The use of a zirconia custom implant-supported fixed partial denture prosthesis to treat implant failure in the anterior maxilla: A clinical report

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Over the last decade, there has been a dramatic rise in patients' esthetic expectations with regard to both conventional and implant prosthodontics. The loss of hard and/or soft tissue dimensions, often unpredictably, around implants, can result in potential embarrassment due to the display of metal components. Patients are understandably reluctant to accept visibility of metal abutments and/or the implant substructures, especially in the esthetic zone, even if biologically sound. The use of 1-piece zirconia implant frameworks or, alternatively, custom zirconia abutments with a zirconia framework, has enabled both a good biological response as well as the ability to improve the esthetic outcome. This clinical report demonstrates the use of a 1-piece zirconia implant-supported fixed partial denture in the anterior maxilla, with minimal soft tissue dimension above the implant shoulder level, which dictated the need for prosthetic soft tissue augmentation. (J Prosthet Dent 2008;100:415-421)

Conventional and implant prosthodontics are undergoing a rapid metamorphosis.[1] Historically, metal ceramic technologies have been the gold standard in both conventional and implant fixed prosthodontics; however, this is currently being challenged. The change has been driven by increasing patient esthetic expectations as well as the continuing pursuit of excellence and improvement in dentistry.[2]

The development of alumina and zirconia crown copings and fixed partial denture substructures has added yet another dimension and refinement in the ability to provide functional and lifelike restorations, and meet ever-increasing esthetic and functional demands.[3]

The ability to use high strength ceramics, such as zirconia, for 1-piece implant-supported fixed partial denture substructures has several advantages.[4,5] These frameworks can be produced using computer-assisted design/computer-assisted manufacturing (CAD/CAM) procedures, with purportedly reproducible fitting accuracy of the framework to the implant interface of approximately 20 μm for complete fixed dentures, and less for partial fixed dentures (Brien Lang, DDS, MS, Professor Emeritus, University of Michigan, oral communication, May 2007). This level of accuracy is considerably less than that for cast gold alloy partial dentures, as described by Ortorp.[6] Historically, a framework would be produced using a milled titanium substructure (Procera Implant Bridge Titanium; Nobel Biocare AB, Göteborg, Sweden) or, alternatively, and more commonly, a cast gold alloy framework. While high accuracy can be achieved with both alternatives, for the larger cast frameworks, technical difficulties can arise in fabricating a passively and accurately fitting framework. This often necessitates sectioning, laser welding, or soldering of the framework. Furthermore, these distortions may be magnified once veneering porcelains are applied. Using a titanium framework creates difficulties in achieving good esthetics, and cannot approximate the esthetic results obtained with metal ceramic or all-ceramic technologies.

Zirconia, like titanium, is a biocompatible material and promotes the health of the surrounding soft tissues.[7-10] Metal ceramic fixed partial dentures are fabricated with a substructure of noble or nonnoble alloy with the potential for corrosion, especially at the implant/prosthetic interface. These materials can display, to one degree or another, depending upon the alloy used, low grade inflammation in the soft tissues surrounding the restorative interface.[11-15]

All-ceramic zirconia fixed partial dentures can now be fabricated with screw retention, facilitating retrievability, due to the ability to design and manufacture a 1-piece zirconia substructure to the implant fitting surface (Procera Implant Bridge Zirconia; Nobel Biocare AB). Until recently, this was the exclusive domain of metal ceramic technologies. Accordingly, the 1-piece all-ceramic substructure can eliminate the need for any abutments and, with appropriate implant placement, can decrease both the cost and complexity of the prosthesis and improve the emergence profile. In some situations, a paucity of soft tissue height above the implant level may be present at the time of definitive restoration or, alternatively, can occur following marginal bone loss and soft tissue recession. The use of conventional technologies may result in patient embarrassment due to the unesthetic display of metal components. This is even more critical in the esthetic zone and especially with high lip line smiles.

