A retrospective analysis of 102 zirconia single crowns with knife-edge margins

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Statement of problem. Clinical reports of feldspathic porcelain veneered-zirconia crowns placed on teeth with knife-edge marginal finish lines have recently been presented but with data available for only a limited number of crowns in the anterior maxilla.

Purpose. This retrospective study evaluated the clinical success and survival of feldspathic porcelain veneered-zirconia crowns fabricated with knife-edge margins in a private practice.

Material and methods. One hundred and two teeth (51 anterior, 51 posterior) were prepared with knife-edge margins and restored with feldspathic porcelain veneered-zirconia crowns. The modified California Dental Association (CDA) criteria were used to clinically evaluate subjects recalled between May and December 2010. Data were analyzed with descriptive statistics.

Results. The mean follow-up time was 20.9 months (SD, 13.6; range, 10-72). One tooth had to be extracted because of an endodontic problem not related with the restoration, 2 crowns had minor chipping of the veneering porcelain, while no crowns exhibited fracture of the zirconia core.

Conclusions. In this retrospective evaluation, feldspathic porcelain veneered-zirconia crowns with knife-edge margins provided clinical performance similar to that reported with other margin designs. (J Prosthet Dent 2012;107:317-321)

Clinical Implications

Results suggest that knife-edge margins in feldspathic porcelain veneered-zirconia crowns do not affect the clinical performance of the restorations.

Zirconia (ZrO_2) has been clinically tested during the last 10 years as an alternative to metal frameworks for fixed prostheses.[1,2] The development of computer-aided design/computer-aided manufacturing (CAD/CAM) technology allows precise and consistent manufacturing of zirconia ceramics with high strength and toughness.[1] Since 1998, 15 studies have demonstrated a 90% or greater success rate with zirconia-based prostheses.[2] Based on the limited number of short-term in vivo studies, zirconia appears to be suitable for the fabrication of single crowns,[3-6] partial fixed dental prostheses (FDPs), and implant abutments,[2] providing that strict protocols are adhered to during the manufacturing and placement process. Moreover several recent in vitro studies have investigated factors that affect fit, marginal discrepancy, bond strength of veneering ceramic.[7-15] One of the currently recommended manufacturer guidelines requires that shoulder, chamfer, or light chamfer marginal finish lines be prepared for zirconia restorations.

Tooth preparations without a defined finish line have historically been defined in several different ways, such as knife edge, feather edge, or

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shoulderless. Generally, they may be termed vertical preparations as opposed to horizontal ones (shoulder, chamfers).[16] These tooth preparations require an acute, knife-edge margin of the restoration. One of the most common indications for knife edge preparations has been the use of periodontally involved teeth as abutments for fixed prostheses.[17] In these patients it is common to observe recession of the gingival margin, so that an eventual tooth preparation with a horizontal finish line design would require the removal of a substantial amount of tooth structure, possibly compromising the long-term prognosis of the tooth. In theory, preserving a maximum amount of sound tooth structure during tooth preparation for fixed abutments, as it is done in vertical preparations, might be a less invasive alternative to a horizontal margin (shoulder or chamfer). This would be true not only for periodontally treated teeth, but also in other clinical conditions such as endodontically treated teeth, vital teeth in young individuals, and teeth affected by caries at the cervical third of the clinical crown.[18] Moreover, when preparing teeth for crowns with metal margins, in vitro tests have measured smaller marginal openings for vertical tooth preparations than horizontal ones.[19] From a periodontal perspective, the suggested advantages of horizontal margins over vertical ones[20,21] have not been clinically demonstrated. However, histological evidence exists showing no difference in periodontal health among different geometrical patterns of margin designs.[22] Moreover, the presence of crown margins in teeth restored with knife edge margins has shown no more influence over gingival conditions than natural teeth in a sample of periodontal patients.[23]

