ACP AMERICAN COLLEGE OF PROSTHODONTISTS
Your smile. Our specialty.℠

Individual Lithium Disilicate Crowns in a Full-Arch, Implant-Supported Rehabilitation: A Clinical Report

Paulo Maló, DDS, PhD,[1] Sérgio Tavares de Sousa, DDS,[2] Miguel De Araújo Nobre, RDH,[3] Carlos Moura Guedes, DDS,[2] Ricardo Almeida, DDS,[2] António Roma Torres, DDS,[2] João Legatheaux, CDT,[4] & António Silva, CDT[4]

[1]Oral Surgery Department, Malo Clinic Lisbon, Lisbon, Portugal
[2]Prosthodontics Department, Malo Clinic Lisbon, Lisbon, Portugal
[3]Research and Development Department, Malo Clinic Lisbon, Lisbon, Portugal
[4]Malo Ceramics, Lisbon, Portugal

Keywords
Implant-supported prosthesis; lithium disilicate; metal framework; retrievable.

Correspondence
Miguel de Araújo Nobre, Research and Development Department, Malo Clinics: Avenida dos Combatentes, 43, 8, Edificio Green Park, 1600–042 Lisboa, Portugal.
E-mail: mnobre@maloclinics.com

The authors deny any conflicts of interest.

Accepted September 15, 2013

doi: 10.1111/jopr.12137

Abstract

This clinical report presents the clinical outcome of a maxillary full-arch implant-supported fixed rehabilitation with lithium disilicate reinforced glass ceramic monolithic crowns opposing a mandibular metal-acrylic implant-supported fixed rehabilitation in a 62-year-old woman. Eight implants were successfully placed (four maxillary, four mandibular), and no complications occurred in the postoperative or maintenance periods. Six months after delivery, the maxillary and mandibular prostheses were found to be clinically, biologically, and mechanically stable, and the patient was satisfied with the esthetics and her ability to function. Although the present indications for the use of lithium disilicate are still restricted to tooth-borne restorations, it is possible to successfully rehabilitate edentulous patients through implant-supported fixed prostheses using lithium disilicate reinforced glass ceramic monolithic crowns.

Meeting a patient's high esthetic demands through a maxillary full-arch implant-supported rehabilitation depends on the achievement of several biological and mechanical goals.[1,2] The choice of materials used in such rehabilitations plays an important role in the final outcome. Porcelain veneering over gold alloys or zirconium oxide frameworks have set the standard for the materials of choice in such cases.[3]

Porcelain veneered single crowns and fixed dental prostheses (FDPs) are well known for fulfilling esthetics, biocompatibility, color stability, and resistance to wear. Nevertheless, chipping and delamination of the veneering porcelain is a very common issue, well known by prosthodontists and extensively reported in the literature.[4] In a series of 59 consecutive cases, Sousa et al reported veneering porcelain chipping and/or delamination in 46.8% of maxillary zirconia layered full-arch implant-supported prostheses after a follow-up period ranging between 12 and 29 months.[5]

The lack of resilience due to the absence of a periodontal ligament in implant-supported restorations demands the use of highly sophisticated materials when trying to overcome fatigue resistance due to occlusal loading. In a complex biomechanical system, where implants, abutments, frameworks, screws, and esthetic veneering materials share masticatory stress conduction, porcelain is the material most commonly prone to failure with immediate esthetic consequences.[4,6,7]

Throughout the years, clinicians and laboratory technicians overcame this limitation through different strategies. One strategy is for a compatible material section between maxillary and mandibular arches, prior to the combination of a maxillary ceramic prosthesis with a mandibular metal-acrylic prosthesis in full-arch rehabilitations. This reduces the overall stiffness of the prosthetic elements as a whole, dramatically reducing mechanical complications.[6] Protecting the restorations with an occlusal splint "night-guard" is another method typically used to protect restorations, particularly when parafunctional habits are present. It may also lessen the odds of porcelain chipping.[8] Another strategy to address the mechanical failure of porcelain is to design individual full-contour crowns to be cemented on a titanium alloy screw-retained bar.[9] The benefit of this concept is based on the ability to remove and repair (or even replace) an individual fractured crown without the need to remove the entire structure,[10,11] which in turn allows a lower cost. As reported in the literature, firing a full-arch ceramic prosthesis after years in the oral cavity may prove catastrophic, with resultant air bubbles visible throughout the ceramic's outer surface.[5,11,12]