Zirconia is a strong biomaterial (flexural strength, 1200 Mpa) and is a unique dental ceramic due to its ability to undergo transformation

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toughening.[16,17] Toughness of a material is the resistance to growth of small cracks and is the best predictor of success of a dental material. When stresses form at a crack tip, additives such as yttrium oxide enable an instantaneous phase transformation to occur, with approximately a 4% expansion, effectively closing the crack. Prevention of crack propagation is of critical importance in high fatigue situations, such as those encountered in mastication and parafunction. This combination of strength, toughness, and transformation toughening properties makes zirconia a unique material for use in high-load situations.[18,19]

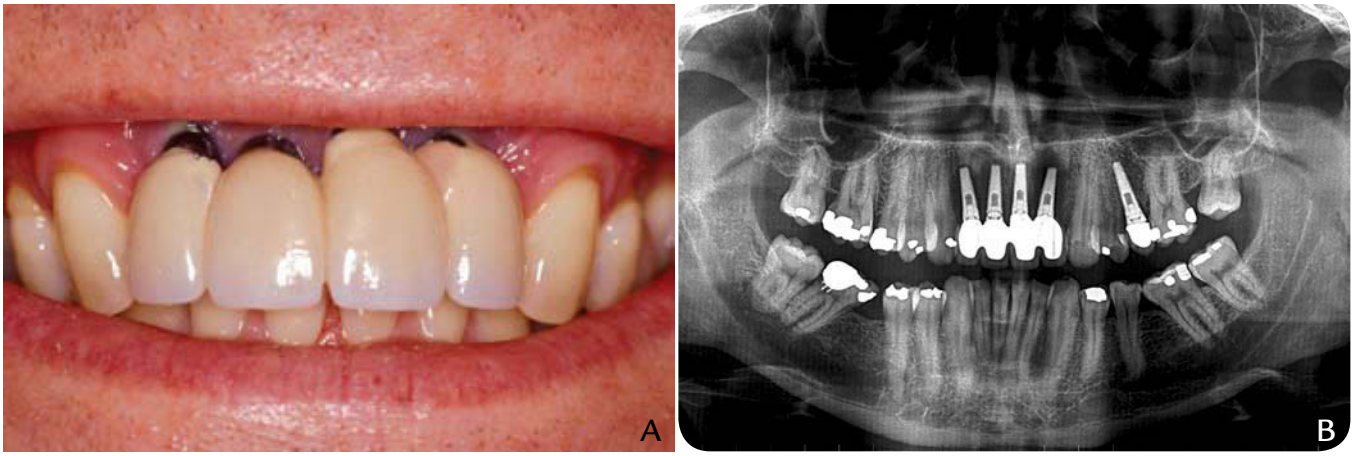
One-piece zirconia implant-supported fixed partial dentures, while still somewhat in the developmental stage, have a promising future, although currently, data related to their use are sparse. The success of zirconia tooth-supported fixed partial dentures provides confidence in their applications. Yttria-stabilized zirconia (Y-TZP) ceramic is a high performance material with excellent mechanical properties suitable for fixed partial dentures.[19-25]

The use of zirconia frameworks in implant prostheses enables the achievement of good esthetic results, using simplified and conventional ceramic techniques.[26] The need to mask the dark oxide color of cast alloys or milled titanium is eliminated. Creating more esthetic and translucent reconstructions, especially in the light shade ranges, is more easily and predictably achieved. The development of new high strength veneering porcelain (120 Mpa) for zirconia and alumina (NobelRondo; Nobel Biocare AB), including new pink porcelains, provides the clinician and dental ceramist with an expansive palette to create natural and esthetic restorative solutions.[27,28] This new technology has the potential to change both the clinical and laboratory aspects of implant reconstructions, offering CAD/CAM substructure manufacture advantages, simplification of procedures, and both biological and esthetic advantages for patients.[29,30]

CLINICAL REPORT

A 48-year-old white man presented with failing implant-supported splinted crowns in the anterior maxilla, replacing the 4 incisor teeth. The patient was dissatisfied with the existing tooth color and esthetic arrangement, as well as the obvious display of metal at the gingival aspects of the crowns, especially when smiling (Fig. 1, A). There was disruption to the normal form and symmetry of the surrounding gingival architecture. The gingival tissues were edematous and inflamed, with exudate upon probing. The patient was also aware of a bad taste and exudate associated with these crowns. Esthetically and functionally, the metal ceramic crowns were considered a failure. Radiographically, large radiolucent areas were evident around all 4 implants (Fig. 1, B). The splinted crowns did not fit accurately to the underlying implants.