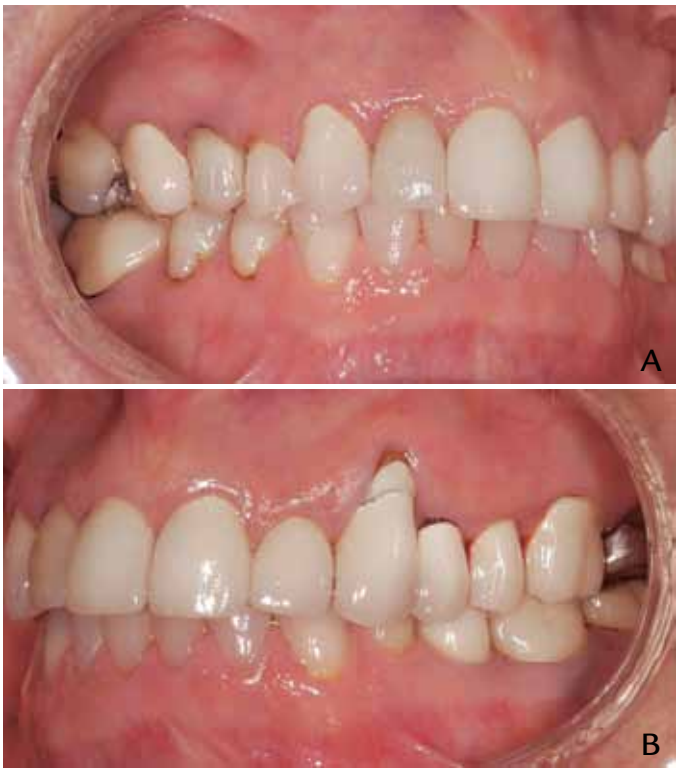
Knife edge margins for zirconia crowns have been evaluated in vitro.[21, 24,25] Significantly higher mean failure load was measured for cemented zirconia copings with knife edge margins versus chamfer.[24] Moreover, when crown fracture load was measured, crowns placed over shoulderless preparations were not significantly different from those placed on shoulder preparations and had greater fracture load than those placed on slight chamfer, deep chamfer, and beveled shoulder preparations.[21] Absolute marginal openings with the feather-edge finish line were significantly lower than those of the chamfer, shoulder and mini-chamfer finish line types.[25]

One clinical study of knife-edge zirconia restorations was recently published with no zirconia framework fractures encountered in a limited number (n=19) of crowns in the anterior maxilla[18] and another reported the use of knife-edge finish lines but no data were presented.[26]

Therefore, the purpose of this retrospective analysis was to examine 102 feldspathic porcelain veneered-zirconia crowns with knife-edge margins (51 anterior, 51 posterior) after periods of service up to 72 months.

MATERIAL AND METHODS

This retrospective study evaluated 102 knife-edge zirconia crowns placed in 31 patients in a private practice in Italy (CEP) (Fig. 1). All patients consecutively treated with zirconia single crowns with knife-edge margins over a 6-year period were included (Table I). All of the crowns were available to follow-up and were evaluated during maintenance appointments between June and December 2010. The clinical evaluation was made by a different clinician working in the same practice who applied the modified California Dental Association (CDA) criteria.[27] The distribution of crowns by tooth position is presented in Table II. At the time of treatment, all teeth received a shoulderless preparation and an occlusal reduction of approximately 2.0 mm. Provisional crowns were fitted and luted with zinc oxide eugenol (ZOE) cement (Temp Bond; Kerr Corporation, Orange, Calif). At



1 Subject requiring remake of existing restorations and correction of periodontal conditions A. Right side, B. Left side.