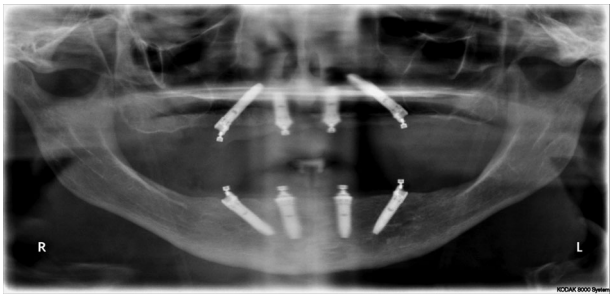

Figure 1 Radiographic control after maxillary full-arch rehabilitation through the "All-on-4" concept (Nobel Biocare AB).

Figure 2 CAD/CAM Titanium framework before finishing the margins.

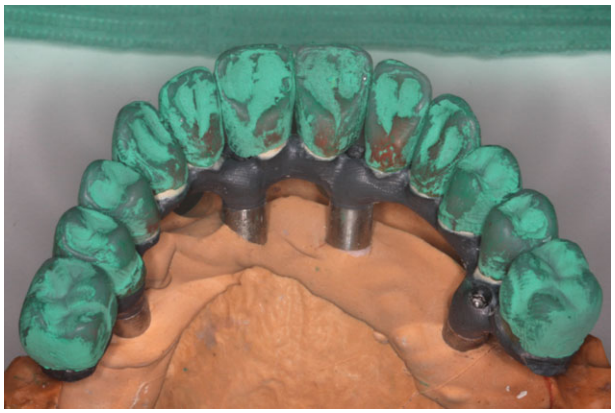

Figure 3 Wax patterns of the 12 individual crowns with optical scanner contrast spray.

The authors have been using individual porcelain crowns with computer-aided design/computer-aided manufacturing (CAD/CAM) zirconium oxide individual copings (Procera Zirconia, Nobel Biocare, AB, Gothenburg, Sweden) cemented on a CAD/CAM titanium alloy screw-retained framework (Procera Implant Bridge, Nobel Biocare) for more than 10 years.[10] Several reports, including a review focused on the prosthetic success outcome of this kind of rehabilitation, show survival rates ranging between 87% and 92.1% with a follow-up between 5 and 15 years.[10]

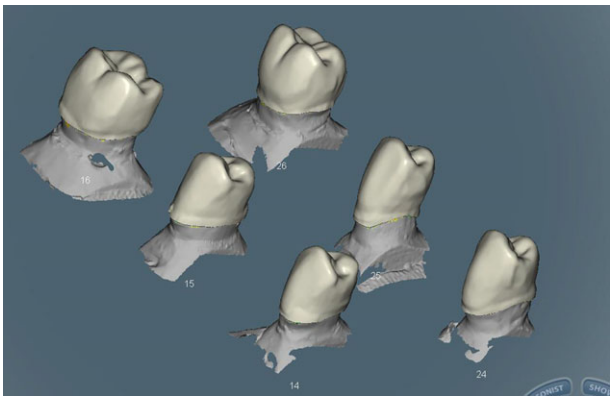

Figure 4 Digital enhancement after double-scanning of the individual crowns.

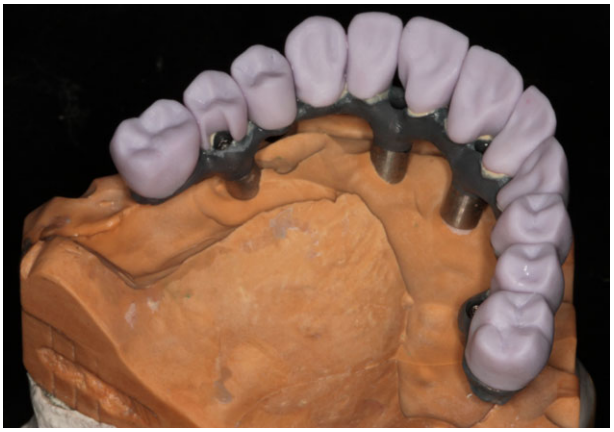

Figure 5 Precrystallized lithium disilicate reinforced glass-ceramic crowns in place on the implant-supported prosthesis.