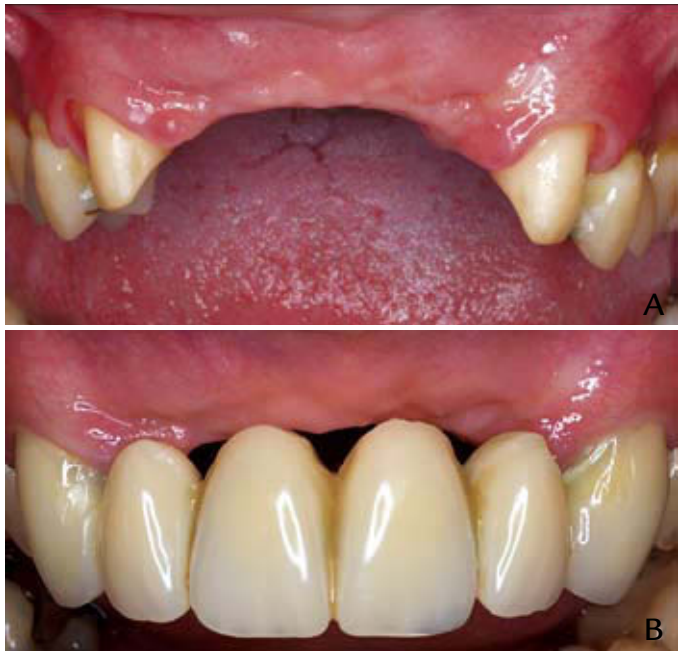
Discussions were held with the patient as to the various treatment options available following the removal of the implants and crowns. These included the use of a removable partial denture, a tooth-supported fixed partial denture, as well as the option of undertaking bone grafting and further implant therapy. The patient was informed of his unfavorable occlusion, including his 90% deep vertical overlap, and the need to correct this, ideally, with orthodontic pretreatment. The patient refused orthodontic treatment due to his age and work commitments and, accordingly, was informed of the negative impact and loading considerations related to any planned prosthesis. The patient also refused any form of removable prosthetic solution, be it provisional or definitive. The author considered that the large pontic span of the maxillary incisor region, the substantive anterior-posterior dimension, the evident parafunctional wear, as well as the deep vertical overlap, collectively contraindicated the tooth-supported fixed partial denture option. Further, it was considered desirable, in this particular situation, to protect the graft site with a fixed provisional restoration so as not to unfavorably load the graft area, especially considering this patient's traumatic occlusion. Both the canine and first premolar teeth were tetracycline stained, with obvious yellow-brown banding. The



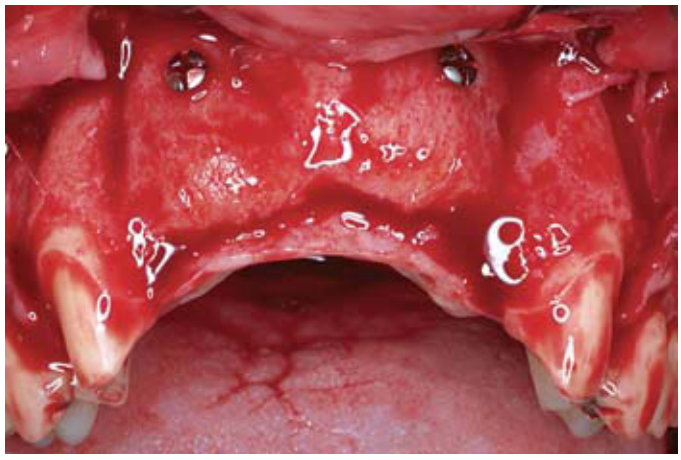
1 A, Pretreatment smile with failing implant-supported, metal ceramic splinted crowns. B, Pretreatment panoramic radiograph.

patient desired an overall improved, long-term esthetic solution. The maxillary left and right first premolar teeth were also rotated and were visible. Discussions were held as to the options of tooth whitening and porcelain veneers versus complete coverage all-ceramic crowns. The patient opted for all-ceramic crowns to complement the future all-ceramic implant-supported fixed partial denture replacing the maxillary incisor teeth.

