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CLINICAL SCIENCE

Outcome of zirconia single crowns made by predoctoral dental students: A clinical retrospective study after 2 to 6 years of clinical service

Ritva Näpänkangas, DDS, PhD,[a] Juha Pihlaja, DDS,[b] and Aune Raustia, DDS, PhD[c]

ABSTRACT

Statement of problem. Zirconia has established its role as a reliable ceramic material for fixed prostheses.

Purpose. The purpose of this retrospective study was to evaluate the outcome of zirconia single crowns made by predoctoral students after 2 to 6 years of clinical service.

Material and methods. A cohort of 88 patients treated with zirconia single crowns (mean 3 crowns per patient, range 1 to 12 crowns) from 2007 to 2010 by predoctoral dental students was identified. The patients were invited to attend a clinical examination.

Results. Sixty-six participants (75%) took part in the clinical follow-up (30 women and 36 men; mean age 60.4 years, range 19 to 81 years). Altogether, 190 teeth with single crowns were examined, and the mean follow-up time was 3.88 years (1.85 to 6.04 years). The most common complications were chipping of veneering porcelain (4%) and loss of cementation (4%). The success rate of the zirconia single crowns after 2 to 6 years was 80% and the survival rate 89%.

Conclusions. Zirconia crowns can be successfully used in predoctoral dental education. The success rate of zirconia single crowns after 2 to 6 years was 80% and the survival rate was 89%, in accordance with previous studies. (J Prosthet Dent 2015;113:289-294)

Zirconia has been established as a reliable ceramic material for fixed prostheses in several follow-up studies.[1-11] The survival rate of zirconia has been shown to be similar to that of metal ceramics for both crowns[12] and partial fixed dental prostheses (FDPs).[13-18] Traditional metal ceramic restorations are still the safest option in patients with bruxism, because studies have shown that the veneering porcelain of ceramic restorations has a higher rate of fracture than that of metal ceramic restorations.[19-21]

Zirconia has better mechanical properties than other ceramics, including alumina, glass ceramics, and lithium disilicate.[22] Zirconia is biocompatible and esthetic, and can withstand both tensile and compressive stress.[22,23] The strength of zirconia allows its use in anterior, premolar, and molar areas.[6] Some studies have shown a higher risk of complications for ceramic crowns in the molar area than in anterior or premolar teeth,[24] but in other studies no difference was seen.[5-7] Compared with lithium disilicate, the bond between the resin cement and the zirconia may be weaker.[25] A phosphate monomer is beneficial in bonding.[26] The retention and resistance of zirconia crowns have to be ensured with adequate preparation of the abutment tooth. Another disadvantage of zirconia is a high prevalence of chipping fractures in the veneering porcelain,[20,21,27] even though the techniques and materials of veneers have been improved.[28-30] One option for restorations is to use monolithic

[a]Senior Lecturer, Department of Prosthetic Dentistry and Stomatognathic Physiology, Institute of Dentistry, University of Oulu; and Medical Research Center, Oulu, Oulu University Hospital and University of Oulu, Finland.
[b]Research Assistant, Department of Prosthetic Dentistry and Stomatognathic Physiology, Institute of Dentistry, University of Oulu; and Medical Research Center, Oulu, Oulu University Hospital and University of Oulu, Finland.
[c]Professor, Department of Prosthetic Dentistry and Stomatognathic Physiology, Institute of Dentistry, University of Oulu; and Medical Research Center, Oulu, Oulu University Hospital and University of Oulu, Finland.

