available	13 (2.5%)	11 (3.6%)	2 (1.0%)	
Age, years	57.33 ±13.80	59.43 ±13.85	54.25 ±13.17	t(513)=4.25, $P<.001$
Smoking				
No	319 (61.9%)	205 (67.0%)	114 (54.5%)	$\chi^2(2)=8.36$,
Yes	61 (11.8%)	32 (10.5%)	29 (13.9%)	$P=.015$
Previous	130 (25.2%)	66 (21.6%)	64 (30.6%)	
Not available	5 (1.0%)	3 (1.0%)	2 (1.0%)	
Tooth site				
Maxillary anterior	45 (8.7%)	40 (13.1%)^A	5 (2.4%)^B	$\chi^2(3)=22.86$,
Maxillary posterior	224 (43.5%)	122 (39.9%)^A	102 (48.8%)^B	$P<.001$
Mandibular anterior	17 (3.3%)	14 (4.6%)	3 (1.4%)	
Mandibular posterior	229 (44.5%)	130 (42.5%)	99 (47.4%)	
Tooth site				
Anterior	62 (12.0%)	54 (17.6%)	8 (3.8%)	$\chi^2(1)=22.40$,
Posterior	453 (88.0%)	252 (82.4%)	201 (96.2%)	$P<.001$
Reason for crown				
Endodontically treated	297 (57.7%)	167 (54.6%)	130 (62.2%)	$\chi^2(3)=9.34$,
Large restoration	124 (24.1%)	70 (22.9%)	54 (25.8%)	$P=.025$
Replacement crown	76 (14.8%)	56 (18.3%)^A	20 (9.6%)^B	
Other[a]	18 (3.5%)	13 (4.2%)	5 (2.4%)	
Previous endodontic treatment	329 (63.9%)	191 (62.4%)	138 (66.0%)	$\chi^2(1)=0.70$, $P=.402$
Pulp vitality				
Vital	52 (10.1%)	28 (9.2%)	24 (11.5%)	$\chi^2(1)=0.32$,
Nonvital	331 (64.3%)	192 (62.7%)	139 (66.5%)	$P=.573$
Not available	132 (25.6%)	86 (28.1%)	46 (22.0%)	
Post				
No	315 (61.2%)	176 (57.5%)^A	139 (66.5%)^B	$\chi^2(1)=4.46$,
Yes	196 (38.0%)	128 (41.8%)^A	68 (32.5%)^B	$P=.035$
Not available	4 (0.8%)	2 (0.7%)	2 (1.0%)	
Post cement				
Glass Ionomer cement	6 (1.2%)	5 (1.6%)	1 (0.5%)	Fisher exact test $P=.406$
RelyX UniCem	139 (27.0%)	84 (27.5%)	55 (26.3%)	
Not available	370 (71.8%)	217 (70.9%)	153 (73.2%)	
Core material				
Bonded composite resin	231 (44.9%)	135 (44.1%)	96 (45.9%)	$\chi^2(2)=1.36$,
Bonded amalgam	18 (3.5%)	8 (2.6%)	10 (4.8%)	$P=.506$
Nonbonded amalgam	22 (4.3%)	13 (4.2%)	9 (4.3%)	
Not available	244 (47.4%)	150 (49.0%)	94 (45.0%)	

Values reported as N(%) or Mean ±SD

^{AB}Different letters represent significant difference between metal-ceramic and zirconia within each category (Bonferroni corrected)

[a] Other reason included embrasure clasp, sensitivity, and unknown

Table 2. Causes of failure

	Overall Sample (n=44)	Metal-Ceramic (n=30)	Zirconia (n=14)	Difference Between Crown Types
All failures				
Crown fracture	1 (2.3%)	0 (0%)	1 (7.1%)	Fisher exact $P=.148$
Tooth fracture	22 (50.0%)	15 (50.0%)	7 (50.0%)	
Crown replaced	8 (18.2%)	4 (13.3%)	4 (28.6%)	
Tooth extracted	13 (29.5%)	11 (36.7%)	2 (14.3%)	
Categorized failure				
Biological	35 (79.5%)	26 (86.7%)	9 (64.3%)	Fisher exact $P=.117$
Technical	9 (20.5%)	4 (13.3%)	5 (35.7%)	
Biological				
Tooth fracture	22 (62.9%)	15 (57.7%)	7 (77.8%)	Fisher exact $P=.431$
Tooth extracted	13 (37.1%)	11 (42.3%)	2 (22.2%)	
Technical				
Crown fracture	1 (11.1%)	0 (0%)	1 (20.0%)	Fisher exact $P>.999$
Crown replaced	8 (88.9%)	4 (100%)	4 (80.0%)	