A provisional fixed partial denture was planned as the provisional restoration, supported by the maxillary left and right canine teeth. All-ceramic crowns were also planned for the maxillary left and right first premolar teeth. The 2 canine teeth were prepared, and impressions (Honigum; DMG, Hamburg, Germany), a shade prescription, and interocclusal records (MegaBite; Discus Dental, Rydalmere, Australia) were made for the provisional restoration. The provisional fixed partial denture was laboratory fabricated from a polyglass composite resin (Gradia; GC Europe NV, Leuven, Belgium). The 4 failing implant-supported crowns and implants were removed, and the sites curetted of granulation tissue. There was extensive loss of the labial plate, resulting in subsequent significant loss of residual ridge height (Fig. 2, A). Collagen sponges (Sulzer Dental, Inc, Carlsbad, Calif) were placed in all implant sites, and the preconstructed provisional restoration was inserted (Fig. 2, B). Following diagnostic workup, including the establishment of the 3-dimensional tooth position for esthetics, lip support, speech, and function, and referral to an oral surgeon, cortico-cancellous block grafts were harvested from the anterior iliac crest and used as onlays to augment the residual alveolar ridge both horizontally and vertically (Fig. 3). Cancellous bone was packed around the block grafts and periosteal releasing incisions were made to allow passive advancement of the buccal flap over the bone graft. The provisional restoration was adjusted and reinserted. Due to aggressive shrinkage of the initial graft, a further bone graft procedure was undertaken at 4 months postiliac grafting, using an allograft (BioOss; Osteohealth, Shirley, NY) along with a resorbable membrane (Inion GTR biodegradable membrane; Inion, Inc, Weston, Fla), following the removal of the retaining screws from the original grafts. Perforations in the graft were made to provide vascular access, and periosteal releasing incisions were made to achieve passive closure. Unfortunately, premature exposure of the membrane occurred. Although antibiotics (amoxycillin 500 mg, 3 times daily for 7 days; Douglas Pharmaceuticals Autralia Ltd, Baulkham Hills, Australia) and chlorhexidine gels (Chlorofluor Gel; Professional Dentist Supplies Pty Ltd, Bayswater, Australia) were used, the membrane needed to be prematurely removed due to an unexpected hyperplastic soft tissue reaction, with histopathology indicating inflamed granulation and fibrovascular tissue. This tissue was excised, resulting in a considerable loss of soft tissue volume. Following subsequent healing, CT (computed tomography) scans were obtained using a radiographic guide. These scans indicated limited bone for implant placement, and it was decided to use two 4.3 x 16-mm tapered implants (Replace Select TiUnite; Nobel Biocare AB). The

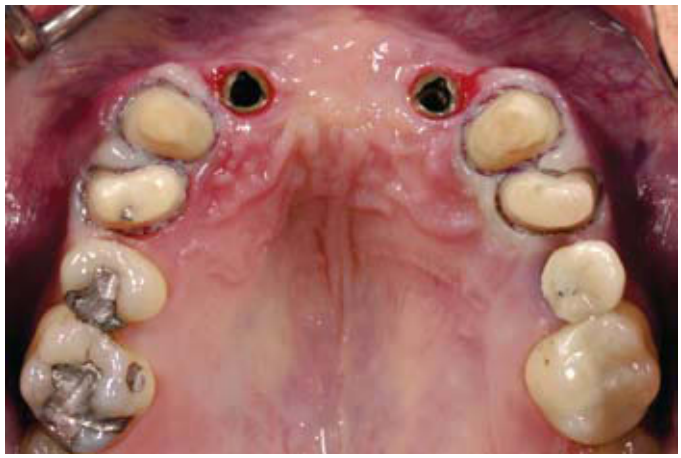


2 A, Residual anterior ridge following implant removal and preparation of canine teeth as provisional fixed partial denture abutments. B, Provisional prosthesis in situ, demonstrating loss of both of hard and soft tissue volume.