Clinical Implications

Zirconia single crowns can be used with adequate survival and success in the predoctoral dental student clinic.

anatomic-contour zirconia without veneering porcelain.[31] A framework fracture is a less frequent complication in zirconia restorations.[32,33]

The marginal gap of zirconia restorations has been shown to be equal to that of metal ceramics.[34,35] The marginal gap has varied among different zirconia materials but has always been clinically acceptable.[36-39] Another issue concerning zirconia restorations is the wear of both zirconia and the antagonist enamel. However, zirconia with adequate surface finish (polishing, glazing) resulted in the least wear of the antagonist enamel among the various dental materials; a smooth surface of zirconia can be obtained with adequate polishing.[40]

In predoctoral dental education, the techniques and materials need to be reliable, because teaching the basic principles of preparation and procedures of prosthetic treatment should be the focus. In addition to the strength of zirconia, the willingness to use metal-free, more esthetic, and less expensive material than metal ceramics also encourages its use in predoctoral dental education alongside metal ceramics. The hypothesis of the study was that zirconia is also suitable for fixed prostheses in predoctoral dental education. The aim of the study was to evaluate the outcome of zirconia single crowns in a 4-year clinical retrospective follow-up study.

MATERIAL AND METHODS

The study protocol was approved by the Ethical Committee of the Northern Ostrobothnia Hospital District (100/2013). A total of 88 patients were treated with 268 zirconia single crowns (mean 2.9 crowns per patient, range 1 to 12 crowns) between 2007 and 2010 by predoctoral dental students (Fig. 1). All patients were invited to a clinical examination, and 66 patients (75%) took part in the study. Nine patients did not attend and did not contact us, 11 patients had moved away (not invited), and 1 patient had died.

Before prosthodontic treatment, the patients received periodontal treatment, caries control, and endodontic treatment, as well as occlusal adjustment if needed. All the preparations were made in accordance with international treatment guidelines.[41] Composite resin (Z250; 3M ESPE) was used for foundation restorations when needed, and a fiber post (RelyX Fiber Post; 3M ESPE) was used in endodontically treated teeth. All the treatment procedures were performed under the supervision of prosthodontists.

Figure 1. Zirconia single crowns restoring maxillary incisors and canine teeth.

Before the definitive cementation of the zirconia single crowns, their esthetic appearance and occlusion were evaluated. The clinical instructor evaluated the fit of the restoration, and the patients were asked whether they were satisfied with the color and esthetics. The restorations were bonded with dual-polymerizing, self-adhesive universal resin cement (RelyX Unicem; 3M ESPE), according to the manufacturer's instructions.

The zirconia frameworks in the single crowns were fabricated from Zirkonzahn Zirconia (Zirkonzahn), NobelProcera Zirconia (Nobel Biocare), or Prettau Zirconia (Zirkonzahn). With Zirkonzahn Zirconia and Prettau Zirconia, the frameworks were fabricated by manual milling and designed for uniform thickness of the veneering porcelain layer. The minimal thickness of the framework was 0.4 mm, and the veneering porcelain (GC Initial Zr; GC Europe) was layered on the frameworks. For NobelProcera Zirconia, the frameworks were fabricated with computer-aided design/computer-aided manufacture (CAD/CAM) and designed for uniform thickness of the veneering porcelain layer. The minimal thickness of the frameworks in the single crowns was 0.4 mm in the anterior area and 0.7 mm in the posterior area. The veneering porcelain (VITA VM 9; VITA Zahnfabrik) was hand layered on the frameworks.

All the follow-up examinations were carried out by the same prosthodontist (R.N.). The participants were asked their opinions about esthetics, color match, contour, gloss, hypersensitivity to cold or heat, gingival bleeding, pain related to the single crowns, and whether they noticed bruxism. At the clinical examination, the periodontal condition (plaque accumulation/plaque index and bleeding on probing/sulcus bleeding index according to Silness and Löe[42]and Mombelli et al[43]), the location of the crown margins related to the gingival margins, caries, or restorations in the crown margin, the presence of endodontic treatment through the prosthetic crown, and the status of the contralateral tooth were evaluated. The difference between the plaque accumulation and

Table 1. Indications for 204 single zirconia crowns

Indication	n	%
Large restoration	81	40
Poor esthetics	31	15
Unstable occlusion	26	13
Fractured restoration or tooth	22	11
Occlusal wear	13	6
Abutment tooth for PRDP	13	6
Old crown	12	6
Periodontal reasons	6	3
TOTAL	204	100

PRDP, partial removable dental prosthesis.

bleeding on probing in the abutment teeth and contralateral teeth were analyzed with the Fisher exact test (α=.05). Porcelain fractures were recorded and classified according to Anusavice.[44] Any dental treatment performed at the Institute of Dentistry after the prosthetic treatment was determined from the patient records (Effica; Tieto).