zirconia group, with no significant difference between groups, Fisher exact $P>.999$ (Table 2). Biological (79.5%) rather than with technical complications were found to be most frequent cause of failure, goodness-of-fit $\chi^2(1)=15.36$, $P<.001$. Tooth fracture (50.0%), specifically, was found to be the most frequent cause of failure, $\chi^2(3)=21.27$, $P<.001$. No significant difference was found between metal-ceramic and zirconia crowns with regard to any of the causes of failure, Fisher exact $P=.148$ and Fisher exact $P=.117$ (Table 2). The Kaplan Meier survival analysis estimates for survival time (years) for metal-ceramic crowns was M=6.26, 95% CI [6.01–6.51] and

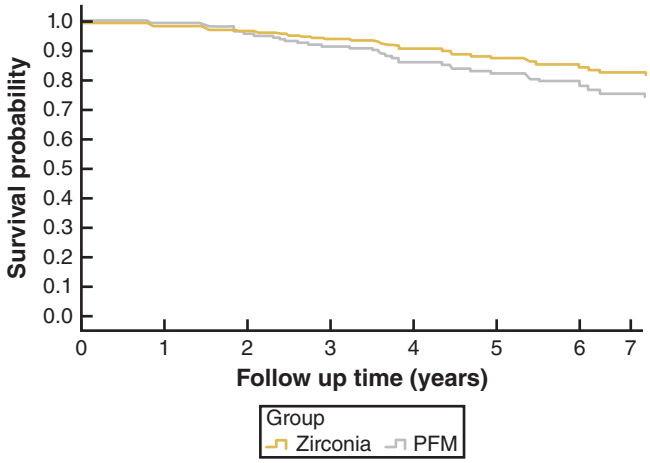

Figure 1. Survival comparison between groups.

zirconia crowns M=6.54, 95% CI [6.31 – 6.77]. No significant difference was found between metal-ceramic and zirconia in terms of failure and time to failure with Cox proportional regression *P*=.106 (Fig. 1).

Within-group comparisons were made looking at predictors of failure. Within the metal-ceramic group, there were significantly more failures among those who had a previous history of smoking (16.7%, *P*=.018) and where the crown did not have a distal proximal contact (15.7% *P*=.014). Within the zirconia group, there were more failures for patients who had received a crown for an endodontically treated tooth (5.4%) or an extensive restoration (3.7%) compared with patients who had received a replacement crown (20%) *P*=.042 (Table 3).

The total number of crowns that survived was 471(91.5%): 276 were metal-ceramic (90.1%) and 195(93.3%) zirconia. Of the crowns that survived, 370(78.6%), metal-ceramic n=217(78.6%) and zirconia n=153(78.5%) had no clinical complications during follow-up and were determined as 'successful.' A total of 101(21.4%) crowns developed complications during follow-up. Surviving crowns demonstrated similar clinical complications, with no significant differences between groups (Table 4). The clinical complications were addressed during routine clinical appointments, and all were in function at the end of follow-up. In a secondary analysis looking at predictors of tooth fracture, anterior tooth sites demonstrated more fractures than posterior tooth sites in both groups, Fisher exact test *P*=.039 (Table 5).