Among the range of commercially available ceramic systems, lithium disilicate reinforced glass ceramic has generated considerable interest throughout the last decade, due to the material's physical properties, excellent esthetic features, ability to comply to adhesive cementation protocols, and versatile fabrication process (either lost-wax technique or more recently, CAD/CAM manufacturing).[13-15] The development of different precrystallized ceramic CAD/CAM blocks of different translucencies allowed for the production of monolithic full-contour anatomical crowns that could later be crystallized and characterized for customization. Monolithic crowns offer a flexural strength of 360 MPa compared to 90 MPa offered by the veneering ceramic in veneered zirconia crowns. According to Guess et al,[13] in a recent laboratory study on fatigue and durability of lithium disilicate reinforced glass ceramic monolithic crowns compared to layered zirconia crowns, the first yielded a failure rate of 0% after 1 million cycles, whereas the second presented 90% of failures after 100,000 cycles.[9,10,13,16,17]

The aim of this clinical report was to describe the full-mouth rehabilitation of a 62-year-old woman with implant-supported fixed prostheses in the maxillary and mandibular arches and to discuss the rationale behind our choice of materials and prosthesis design in an attempt to overcome porcelain chipping.

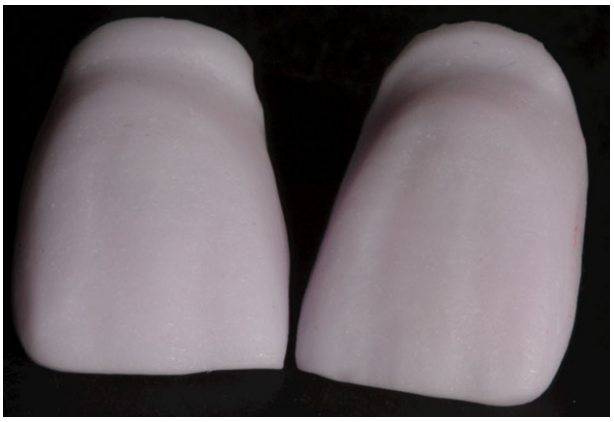

Figure 6 Aspect of the precrystallized central incisors showing secondary anatomy.

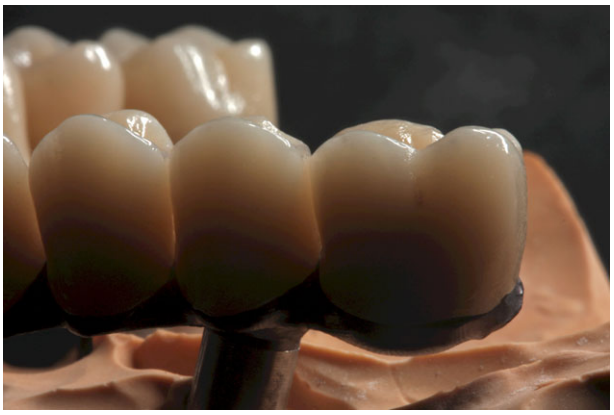

Figure 7 Translucency of the crystallized and cemented posterior crowns.

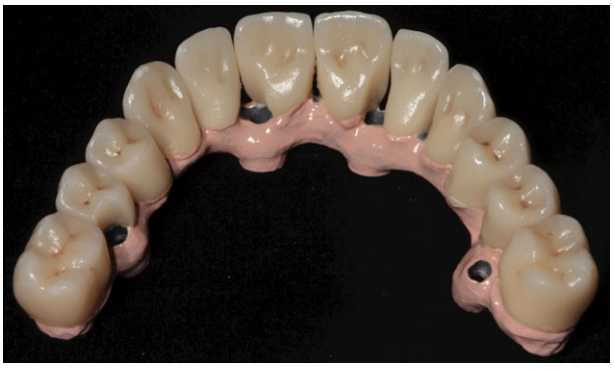

Figure 8 Cemented crowns on the maxillary implant-supported prosthesis.

