Bonding Lithium Disilicate Ceramic to Feather-Edge Tooth Preparations: A Minimally Invasive Treatment Concept

Davide Cortellini[a] / Angelo Canale[b]

Purpose: To report the short-term clinical outcome of a new minimally invasive prosthetic approach utilizing monolithic lithium-disilicate full crowns bonded to feather-edge tooth preparations.

Materials and Methods: 235 teeth, 136 anterior and 99 posterior, requiring a full crown were prepared with a feather-edge finish line providing a minimum space on the vertical walls of 0.3 mm at the margin, 0.5 mm along the axial walls, and an occlusal space of 1 to 1.5 mm to ensure sufficient resistance of the restoration. The dental technician manufactured the monolithic restorations using either CAD-CAM or pressed technology. The restorations were individualized with a staining technique to obtain the necessary esthetic characterization and bonded to the natural abutments using an adhesive cementation procedure.

Results: Out of 235 treated elements, only one monolithic restoration in a molar position fractured after 3 years of service. No biological or technical complications were observed. The final esthetic result was optimal.

Conclusion: This procedure can be considered a further option for the conservative restorative treatment of single elements where a full crown is required.

Keywords: lithium disilicate, monolithic, feather edge, minimally invasive, all-ceramic, adhesion, full crown, preparation design.

J Adhes Dent 2012; 14: 7–10.
doi: 10.3290/j.jad.a22708

Submitted for publication: 01.09.11; accepted for publication: 18.11.11

The challenge currently facing reconstructive dentistry is how to obtain excellent esthetic results while preserving the biological structures involved as much as possible. Today, the clinician and the technician have materials and procedures at their disposal which make it possible to recreate esthetics and function in a simpler and more predictable way. New-generation all-ceramic restorations and adhesive systems allow a greater preservation of residual hard tooth structures especially with regard to single elements.[8,9,21]

Lithium disilicate ceramic used in its monolithic form and individualized with a staining technique is a material particularly suited to situations of erosion or abrasion where it is necessary to replace or restore damaged enamel through a "re-enamelling" process,[5] cases of prosthetic correction of malpositioned or diastematic teeth, and restorations of teeth incongruous in shape or color due to extended, poor-quality composite fillings. This material can be bonded to residual enamel and dentin after etching the ceramic with hydrofluoric acid (HF) and silanization, using latest-generation dual-curing resin cements.[4]

Being able to create an adhesive link between the ceramic restoration and the dental substrate allows the clinician to perform more conservative tooth preparations, in some cases avoiding a horizontal chamfer/shoulder conventionally recommended for all-ceramic crowns. Feather-edge or knife-edge preparation may be generally defined as "vertical preparations", as opposed to horizontal finish lines such as chamfer or shoulder.[15] These tooth preparations are associated with an acute margin of the restoration. Although a feather-edge preparation is commonly indicated in the use of periodontally involved teeth as abutments for fixed prostheses,[7] this approach may represent a less invasive alternative to a horizontal margin in various clinical conditions, such as endodontically treated teeth or vital teeth in young individuals which require a modification in color or shape or are compromised by erosive-abrasive pathologies.[20] A feather-edge preparation makes it possible to keep more tooth substance, including more enamel, in the cervical area in proximity of the CEJ (cementoenamel junction). Furthermore, this approach can contribute to limiting pulpal irritation in vital teeth as a consequence of a well preserved pulp-preparation distance in the cervical area, which represents the most sensitive zone for the pulp.[22]

[a] *Prosthodontist in Private Practice, Riccione, Italy; Member of Executive Council of the Italian Academy of Prosthodontics (AIOP). Performed all clinical procedures, recorded all clinical data, wrote the article.*

[b] *Certified Dental Technician, Dental Laboratory Angelo Canale, Rimini, Italy. Constructed all LiDiSi restorations and contributed significantly to the development of the technique presented in this paper.*

Correspondence: *Dr. Davide Cortellini, Via I. Nievo 11 47838 Riccione (RN) Italy. Tel: +39-(0)541-607193. e-mail: davidecortellini@gmail.com*

Fig 1 Preoperative view of a natural dentition exhibiting wear of incisal margins and incongruous composite and metal-ceramic restorations.

Fig 2 Preoperative view of the patient's smile. Irregularities and discolorations give an unpleasant appearance.

Table 1 Follow-up of monolithic LiDiSi ceramic crowns

Year performed	Number of crowns	Follow-up range (months)	Follow-up mean (months)
2007	22	36 to 48	42.59
2008	39	35 to 24	31.2
2009	77	23 to 12	17.49
2010	97	11 to 06	8.12
TOTAL	235	6 to 48	18.04

Fig 3 Knife-edge preparations provide a minimum space of 0.3 mm at the margin, 0.5 mm along the axial walls and 1 to 1.5 mm occlusally.