TABLE I. Distribution of patients and crowns cemented

	Number of Crowns	Number of Subjects
	1	15
	2	5
	3	4
	4	2
	5	1
	6	1
	8	2
	11	1
	19	1
Total	102	31

TABLE II. Distribution, mean age, standard deviation, median age, and range (months) of crowns at time of clinical evaluation

	n	Mean (SD)	Median	Range
Incisors	37	23.4 (19.6)	14	10-72
Canines	13	20.2 (12.8)	17	10-56
Premolars	29	20.3 (8.2)	21	12-56
Molars	22	17.6 (4.6)	16	13-25
Total	101	20.9 (13.6)	16	10-72

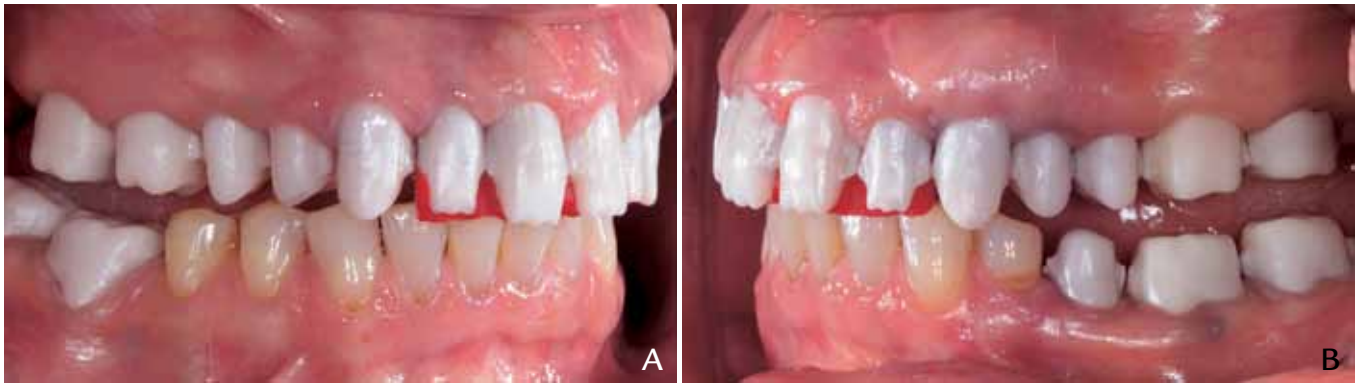
TABLE III. Distribution of zirconia frameworks according to CAD/CAM procedure

Product	Manufacturer	Number of Crowns
Biotech	Biotech srl Nerviano, Italy	12
Diadem	Ivoclar Vivadent AG Schaan, Liechtenstein	19
IPS e.max ZirCAD	Ivoclar Vivadent AG Schaan, Liechtenstein.	2
Lava	3M ESPE St Paul, Minn	52
Procera	Nobel Biocare Göteborg, Sweden	7
Wieland	Wieland Dental GmbH Pforzheim, Germany	1