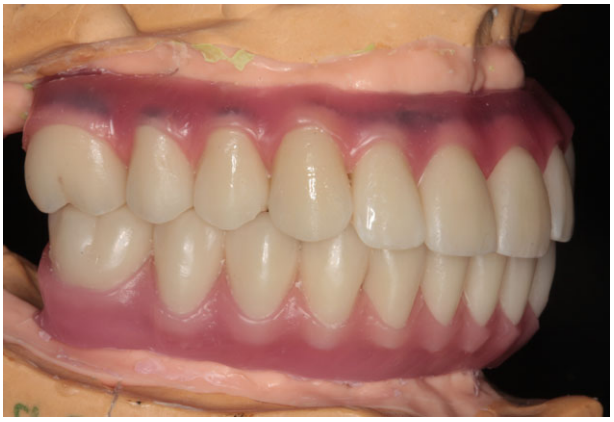

Figure 9 Waxing of the pink tissues before acrylic processing.

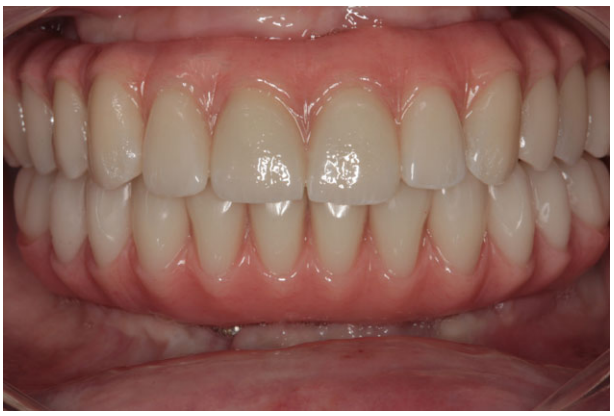

Figure 10 Definitive rehabilitation after delivery.

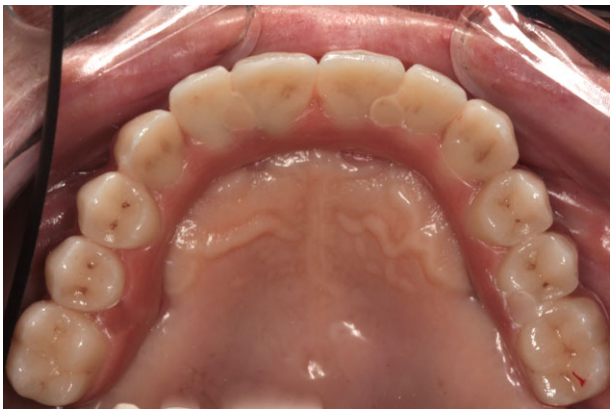

Figure 11 Occlusal view of the maxillary definitive rehabilitation.

Clinical report

A 62-year-old female patient was referred to a private practice (Lisbon, Portugal) in January 2011. She complained of maxillary denture intolerance after more than 30 years of edentulism. After a careful medical history (which was unremarkable), physical examination (maxillary and mandibular class 2 edentulous ridges, according to the Prosthodontic Diagnostic Index for complete edentulism[18]) and cone beam CT-scan (Kodak 9500 CBCT; Eastman Kodak, Rochester, NY) evaluation, a maxillary full-arch, implant-supported rehabilitation with an immediate occlusal loading protocol was proposed.

Standard open-flap surgery was performed under general anesthesia for a complete maxillary and mandibular full-arch rehabilitation with the placement of four implants in each arch

(NobelSpeedy Groovy; Nobel Biocare) according to the "All-on-4" concept[19] (Fig 1). Straight and angulated abutments were installed (Multi-Unit Abutment; Nobel Biocare). Immediate screw-retained interim prostheses were delivered on the same day of surgery. During the first 6 months postoperative, regular oral hygiene appointments, which included patient instruction, peri-implant charting, and panoramic radiographs, were performed to monitor bone levels and peri-implant soft tissues. Simultaneously, the occlusion was adjusted to obtain even contacts in centric occlusion, canine guidance during lateral excursions, and incisive guidance during protrusion, using 200- and a 12-μm occlusion paper (Dr. Jean Bausch GmbH & Co., Köln, Germany).[19]