The longevity of the single zirconia crowns was measured from the day the crown was cemented to the day of a complication, or, if no complications occurred, to the day of the clinical examination. A Kaplan-Meier survival analysis was performed on the basis of these facts and the survival percentage was counted at the point of 4 years because of the low number of single crowns after that time. A successful single crown was defined as a crown that had remained unchanged over the observation period (according to Tan et al[45]). A survived single crown was defined as a crown that was in situ at the examination visit, regardless of its recementation or porcelain fractures (according to Tan et al[45]).

RESULTS

Altogether, 30 women and 36 men were examined. Mean age was 60.4 years (19 to 81 years). Mean follow-up was 3.88 years (1.85 to 6.04 years). Altogether, 204 teeth were prepared for crowns – Zirkonzahn 164 crowns (80%), Procera 21 crowns (21%), and Prettau 19 crowns (9%). The mean number of crowns was 2.9 crowns per patient (range 1 to 10 crowns).

The most common indication for a zirconia single crown was a large existing restoration in the tooth (81/204, 40%) (Table 1). Other common indications were poor esthetics (31/204, 15%) and unstable occlusion (26/204, 13%). The distribution of zirconia single crowns is presented in Figure 2. The opposing dentition was the patient's own teeth in 82% of restorations, a crown or partial FDP in 12%, a complete denture in 4%, and a partial removable dental prosthesis in 2% of the restorations.

One participant had lost all 6 zirconia crowns because of loss of cementation (1 crown), because of root fracture

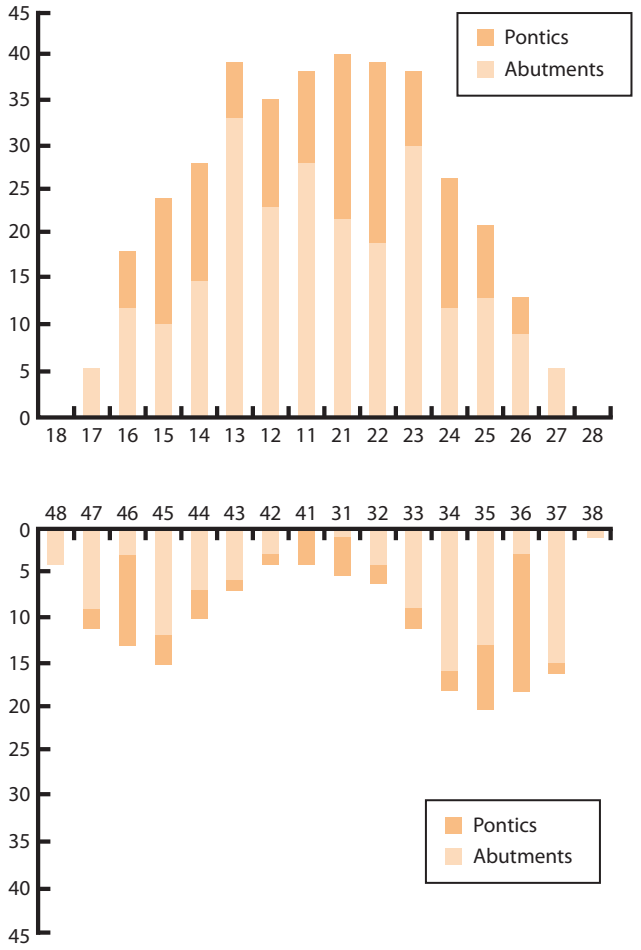

Figure 2. Distribution of single zirconia crowns in dentition.