This type of finish line has already been tested in vitro with zirconia crowns[2,18] and various clinical reports of feather-edge zirconia restorations have been recently presented,[16,20] but no publications to date have examined the use of feather-edge margins with lithium disilicate ceramic. The aim of this study was to present a minimally invasive prosthetic approach utilizing monolithic lithium disilicate (LiDiSi) full crowns bonded to feather-edge tooth preparations and evaluate their clinical performance over a 4-year period. The hypothesis is that adhesively cemented LiDiSi crowns may be compatible with the feather-edge type of preparation.

MATERIALS AND METHODS

In the years 2007 to 2010, 235 LiDiSi crowns were inserted into 76 patients (44 female, 32 male) in a private office by one dentist. The mean age of this patient group was 36 years (range: 20 to 61 years). 136 crowns were located in the anterior area and included 22 canines and 114 incisors. The remaining 99 posterior elements consisted of 59 premolars and 40 molars. Erosion, abrasion, coronal destruction, and need for esthetic improvement were diagnoses which led to the treatment decision "crown" (Figs 1 and 2). The inclusion criteria were: healthy adult patient, adequate level of oral hygiene, absence of pulpal disease, absence of periapical pathologies, probing pocket depths ≤ 3, adequate amount of residual tooth structure.

Patients with symptoms of parafunctions were included in the study. These patients were instructed to wear an acrylic splint after the completion of the prosthetic therapy to protect the restorations. Teeth with symptoms of pulpal disease or showing periapical lesions were submitted to endodontic treatment prior to crown preparation. Periodontal surgery for pocket elimination was performed for teeth exhibiting probing pocket depth ≥ 5 mm at baseline.

The patients agreed to a recall program every 6 months for the routine oral hygiene procedures. The follow-up range is shown in Table 1.

Exclusion criteria included patients with insufficient level of plaque control (FMPS > 20), severe periodontal disease, and inability to attend the follow-up recall.

Restorative Procedure

In the first session, the crowns were prepared as follows. Feather-edge tooth preparations were performed with a flame bur separating the interproximal contact points and following the gingival contour in order to eliminate the natural tooth undercuts to enable an adequate fit of the restorations. A minimum space of 0.3 mm at the margin, 0.5 mm along the axial walls, and 1 to 1.5 mm on the occlusal surface to ensure sufficient resistance of the restoration was provided at the completion of tooth reduction. The final form of the preparation was slightly conical (2 to 6 degrees) making possible a complete 360-degree view of the cervical perimeter of the natural abutment (Fig 3). The finish line was located either in a juxtagingival position or slightly inside the gingival sulcus, for about 0.3

Fig 4 Monolithic LiDiSi restorations show a natural appearance. The tissue response is optimal with no signs of inflammation.

Fig 5 Postoperative view of the patient's smile: full conservative LiDiSi crowns restore the compromised tooth structure, creating a good esthetic result.

to 1 mm depending on the specific clinical situation and especially on the need to hide dyschromic abutments.

Temporization was done using resin provisional crowns relined with acrilyc resin (Duralay, Reliance Dental; Alsip, IL, USA) at the same appointment as the tooth preparation. Care was taken to create a very precise and well-refined margin for an optimal adaptation of the gingival tissues.

Final impressions were taken with a polyether material (Impregum Penta, 3M ESPE; St Paul, MN, USA) one month later using a retraction cord (Ultrapak, Ultradent; South Jordan, UT, USA). In the laboratory, the monolithic crowns were manufactured using either a CAD-CAM (23 crowns, e.max CAD, Ivoclar Vivadent; Schaan, Liechtenstein) or a pressed technology (212 crowns, e.max Press, Ivoclar Vivadent) and were individualized with a staining technique to obtain the necessary esthetic characterization.

Cementation of the definitive lithium disilicate crown was done utilizing rubber-dam when the finish line was located juxtagingivally. In this case a conventional adhesive procedure including etching, priming, and bonding (Scotchbond, 3M) of the tooth surface was performed and a light-curing resin cement was used (Variolink Veneer, Ivoclar Vivadent). When the margin was placed inside the intrasulcular compartment, alternative systems to isolate the environment from moisture, such as retractors for the lips, cotton rolls, or retraction cords to control the sulcular fluid were used. In these cases, a simplified adhesive cementation procedure with a dual-curing adhesive system (Multilink Automix, Ivoclar Vivadent) was selected.[1,13] In all cases, the inner surface of the restoration was etched with HF for 20 s and silanized before the application of the resin cement.