Following the customary healing period for maxillary and mandibular implants, abutment level silicone impressions were taken (Light Body and Putty Soft Fast Setting; Zhermack Co, Rovigo, Italy). In a subsequent appointment, a facebow record and an interocclusal record (Occlufast Rock; Zhermack Co) were made using the fixed provisional prostheses. The master casts were mounted on a semiadjustable articulator (Artex Articulator System; Girrbach Dental GmbH, Pforzheim, Germany). Denture acrylic teeth (Pala Premium Line; Heraeus Kulzer GmbH, Hanau, Germany) were used to try in the esthetic and functional positioning of teeth, and after the patient's approval, these were processed as a second interim prosthesis using pink acrylic resin (PalaXpress Ultra; Heraeus Kulzer GmbH) and temporary abutment level cylinders (Temporary Coping Multi-Unit Titanium; Nobel Biocare).

The manufacturing process of the definitive prostheses started once the patient was comfortable with the esthetic and functional aspects, 4 weeks following the delivery of the second prosthesis. A silicone mask index (Zetalabor; Heraeus Kulzer GmbH) was made with the maxillary and mandibular interim prostheses removed from the patient and screwed onto the master casts to serve as a guide for the final restoration.

A resin framework template (GC Pattern Resin; GC Co, Alsip, IL) was fabricated according to the contour of the maxillary second interim prosthesis with individual abutment preparations to accommodate the corresponding individual ceramic crowns. Reduction in the abutment component of the framework allowed for optimal crown thickness, with a minimum of 1.5 mm on all aspects. This pattern was scanned (Nobel Procera optical scanner; Nobel Biocare), and CAD designed. A titanium screw-retained bar was manufactured after CAM processing (Fig 2). Only the stone model was scanned for margin information. The wax pattern was scanned for final contour information. The titanium framework was not tried in prior to scanning the preparations.

A light-curing opaque liner (Monopaque; Ivoclar Vivadent AG, Schaan, Liechtenstein) was applied to the abutment components of the titanium bar. A silicone impression (Light Body and Putty Soft Fast Setting) was made on the bar and poured in extra-hard gypsum (Vel-Mix Die Stone Gypsum; Kerr Dental Laboratory Products, Orange, CA). An individual full-contour wax-up was completed (Dental Wax; Yeti Dentalprodukte GmbH, Engen, Germany; Fig 3). Once each individual crown was double-scanned for both abutment and outer contour (Nobel Procera optical scanner; Fig 4), precrystalized lithium disilicate reinforced glass ceramic crowns (IPS e.max CAD, Ivoclar Vivadent AG) were fabricated (Figs 5 and 6). A try-in of the maxillary titanium substructure, precrystallized individual crowns, and mandibular acrylic prosthesis was performed before finishing the rehabilitation.

The crowns were later crystallized, custom trimmed, and stained following the manufacturer's instructions and according to the patient's individual characteristics and esthetic expectations (Figs 7 and 8). To keep the retrievability of the prosthesis as a whole, crowns #4 and #8 were drilled using a high-speed water-cooled handpiece (Synea; W&H, Burmoos, Austria) in their palatal aspect to gain direct access to the structure's retention screws.

Crowns were cemented according to an adhesive cementation protocol (Multilink Automix; Ivoclar Vivadent AG). Gingival anatomy was waxed up for a try-in (Preparation Wax Pink; Yeti Dentalprodukte GmbH). Following the patient's approval, the prosthesis with the waxed gingival form was invested in the lower half of a flask (Duoflask; Heraeus Kulzer GmbH). Once the plaster was set, the prosthesis was sprued, and pink acrylic resin (PalaXpress Ultra) was injected according to the manufacturers' protocol (Fig 9). In the mandible, a metal-acrylic hybrid prosthesis was fabricated, using a titanium bar as substructure (Titanium Implant Bridge, Nobel Biocare), acrylic teeth (Pala Premium Line; Heraeus Kulzer GmbH), and pink acrylic resin (PalaXpress Ultra).

Eight months after implant placement, both the maxillary and mandibular prostheses were delivered (Figs 10 and 11). All the prosthetic screws were given a final torque of 15 N/cm. The prosthetic screw access holes were sealed using cotton pellets and composite material (Aelite Flow A3; Bisco Inc., Schaumburg, IL), and the occlusion was evaluated and adjusted to a mutually protected occlusion scheme respecting the patient's centric relation.