(2 crowns), and because of a change in the treatment plan for the removable prosthesis (3 crowns). One participant lost 1 molar tooth with a crown because of root fracture, and thereafter 3 other adjacent teeth with crowns were prepared for the abutment teeth of a partial fixed dental prosthesis. The number of individuals in the clinical examination remained at 64. In addition, 2 lost crowns were attributed to cementation and 2 to periapical endodontic infections. The number of crowns in the clinical follow-up remained 190.

Most of the participants were satisfied with the esthetics (63/64 participants), color-match (61/64), contour (61/64), and gloss (64/64) of the zirconia single crowns. Three participants suffered from hypersensitivity to cold, and 3 of 64 participants noticed gingival bleeding. One participant experienced pain. Self-reported bruxism was reported by 26 of 64 participants.

More plaque was seen in contralateral teeth than in teeth with zirconia crowns, but the difference was not statistically significant (P=.376) (Table 2). More bleeding on probing was seen in teeth with zirconia crowns than in contralateral teeth (P=.012) (Table 3).

Table 2. Plaque accumulation (Plaque index) in abutment teeth (n=190) and in contralateral teeth

Plaque Index	Abutment Teeth (%)	Contralateral Teeth (%)
No detection of plaque	77	41
Plaque only recognized by running a probe across the marginal surface of the crown	17	56
Plaque can be seen by the naked eye	6	3

P=.376; Fisher exact test.

Table 3. Bleeding on probing (sulcus bleeding index) around abutment teeth (n=190) and contralateral teeth

Bleeding on Probing	Abutment Teeth (%)	Contralateral Teeth (%)
No bleeding when a periodontal probe is passed along the gingival margin	49	39
Isolated bleeding when a periodontal probe is passed along the gingival margin	40	60
Confluent bleeding when a periodontal probe is passed along the gingival margin	11	1

P=.012; Fisher exact test.

Figure 3. Porcelain fracture in zirconia single crown for maxillary left canine (Grade 1 according to Anusavice[43]). Fracture did not affect function or esthetics and surface has been polished.

Figure 4. Porcelain fracture in zirconia single crown for maxillary right incisor (Grade 1 according to Anusavice[43]). Fracture did not affect function or esthetics and surface has been polished. Bleeding on probing was seen in abutment tooth; location of crown margin was subgingival.

The location of the crown margin was subgingival in 43% of the single crown, marginal in 53%, and supragingival in 4%.

Caries were not found and endodontic treatment was not performed through the prosthetic crown in any of the teeth with zirconia single crowns examined at follow-up. The most common complications were chipping of the veneering porcelain (4%) (Figs. 3, 4) and loss of cementation (4%) (Table 4). According to Anusavice,[44] 3 porcelain fractures were grade 3 (severe chipping fractures requiring replacement of single crowns) and 6 porcelain fractures were grade 1 (fracture surfaces were polished; fractures did not affect function or esthetics). The success rate was 80%, and the survival rate was 89% after 4 years (Fig. 5).

DISCUSSION

The survival rate of zirconia single crowns made by predoctoral dental students in the present study was 89%, in accordance with previous clinical follow-up studies, which found survival rates of 97.3% (5 years, ceramic restorations),[5] 98.1% (5 years),[10] 88.8% (5 years),[7] and 98.2% (3 years).[9] The success rate (80%) here was lower than that reported earlier by Monaco et al[10] (94.3% after 5 years). The limitation of the study was that the zirconia crowns were performed by predoctoral dental students and this may affect the survival of the single crowns. Parafunctional habits and endodontically treated teeth pose a greater risk for failures.[5,10,20] Thus, complications may accumulate in the same individuals and, in the case of complication in 1 crown, the risk for a complication in another crown may increase in an individual with multiple crowns. Early repairable chipping of veneering porcelain may increase the risk for unrepairable porcelain damage later.[13,14] The indications for choosing a material between ceramics, metal ceramics, or high-gold alloys must be well indicated in individual situations.