Table 3. Predictors of failure

	Failure Rates N (%)		
	Overall Sample (n=44)	**Metal-Ceramic (n=30)**	**Zirconia (n=14)**
Sex	*P*=.488	*P*=.157	*P*=.544
Male	19 (9.6%)	14 (13.1%)	5 (5.6%)
Female	24 (7.9%)	15 (8.0%)	9 (7.7%)
Age, years	OR=1.02	OR=1.02	OR=1.01
	P=.126	*P*=.144	*P*=.856
Smoking	*P*=.075	*P*=.018^{F}	*P*=.927^{F}
No	20 (6.3%)	13 (6.3%)^{A}	7 (6.1%)
Yes	7 (11.5%)	5 (15.6%)	2 (6.9%)
Previous	16 (12.3%)	11 (16.7%)^{B}	5 (7.8%)
Tooth site	*P*=.609	*P*=.758^{F}	*P*=.479^{F}
Maxillary anterior	6 (13.3%)	5 (12.5%)	1 (20.0%)
Maxillary posterior	17 (7.6%)	11 (9.0%)	6 (5.9%)
Mandibular anterior	2 (11.8%)	2 (14.3%)	0 (0%)
Mandibular posterior	19 (8.3%)	12 (9.2%)	7 (7.1%)
Tooth site	*P*=.190	*P*=.390	*P*=.431^{F}
Anterior	8 (12.9%)	7 (13.0%)	1 (12.5%)
Posterior	36 (7.9%)	23 (9.1%)	13 (6.5%)
Reason for crown	*P*=.457	*P*=.716^{F}	*P*=.042^{F}
Endodontic treatment	25 (8.4%)	18 (10.8%)	7 (5.4%)^{A}
Large restoration	8 (6.5%)	6 (8.6%)	2 (3.7%)^{A}
Replacement crown	8 (10.5%)	4 (7.1%)	4 (20.0%)^{B}
Other[a]	3 (16.7%)	2 (15.4%)	1 (20.0%)
Previous endodontic treatment	*P*=.770	*P*=.367	*P*=.561^{F}
No	15 (8.1%)	9 (7.8%)	6 (8.5%)
Yes	29 (8.8%)	21 (11.0%)	8 (5.8%)
Pulp vitality	*P*=.954	*P*>.999^{F}	*P*=.691^{F}
Vital	5 (9.6%)	3 (10.7%)	2 (8.3%)
Nonvital	31 (9.4%)	21 (10.9%)	10 (7.2%)
Post	*P*=.968	*P*=.806	*P*=.776^{F}
No	27 (8.6%)	18 (10.2%)	9 (6.5%)
Yes	17 (8.7%)	12 (9.4%)	5 (7.4%)
Core	*P*=.408	*P*=.657^{F}	*P*=.602^{F}
Bonded composite resin	17 (7.4%)	13 (9.6%)	4 (4.2%)
Bonded amalgam	1 (5.6%)	0 (0%)	1 (10.0%)
Nonbonded amalgam	0 (0%)	0 (0%)	0 (0%)
Opposing	*P*=.223	*P*=.252^{F}	*P*=.173^{F}
Natural tooth	35 (8.1%)	23 (8.8%)	12 (6.9%)
Missing tooth	7 (9.6%)	6 (14.6%)	1 (3.1%)
Complete/implant-supported denture	2 (25.0%)	1 (20.0%)	1 (33.3%)
Mesial bound by natural teeth	*P*=.180	*P*=.108^{F}	*P*>.999^{F}
No	9 (12.7%)	8 (16.7%)	0 (0%)
Yes[b]	35 (7.9%)	22 (8.5%)	7 (3.9%)
Distal bound by natural teeth	*P*=.065	*P*=.014	*P*=.763^{F}
No	19 (11.9%)	16 (15.7%)	3 (5.3%)
Yes[b]	25 (7.0%)	14 (6.9%)	11 (7.2%)

^{AB}Different letters represent significant difference between smoking categories and between reasons for crown

^{F}Fisher exact test *P* value

Note: Values reported as N (%); OR=odds ratio from logistic regression

[a] Other reasons included embrasure clasp, sensitivity, and unknown

[b] Including implants

DISCUSSION

The results supported the null hypothesis that no difference in survival and clinical complications would be found between zirconia and metal-ceramic crowns cemented on single teeth and followed up for the same time. Although nonmetallic restorative materials provide improved esthetics, there is still uncertainty regarding their longevity when compared with metal-ceramic restorations.[9] An estimated survival of 94.4 ±2.78% was reported for 1269 high noble alloy metal-ceramic crowns provided between 1996 and 2008.[19] Five-year survival rates of ceramic crowns have been reported to range from 90.7% to 96.6% depending upon the type of ceramic used and location of the crown in the anterior or posterior region.[10] When compared with gold crowns,