Patients were recalled every 6 months for the routine oral hygiene appointment, and all restorations were assessed by the same clinician who performed the clinical treatment, using mirrors, probes, and radiographs. The following parameters were checked during the recall appointments: plaque index, gingival index (GI) after Silness and Löe, crown fracture, chipping, loss of retention, caries, and postoperative sensitivity.

RESULTS

Out of 235 LiDiSi crowns, only one monolithic restoration in a molar position fractured after 3 years of service in a patient with severe parafunctional habits. No loss of retention could be observed. No biological complications including secondary caries could be detected. A GI score of 1 was found in 18 crowns, while a plaque index score of 1 was detected in 12 cases. According to the clinical and radiographic examinations, no differences occurred between the groups of CAD-CAM manufactured and pressed crowns in regard to precision and marginal stability. The fractured crown belonged to the pressed group of the LiDiSi restorations. Patients did not show any symptoms of pulp irritation, such as pain during mastication or temperature sensitivity, and were very satisfied with the natural and esthetic appearance of the crowns (Figs 4 and 5).

DISCUSSION

The tooth preparation proposed is based on maximum preservation of dental substance, especially in the cervical area where the pulp-preparation distance is of vital importance, both for the strength of the abutment and to reduce the onset of pulp complications.

The literature contains ample criticism of the feather-edge margin, mainly because of the presence of an overcontour and the consequent fragility of the crown, determined by the limited thickness of the restoration in the cervical area.[17] It should be emphasized that in daily dental practice, however, these problems have no real clinical significance and do not seem to constitute a concrete risk factor either for the periodontal health or for the strength of the restoration, provided that the correct clinical and technical requisites are observed. Tissue response is seen to be optimal over time, with stability of gingival position and absolutely no signs of inflammation. This can be explained by the anatomical condition which is obtained through this approach, consisting of creating an artificial CEJ similar to the cementoenamel junction found in nature.[14,15] The margin of the restoration creates an overcontour, exactly as it happens in the natural CEJ, where a change in the inclination of the profile between the root and the crown is always present (Fig 6). This slight marginal convexity provides support for the periodontal tissue, ensuring excellent stability of the gingival contour. The prosthesis margin remains located in the superficial portion of the intrasulcular compartment without damaging the periodontal attachment.[11] Moreover, a vertical margin

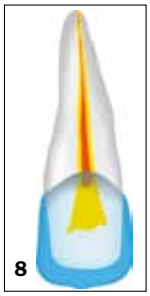

Fig 6 The CEJ of a natural tooth exhibits a change in the inclination of the profile between the root and the crown. The crown profile is slightly convex in the cervical area.
Fig 7 Knife-edge preparations are generally associated with a high level of precision. The LiDiSi crown appears on the radiograph as new enamel of a vital element.
Fig 8 In the cervical area, the restoration is slightly enlarged to increase the marginal toughness and to support the gingival tissues. The final anatomy mimics the shape of a natural CEJ.

is compatible with a high level of precision,[3] which also has an impact on the health of the marginal tissue, and facilitates a lower incidence of decay infiltration (Fig 7).

Various in vitro studies have employed finite element models to evaluate the stress distribution within a crown and the effects of different variables such as type and thickness of cement, thickness of restoration, supporting tooth core, loading position, and finish line margin,[6,17,19] concluding that a chamfer preparation is advisable to reduce stress development in the marginal area. Despite these in vitro findings, no scientific demonstration exists to support the concept that a feather-edge finish line would lead to failure of all-ceramic crowns in clinical dental practice. A recent investigation showed that the fracture strength of monolithic LiDiSi may surpass that of veneered zirconia.[12]

In the technique presented here, the risk of stress concentration at the core/veneer interface is avoided by using monolithic LiDiSi. The strength of the final restoration is guaranteed both by an adequate occlusal thickness and by a reinforcement of the marginal area by means of a slight enlargement of the emergent profile through a thin increment of ceramic material. This moderate increase of the marginal thickness creates a cervical collar which reinforces the restoration (Fig 8). Furthermore, a feather-edge preparation allows preservation of a greater amount of enamel, especially in the cervical area of the prepared element, thus improving the adhesion mechanism. The possibility of etching and silanizing the restoration and the use of contemporary adhesive cements lead to the creation of an adhesive link between restoration and abutment,[10] which contributes to improving the final resistance.

CONCLUSION

The prosthetic procedure presented in this article might be taken into consideration as a further option in the conservative restorative treatment of single elements where a full crown is required. Prospective clinical studies are needed to scientifically validate this clinical approach.