Several attempts have been made to improve the fracture rate of veneering porcelain in zirconia restorations. Anatomically designed frameworks have been shown to result in a lower rate of porcelain fractures.[28,31] Guess et al[29] showed in an in vitro study that anatomically shaped monolithic lithium disilicate crowns (IPS e-max CAD) resulted in fatigue-resistant crowns compared with hand-layer, veneered zirconia crowns (IPS e-max Zir-CAD/Ceram). The tooth should be adequately reduced to provide sufficient thickness of the veneering porcelain. Occlusion must be evaluated properly, because the number and distribution of occlusal contact points have been shown to significantly influence the stresses induced by occlusal forces in ceramic restorations.[19] In addition, parafunctional habits have to be taken into consideration in treatment planning.[20]

It has been shown that biofilm formation on various types of dental ceramics differ significantly; in particular,

Table 4. Complications in 204 zirconia single crowns

	Zirkonzahn Zirconia		NobelProcera Zirconia		Prettau Zirconia		Total	
Complication	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
No complication	138	84	17	82	18	95	173	85
Porcelain fracture	7	4	2	9	0	0	9	4
Loss of cementation	5	3	2	9	1	5	8	4
Loss of crown								
loss of cementation	3	2	0	0	0	0	3	2
root fracture	3	2	0	0	0	0	3	2
periapical endodontic infections	2	1	0	0	0	0	2	1
change in treatment plan	6	4	0	0	0	0	6	3
Total	164	100	21	100	19	100	204	100

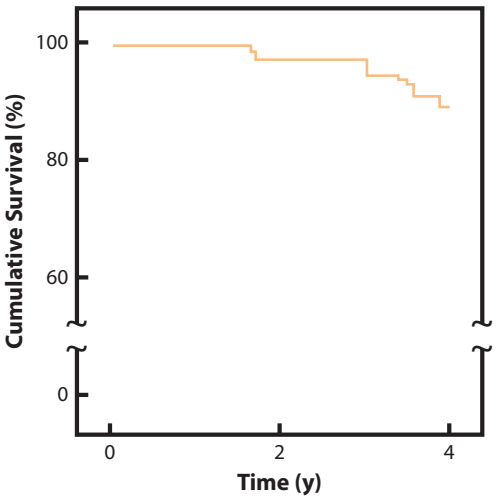

Figure 5. Survival rate in 204 zirconia single crowns was 89% after 4 years.

zirconia exhibited low plaque accumulation compared to glass-ceramic and a lithium disilicate glass-ceramic.[46] Studies have also shown variations in plaque formation among enamel and restorative materials, but it has been concluded that instructing the patient to maintain proper oral hygiene and home care is more important than the choice of restorative material.[47]

On the contrary, the difference between teeth with crowns and contralateral teeth in terms of gingival bleeding was not as clear as the amount of plaque would show. Plaque and gingivitis is obviously one reason for gingival bleeding, but a subgingival crown margin can also cause gingival bleeding, especially when the biological width has been disturbed. Ideally the restoration margin should be placed no more than 0.5 mm subgingivally to prevent the encroachment of biological width and the chronic periodontal inflammation.[48] In addition, localized gingival irritation can be caused by excess cement, which was shown to be a common early complication of single crowns.[49]

Some differences were seen in the number of complications between the zirconia systems, but the number of Zirkonzahn Zirconia and Prettau Zirconia was quite low in this study, and no comparison between the systems was done. However, zirconia systems may exhibit differences, particularly in terms of mechanical failures, marginal adaptation, and color matching,[36,39] although zirconia fabricated by CAD/CAM demonstrated a similar and acceptable marginal fit when compared with metal ceramics.[34] It is important to record the manufacturers of materials in patient files, because in the case of a complication or a possible warranty issue, the material must be identified.

CONCLUSIONS

Zirconia can be successfully used in predoctoral dental education. The success rate of the zirconia single crowns after 4 years was 80%, and the survival rate was 89%, in accordance with previous studies.

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Corresponding author:
Dr Ritva Näpänkangas
University of Oulu
Box 5281, FIN-90014 Oulu
FINLAND
Email: ritva.napankangas@oulu.fi