Table 4. Survival observations with nonfailed crowns

	Overall Sample (n=471)	Metal-Ceramic (n=276)	Zirconia (n=195)	Difference Between Crown Types
Success- no observed issues	370 (78.6%)	217 (78.6%)	153 (78.5%)	$\chi^2(1)=0.00$, $P=.966$
Occlusal/crown adjustment	18 (3.8%)	10 (3.6%)	8 (4.1%)	$\chi^2(1)=0.07$, $P=.789$
Follow up sensitivity/pain	39 (8.3%)	22 (8.0%)	17 (8.7%)	$\chi^2(1)=0.08$, $P=.772$
Open margin	7 (1.5%)	5 (1.8%)	2 (1.0%)	Fisher exact $P=.705$
Recurrent caries	7 (1.5%)	3 (1.1%)	4 (2.1%)	Fisher exact $P=.455$
Infection	8 (1.7%)	4 (1.4%)	4 (2.1%)	Fisher exact $P=.723$
Endodontic treatment	5 (1.1%)	3 (1.1%)	2 (1.0%)	Fisher exact $P>.999$
Repaired/polished porcelain	5 (1.1%)	4 (1.4%)	1 (0.5%)	Fisher exact $P=.409$
Tooth mobility				
No	461 (97.9%)	272 (98.6%)	189 (96.9%)	Fisher exact $P=.251$
Loose crown	7 (1.5%)	2 (0.7%)	5 (2.6%)	
Loose tooth	3 (0.6%)	2 (0.7%)	1 (0.5%)	
Crown recemented	7 (1.5%)	2 (0.7%)	5 (2.6%)	Fisher exact $P=.132$
Endodontic treatment not healing	3 (0.6%)	1 (0.4%)	2 (1.0%)	Fisher exact $P=.572$
Periodontitis/bone loss	36 (7.6%)	25 (9.1%)	11 (5.6%)	$\chi^2(1)=1.89$, $P=.169$
Irreversible pulpitis	4 (0.8%)	0 (0%)	4 (2.1%)	Fisher exact $P=.029$
Periapical radiolucency	3 (0.6%)	2 (0.7%)	1 (0.5%)	Fisher exact $P>.999$
Chipped crown	2 (0.4%)	2 (0.7%)	0 (0%)	Fisher exact $P=.514$
Total number of observations				
0	370 (78.6%)	217 (78.6%)	153 (78.5%)	Fisher exact $P=.250$
1	65 (13.8%)	42 (15.2%)	23 (11.8%)	
2	26 (5.5%)	11 (4.0%)	15 (7.7%)	
3	8 (1.7%)	4 (1.4%)	4 (2.1%)	
4	2 (0.4%)	2 (0.7%)	0 (0.0%)	

Note: Values reported as N (%)

[AB]Different letters represent significant difference between metal-ceramic and zirconia within each category (Bonferroni corrected)

$ZrSiO_4$ was reported to have inferior marginal integrity and increased marginal discoloration and was not recommended for posterior restorations.[20] A previous study on both zirconia and metal-ceramic single crowns reported a significantly lower estimated 5-year survival rate for the zirconia crowns.[10]

The present study directly compared the survival, failure, success, and complications of monolithic zirconia crowns with metal-ceramic crowns in a setting where procedures for patient selection, abutment preparation, crown insertion, and follow-up were standardized. The survival rates and clinical complications between the 2 groups were found to be similar and fell within the range reported in similar studies.[5,14] However, they also differed from previously reported results, possibly because of the limited data comparisons available for similar variables, including a direct comparison with metal-ceramic crowns inserted at the same time, anterior versus posterior sites, type of alloy used in crown fabrication, absence of veneering porcelain and use of yttrium stabilized zirconia for crown fabrication.[11,13,20,21] Biological complications, as reported in the present study, were also reported as a common complication in a previous study.[19]

Definitive conclusions cannot be drawn regarding the predictors of tooth fracture. The results should be interpreted with caution because of the small sample sizes and because the predictors of tooth fracture were not the primary outcome tested in the study. Future research should focus specifically on fractured teeth and their associations with other predictors. The type of cement used was not evaluated because the clinical records were often not clear. However, it was recently reported that there were no differences in the retention of monolithic zirconia crowns with the 2 dual-polymerizing self-adhesive resin cements, Rely-X Unicem or Panavia SA Cement, commonly used in the predoctoral clinic.[22]

The present study serves to inform dentists that the survival rate and clinical complications to be expected when using monolithic zirconia are similar to those of metal-ceramic single tooth complete coverage restorations. Limitations of the study included the retrospective design and lack of specific inclusion and exclusion criteria or randomization. The results cannot be extrapolated to veneered zirconia crowns or zirconia crowns used as abutments for removable partial dentures. In addition, the university setting limits the generalizability of results because of the crown selection criteria and protocols followed for clinical procedures. Future research should include a clinical evaluation at follow-up, including the wear of opposing enamel and a private practice assessment of a similar patient population.