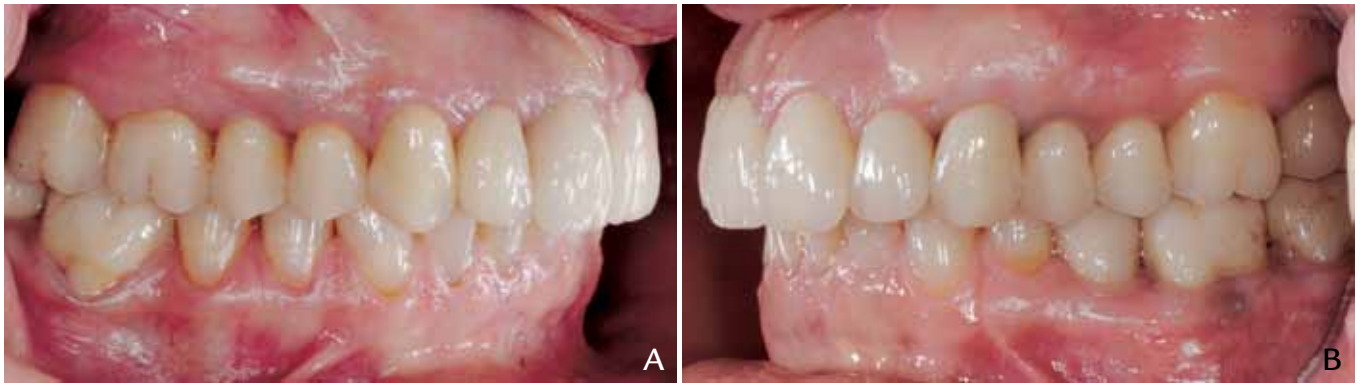
least 2 weeks after tooth preparation and after a double retraction cord technique was used to manipulate the soft tissue (Ultrapack; Ultradent Products Inc, South Jordan, Utah) impressions were made with a polyether impression material (Impregum Penta; 3M ESPE AG, Seefeld, Germany. Impressions were poured and casts were scanned to obtain 3-dimensional (3-D) data sets for the fabrication of the zirconia knife-edge margin frameworks by using a CAD/CAM procedure (Table III). Frameworks were designed to provide adequate support to veneering ceramic. To avoid a bulky emergency profile a thinned zirconia margin, triangular in section, with height ranging from 0.5 mm in the vestibular areas up to 3.0 mm in the interproximal areas was created allowing space for veneering ceramic coronal to it. The frameworks were then clinically fitted on the abutments with a silicone material (Fit Checker Black; GC America Inc, Alsip Ill) (Fig. 2). The copings were then veneered with feldspathic porcelain and the crowns were cemented (Fig. 3). All patients were enrolled in a maintenance program every 3 to 6 months according to their periodontal conditions. During maintenance appointments, between June and December 2010, the crowns were visually evaluated for apparent alterations in their structure (chips, cracks, fractures) while marginal integrity was carefully evaluated with a sharp dental explorer. Data were gathered according to the modified CDA criteria and evaluated with descriptive statistics.

RESULTS

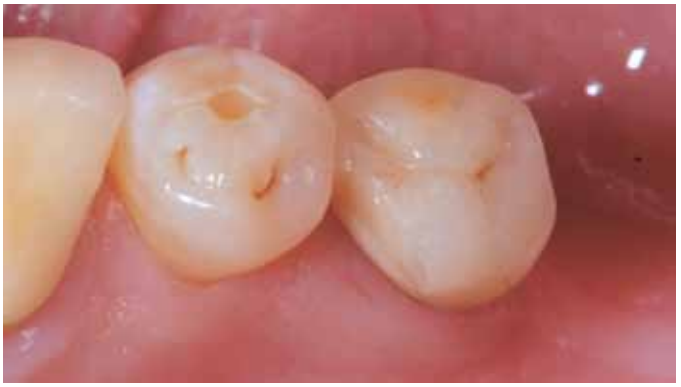
One tooth had to be extracted due to an endodontic complication not related to the restoration. The tooth was a maxillary left lateral incisor which had previously been treated with a metal ceramic crown and a metal post. No attempt was made to remove the original post to perform a new endodontic treatment at the time of preparation for the zirconia crown.



2 Evaluation of zirconia cores. A. Right side, B. Left side.



3 Definitive single crowns. A, Right side, B Left side.



4 Chipping on mandibular right second premolar near to proximal contact area, after 18 months. Crown was rated "tango" (insufficient but repairable) for anatomic form and repaired with composite resin.

Eight months after cementation of the zirconia crown, the tooth developed a periapical lesion and a fistula; it was then extracted and an implant placed. The patient was treated with 6 other zirconia crowns according to the same protocol, which were all available for evaluation. Therefore, at the time of clinical evaluation (mean, 20.9 months; SD, 13.7 months; median 16 months; range, 10-72 months), 101 of the 102 crowns were available (Table II). Of these, none showed core fracture. All crowns were rated excellent for marginal integrity, while 99 were rated excellent for surface and anatomic form. One crown was rated acceptable for anatomic form because of chipping of the veneering porcelain, which required polishing, while one crown was rated insufficient but repairable because of chipping of the veneering porcelain adjacent to the proximal contact area (Fig. 4). For this patient, the veneering porcelain was etched and silanated and an adhesive direct composite resin restoration was placed. Ninety-three crowns were rated excellent and 8 acceptable for color (Table IV).