REFERENCES

1. Behr M, Hansmann M, Rosentritt M, Handel G. Marginal adaptation of three self-adhesive resin cements vs. a well-tried adhesive luting agent. Clin Oral Investig 2009;13:459-464.
2. Beuer F, Aggstaller H, Edelhoff D, Gernet W. Effect of preparation design on the fracture resistance of zirconia crown copings. Dent Mater J 2008;27:362-367.
3. Çömlekoğlu ME, Dündar M, Gokce B, Özcan M, Güngör MA, Artunç C. Influence of cervical finish line type on marginal adaptation of zirconia ceramic crowns. Oper Dent 2009;34:586-592.
4. Conrad HJ, Seong WJ, Pesun IJ. Current ceramic materials and systems with clinical recommendations: a systematic review. J Prosthet Dent 2007;98:389-404.
5. Cortellini D, Parvizi A. Rehabilitation of severely eroded dentition utilizing all-ceramic restorations. Pract Proced Aesthet Dent 2003;15: 275-282.
6. De Jager N, Pallav P, Feilzer AJ. The influence of design parameters on the FEA-determined stress distribution in CAD-CAM produced all-ceramic dental crowns. Dent Mater 2005;21:242-251.
7. Di Febo G, Carnevale G, Sterrantino SF. Treatment of a case of advanced periodontitis: clinical procedures utilizing the "combined preparation" technique. Int J Periodontics Restorative Dent 1985;5:52-62.
8. Edelhoff D, Brix O. All-ceramic restorations in different indications: a case series. J Am Dent Assoc 2011; 142(suppl 2):14S-9S.
9. Edelhoff D, Sorensen JA. Tooth structure removal associated with various preparation designs for posterior teeth. Int J Periodontics Restorative Dent 2002;22:241-249.
10. Flury S, Lussi A, Peutzfeldt A, Zimmerli B. Push-out bond strength of CAD/CAM-ceramic luted to dentin with self-adhesive resin cements. Dent Mater 2010;26:855-863.
11. Gargiulo AW, Wentz FM, Orban BJ. Dimensions and relations of the dentogingival junction in humans. J Periodontal 1961;32:261-267.
12. Guess PC, Zavanelli RA, Silva NR, Bonfante EA, Coelho PG, Thompson VP. Monolithic CAD/CAM lithium disilicate versus veneered Y-TZP crowns: comparison of failure modes and reliability after fatigue. Int J Prosthodont 2010;23:434-442.
13. Klosa K, Wolfart S, Lehmann F, Wenz HJ, Kern M.The effect of storage conditions, contamination modes and cleaning procedures on the resin bond strength to lithium disilicate ceramic. J Adhes Dent 2009;11: 127-135.
14. Loi I, Galli F, Scutellà F, Di Felice A. Il contorno coronale protesico con tecnica di preparazione BOPT (Biologically Oriented Preparation Technique): considerazioni tecniche.
15. Pardo GI. A full cast restoration design offering superior marginal characteristics. J Prosthet Dent 1982;38: 539-543.
16. Patroni S, Chiodera G, Caliceti C, Ferrari P. CAD/CAM technology and zirconium oxide with feather-edge marginal preparation. Eur J Esthet Dent 2010;5:78-100.
17. Proos KA, Swain MV, Ironside J, Steven GP.Influence of margin design and taper abutment angle on a restored crown of a first premolar using finite element analysis. Int J Prosthodont 2003;16:442-449.
18. Reich S, Petschelt A, Lohbauer U. The effect of finish line preparation and layer thickness on the failure load and fractography of ZrO_2 copings. J Prosthet Dent 2008;99:369-376.
19. Rekow ED, Harsono M, Janal M, Thompson VP, Zhang G. Factorial analysis of variables influencing stress in all-ceramic crowns. Dent Mater 2006;22:125-132.
20. Schmitt J, Wichmann M, Holst S, Reich S. Restoring severely compromised anterior teeth with zirconia crowns and feather-edged margin preparations: a 3-year follow-up of a prospective clinical trial. Int J Prosthodont 2010;23:107-109.
21. Valenti M, Valenti A. Retrospective survival analysis of 261 lithium disilicate crowns in a private general practice. Quintessence Int 2009;40: 573-579.
22. Wisithphrom K, Murray PE, About I, Windsor LJ. Interactions between cavity preparation and restoration events and their effects on pulp vitality. Int J Periodontics Restorative Dent 2006;26:596-605.

Clinical relevance: Bonded LiDiSi monolithic crowns to feather-edge preparations represent a minimally invasive prosthetic procedure to restore natural teeth. This approach is associated with a predictable and stable result in terms of both esthetics and function.