Follow-up up visits were scheduled every 6 weeks during the first 3 months, 6 months after the insertion of definitive prostheses, and every 6 months after that. At 6 months, the prosthesis was removed. Biological (inflammation, peri-implant infection, suppuration, supporting bone) and mechanical (prosthetic screw loosening evaluated through torque values, fractures, chipping) complications were assessed. Further follow-ups were carried out 12 and at 18 months after delivery.

Outcome

The definitive rehabilitation remained stable during the 18 months after its connection. No biological or mechanical complications occurred during the follow-up of this clinical report. The patient was satisfied with the esthetics and function of the prostheses. Supporting bone levels remained stable (absence of marginal bone resorption >2 mm compared to baseline bone levels, determined through periapical radiographs), and soft tissues maintained a healthy appearance without any signs of inflammation or suppuration. Eighteen months following delivery, all screws were still fully torqued to 15 N/cm as suggested by the manufacturer, and no chipping or wear of the ceramic was observed. The interface between the ceramic crowns and the acrylic gingival anatomy remained visually intact and free of pigmentation.

Discussion

The pursuit of truly reliable implant-supported full-arch rehabilitations has always been a challenge for dentists and laboratory technicians. The ability to resist fatigue in implant-supported restorations can be attributed to the lack of resilience in these prosthetic systems. The choice of individual ceramic-layered crowns cemented on a metal substructure addresses to some extent the mechanical failures in ceramic, yet it does not prevent them from happening.[10]

There are some advantages and disadvantages of processing the plastic acrylic after the crowns have been cemented. On one hand, this procedure allows hiding of crown margins. In addition, the sealing of the acrylic resembles the esthetics of the anatomical gingival sulcus and allows removal of the excess cement before processing the pink esthetics. On the other hand, this procedure might represent a disadvantage when replacing an individual crown, where it may force replacement of the entire pink acrylic in order to avoid a different color patch of the new acrylic.

Lithium disilicate reinforced glass-ceramic monolithic crowns have proved to be superior in terms of flexural strength and fatigue resistance when compared to any ceramic-layered system (regardless of using metal or zirconia as an infrastructure).[13] Alumina crowns have optimal esthetic properties; however, their mechanical properties contraindicate their use in implant-supported restorations. Zirconia has proved to be superior in terms of its mechanical stability, but poses an esthetic problem due to its white opaque nature. Also, the absence of chemical bonding between zirconia and the layering porcelain still remains a concern regarding reliability.[20] The introduction of precrystallized CAM blocks allowed the fabrication of highly cost-effective ceramic restorations with very satisfying esthetics. Presently, this kind of monolithic pigment stained ceramic crowns may be unable to perfectly match the optical properties of an adjacent natural tooth but when dealing with a full-mouth rehabilitation, especially in elderly patients, a natural and satisfying esthetic result can be achieved. In addition, this option can also reduce the odds of porcelain chipping.[21-24]

These type of ceramics have just recently been introduced to the dental industry with very promising results, yet manufacturers still show prudence by limiting their indications to tooth-supported restorations.[25] Despite these restrictions, it is our belief that monolithic ceramic crowns may prove to be reliable and cost-effective when used to rehabilitate implants, regardless of the mechanical issues involved. More studies with a higher hierarchy of clinical evidence and study design and longer follow-up periods are necessary to test this hypothesis.

Conclusion

Although the present indication for the use of lithium disilicate is restricted to tooth-borne restorations, our report suggests that it could be a good material of choice for implant rehabilitations in the completely edentulous patient.

Acknowledgments

The authors would like to thank Ana Bastos, CDT, and Ricardo Manique, CDT, at MaloCeramics dental laboratory.