TABLE IV. Clinical rating (California Dental Association) for zirconia crowns at time of clinical evaluation (June-December 2010, n=101)

Product	Manufacturer	Number of Crowns
Biotech	Biotech srl Nerviano, Italy	12
Diadem	Ivoclar Vivadent AG Schaan, Liechtenstein	19
IPS e.max ZirCAD	Ivoclar Vivadent AG Schaan, Liechtenstein.	2
Lava	3M ESPE St Paul, Minn	52
Procera	Nobel Biocare Göteborg, Sweden	7
Wieland	Wieland Dental GmbH Pforzheim, Germany	1

DISCUSSION

Among the metal-free materials used for small FDPs, zirconia has demonstrated good results in follow-up studies of up to 5 years[2] However, there are only a few studies on the clinical performance of zirconia crowns in contrast to several reports on zirconia FDPs.[3-6]

The present study found favorable results for knife-edge feldspathic porcelain veneered-zirconia crowns placed in a general dental practice. Clinical performance was similar to data reported with other margin designs.[3-6] According to the CDA evaluation, the clinical quality of all crowns was in the satisfactory range, except for anatomic form in 1 crown. Patient satisfaction with the crowns was high. No caries was detected and no adverse soft tissue reactions around the crowns were observed. Margin integrity was rated excellent in all crowns.

The authors of 2 studies have reported on the use of knife-edge margin design for a limited number of zirconia crowns.[18,26] The present study, however, is the first, to the authors' knowledge, to report the use of knife-edge margins for zirconia crowns in a greater number of crowns and patients. The recorded results compare favorably with the data on 19 crowns in the anterior maxilla published by Schmitt in 2010.[18]

Several limitations of this retrospective study should be considered. Treatment was rendered in one private practice by a single clinician. Crowns were evaluated, however, by a different clinician working in the same practice. The crowns were not placed simultaneously and patients had different numbers of crowns. The same type of margin was prepared with different CAD/CAM systems. It is not possible to compare the different systems, because of the different numbers of crowns. However, the low occurrence of failure was common to all systems used.

This study reports practice-based clinical data and related shortcomings and advantages. For example, the use of different systems for the same treatment approach is common in a general dental practice. Therefore, it may be possible to achieve good clinical results by using the same technical approach with different systems.

However, all of the patients were highly motivated and complied well with maintenance appointments. Therefore, no loss of follow-ups occurred and 100% of the originally placed crowns could be clinically examined.

Knife-edge zirconia margins have recently been tested in vitro.[21,24,25] Despite the favorable data shown in 2 studies,[21,25] recommendations were made to avoid vertical preparations. According to Comlekoglu et al,[25] the feather-edge type of finish line exhibited the least absolute marginal opening (AMO) and marginal opening (MO) values, but the authors do not recommend it for clinical practice, since it could trigger a wedging effect at the margins and may provide additional marginal bulk. Beuer et al [21] reported favorable stress distribution pattern results of shoulderless preparation during loading; nevertheless the authors define it as obsolete from a periodontal point of view. Both statements besides being in contrast with the authors' in vitro findings are not supported by existing scientific evidence.

The results of the present study suggest that for zirconia crowns, knife-edge margins allow clinical performance similar to that reported with other margin designs,[3-6] thereby requiring less removal of tooth structure. Existing recommendations to avoid knife-edge margins for zirconia crowns [21,25] were not supported by the present study or the results of Schmitt et al.[18] However, longer observation periods, in the context of randomized controlled trials, are indicated to compare the long-term effectiveness of zirconia crowns fabricated with different marginal designs.

CONCLUSIONS

In this retrospective evaluation results suggest that for zirconia crowns, knife-edge margins allow clinical performance similar to that reported with other margin designs but with less invasive preparations.

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