Table 5. Factors predicting tooth fracture

	Tooth Fracture N (%)		
	Overall Sample (n=22)	**Metal-Ceramic (n=15)**	**Zirconia (n=7)**
Sex	*P*=.139	*P*=.050	*P*>.999[F]
Male	12 (6.3%)	9 (8.8%)	3 (3.4%)
Female	10 (3.4%)	6 (3.4%)	4 (3.6%)
Age, years	OR=1.01	OR=1.03	OR=0.98
	P=.450	*P*=.243	*P*=.480
Smoking	*P*=.139[F]	*P*=.029[F]	*P*>.999[F]
No	10 (3.2%)	6 (3.0%)[A]	4 (3.6%)
Yes	3 (5.3%)	2 (6.9%)	1 (3.6%)
Previous	9 (7.3%)	7 (11.3%)[B]	2 (3.3%)
Tooth site	*P*=.071[F]	*P*=.191[F]	*P*=.249[F]
Maxillary anterior	4 (9.3%)	3 (7.9%)	1 (20.0%)
Maxillary posterior	10 (4.6%)	6 (5.1%)	4 (4.0%)
Mandibular anterior	2 (11.8%)	2 (14.3%)	0 (0%)
Mandibular posterior	6 (2.8%)	4 (3.3%)	2 (2.1%)
Tooth site	*P*=.039[F]	*P*=.156[F]	*P*=.250[F]
Anterior	6/60 (10.0%)	5 (9.6%)	1 (12.5%)
Posterior	16/433 (3.7%)	10 (4.2%)	6 (3.1%)
Reason for crown	*P*=.289[F]	*P*=.342[F]	*P*=.161[F]
Endodontically treated	16 (5.6%)	11 (6.9%)	5 (3.9%)
Large restoration	2 (1.7%)	2 (3.0%)	0 (0%)
Replacement crown	3 (4.2%)	1 (1.9%)	2 (11.1%)
Other[a]	1 (6.3%)	1 (8.3%)	0 (0%)
Previous endodontic treatment	*P*=.082	*P*=.151	*P*=.431[F]
No	4 (2.3%)	3 (2.8%)	1 (1.5%)
Yes	18 (5.7%)	12 (6.6%)	6 (4.4%)
Pulp vitality	*P*>.999[F]	*P*=.677[F]	*P*=.594[F]
Vital	2 (4.1%)	2 (7.4%)	0 (0%)
Nonvital	18 (5.7%)	11 (6.0%)	7 (5.1%)
Post	*P*=.272	*P*=.741	*P*=.226[F]
No	11 (3.7%)	8 (4.6%)	3 (2.3%)
Yes	11 (5.8%)	7 (5.7%)	4 (6.0%)
Core	*P*=.528[F]	*P*>.999[F]	*P*=.427[F]
Bonded composite resin	7 (3.2%)	5 (3.9%)	2 (2.1%)
Bonded amalgam	1 (5.6%)	0 (0%)	1 (10.0%)
Nonbonded amalgam	0 (0%)	0 (0%)	0 (0%)
Opposing	*P*>.999[F]	*P*=.539[F]	*P*=.626[F]
Natural tooth	19 (4.5%)	12 (4.8%)	7 (4.1%)
Missing tooth	3 (4.3%)	3 (7.9%)	0 (0%)
Complete/implant-supported denture	0 (0.0%)	0 (0%)	0 (0%)
Mesial bound by natural teeth	*P*=.203[F]	*P*=.064[F]	*P*>.999[F]
No	5 (7.5%)	5 (11.1%)	0 (0%)
Yes[b]	17 (4.0%)	10 (4.1%)	7 (3.9%)
Distal bound by natural teeth	*P*=.117	*P*=.009[F]	*P*=.193[F]
No	10 (6.7%)	10 (10.4%)	0 (0%)
Yes[b]	12 (3.5%)	5 (2.6%)	7 (4.7%)

Note: Values reported as N (%); OR=odds ratio from logistic regression; [F] Fisher exact test *P*-value

[AB] Different letters represent significant difference between smoking categories

[a] Other reasons included embrasure clasp, sensitivity and unknown reasons

[b] Including implants

CONCLUSIONS

Based on the results of this clinical study, the following conclusions were drawn:

1. Over the study follow-up period, the survival rate of monolithic zirconia crowns was 91.5% and was comparable with that of metal-ceramic crowns.
2. Similar clinical complications were observed in both survival groups during the same period of follow-up.
3. Biological complications, especially tooth fracture, were a significantly more frequent with both types of crowns.
4. Zirconia and metal-ceramic crowns that survived with no clinical complications demonstrated no significant differences between groups.

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Neena L. D'Souza: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Supervision, Writing- original draft preparation. **Emma Jutlah:** Data curation, Investigation, Formal analysis. **Rachel Deshpande:** Data curation. **Eszter Somogyi-Ganss:** Project administration, Writing- review and editing.

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