References

1. Raptis NV, Michalakis KX, Hirayama H: Optical behavior of current ceramic systems. Int J Periodontics Restorative Dent 2006;26:31-41
2. Kan JY, Rungcharassaeng K, Bohsali K, et al: Clinical methods for evaluating implant framework fit. J Prosthet Dent 1999;81:7-13
3. Cobb GW Jr., Metcalf AM, Parsell D, et al: An alternate treatment method for a fixed-detachable hybrid prosthesis: a clinical report. J Prosthet Dent 2003;89:239-243
4. Jemt T, Henry P, Linden B, et al: Implant-supported laser-welded titanium and conventional cast frameworks in the partially edentulous law: a 5-year prospective multicenter study. Int J Prosthodont 2003;16:415-421
5. Sousa S, Pragosa A, Crispim P: Assessement of prosthetic complications in full-arch implant supported zirconia bridges: a restrospective analysis of 59 consecutive cases with a 12–29 month follow-up. Clin Oral Implants Res 2009;20:1056-1061
6. Kim Y, Oh TJ, Misch CE, et al: Occlusal considerations in implant therapy: clinical guidelines with biomechanical rationale. Clin Oral Implants Res 2005;16:26-35
7. Kinsel RP, Lin D: Retrospective analysis of porcelain failures of metal ceramic crowns and fixed partial dentures supported by 729 implants in 152 patients: patient-specific and implant-specific predictors of ceramic failure. J Prosthet Dent 2009;101:388-394
8. Curtis DA, Sharma A, Finzen FC, et al: Occlusal considerations for implant restorations in the partially edentulous patient. J Calif Dent Assoc 2000;28:771-779
9. Jemt T, Back T, Petersson A: Precision of CNC-milled titanium frameworks for implant treatment in the edentulous jaw. Int J Prosthodont 1999;12:209-215
10. Maló P, de Araújo Nobre M, Borges J, et al: Retrievable metal ceramic implant-supported fixed prostheses with milled titanium frameworks and all-ceramic crowns: retrospective clinical study with up to 10 years of follow-up. J Prosthodont 2012;21:256-264
11. Ozcan M: Fracture reasons in ceramic-fused-to-metal restorations. J Oral Rehabil 2003;30:265-269
12. Blum IR, Jagger DC, Wilson NH: Defective dental restorations: to repair or not to repair? Part 2: All-ceramics and porcelain fused to metal systems. Dent Update 2011;38:150-158
13. Guess PC, Zavanelli RA, Silva NR, et al: 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
14. Makarouna M, Ullmann K, Lazarek K, et al: Six-year clinical performance of lithium disilicate fixed partial dentures. Int J Prosthodont 2011;24:204-206
15. Giannetopoulos S, van Noort R, Tsitrou E: Evaluation of the marginal integrity of ceramic copings with different marginal angles using two different CAD/CAM systems. J Dent 2010;38:980-986
16. Silva NR, Thompson VP, Valverde GB, et al: Comparative reliability analyses of zirconium oxide and lithium disilicate restorations in vitro and in vivo. J Am Dent Assoc 2011;142:S4-S9
17. Chitmongkolsuk S, Heydecke G, Stappert C, et al: Fracture strength of all-ceramic lithium disilicate and

porcelain-fused-to-metal bridges for molar replacement after dynamic loading. Eur J Prosthodont Restor Dent 2002;10:15-22
18. Malo P, Rangert B, Nobre M: "All-on-Four" immediate-function concept with Branemark System implants for completely edentulous mandibles: a retrospective clinical study. Clin Implant Dent Relat Res 2003;5:S2-S9
19. Zahran M, El-Mowafy O, Tam L, et al: Fracture strength and fatigue resistance of all-ceramic molar crowns manufactured with CAD/CAM technology. J Prosthodont 2008;17:370-377
20. Denry I, Holloway J: Ceramics for dental applications: a review. Materials 2010;3:351-368
21. Magne P, Schlichting LH, Maia HP, et al: In vitro fatigue resistance of CAD/CAM composite resin and ceramic posterior occlusal veneers. J Prosthet Dent 2010;104:149-157
22. Sahin S, Cehreli MC, Yalcin E: The influence of functional forces on the biomechanics of implant-supported prostheses—a review. J Dent 2002;30:271-282
23. Bindl A, Luthy H, Mormann WH: Strength and fracture pattern of monolithic CAD/CAM-generated posterior crowns. Dent Mater 2006;22:29-36
24. Wolfart S, Eschbach S, Scherrer S, et al: Clinical outcome of three-unit lithium-disilicate glass-ceramic fixed dental prostheses: up to 8 years results. Dent Mater 2009; 25:e63-e71
25. The Academy of Prosthodontics: The glossary of prosthodontic terms. J Prosthet Dent 2005;94:10-92