3 Exposure of anterior alveolus following autogenous cortico-cancellous block, bone grafts.

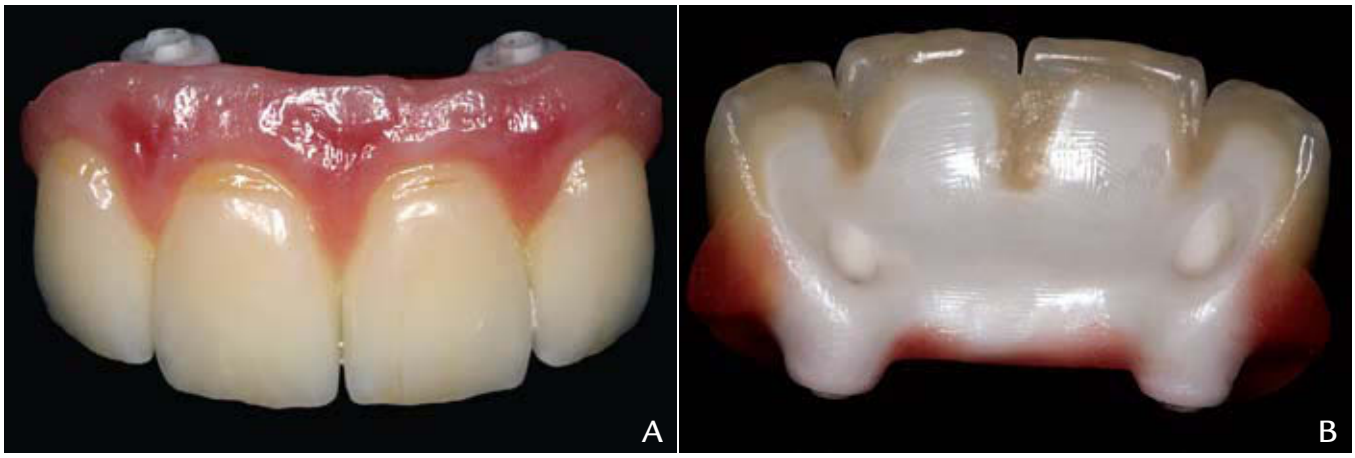
implants were placed in the lateral incisor positions and angulated for future palatal access through the prosthesis. Resonance frequency analysis (Osstell AB, Göteborg, Sweden) was undertaken for both implants at placement, indicating ISQ (implant stability quotient; an electronic reading of 0-100 indicating stability of the implant) readings of 60 for the left lateral incisor and 63 for the right lateral incisor. An arbitrary ISQ value of 60 to 65 or greater is considered suitable for loading of an implant.[31-33] An implant-level impression (Honigum; DMG) was made for fabrication of an implant-supported provisional restoration to be used immediately following the uncovering of the implants.



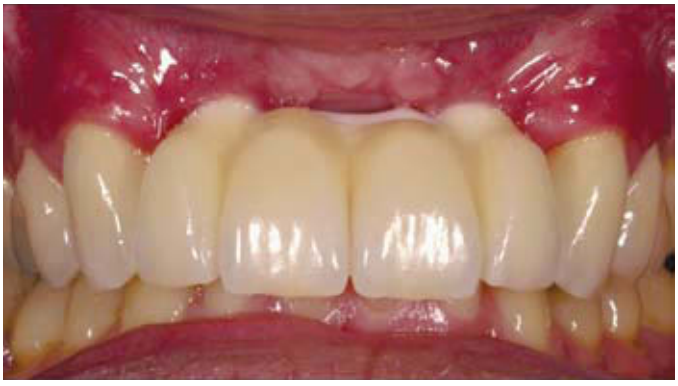
4 Occlusal view of implants in lateral incisor positions and prepared canine and first premolar teeth, prior to impression-making procedures.

Further bone grafting was attempted at the time of implant insertion using autogenous bone harvested locally (mx-grafter; Maxilon Laboratories, Inc, Hollis, NH), and bone sieve. The autogenous bone graft was further augmented with allograft material (BioOss; Osteohealth) and covered with 2 layers of resorbable collagen membrane (Bio-Gide; Geistlich Pharma AG, Wolhusen, Switzerland). A connective tissue graft was also prepared to increase the vertical soft tissue dimension, and the provisional restoration was reinserted. Following a further healing period of 4 months, it was evident that there was still insufficient soft tissue volume to achieve ideal esthetics and emergence profile of the prosthesis, despite the various hard and soft tissue augmentation procedures. While a further connective tissue graft was considered, it was decided in discussion with the patient to use a prosthetic replacement for the soft tissue deficiency. The 2 implants were exposed approximately 7 months later, with 2 threads exposed labially, above the bone crest, around each implant, and minimal soft tissue dimension above the implant shoulders. A second implant-supported provisional restoration was inserted along with single provisional crowns on the maxillary left and right canines. It was evident from the provisional restoration contours and soft tissue interface that prosthetic soft tissue replacement would be required in the definitive restoration to achieve an acceptable esthetic result with appropriate crown height-to-width ratios. The provisional prosthesis and single crowns were left in situ for approximately 4 months, at which time definitive preparations of the canine and premolar teeth, bilaterally, were undertaken. The premolars were prepared due to the patient's preference to achieve an improved esthetic treatment and long-term result, as both teeth were rotated buccodistally and tetracycline stained, and a transfer implant registration was made of the 2 implants in the lateral incisor regions (Fig. 4). Diagnostic records, including diagnostic casts, shade prescription (including gingival shading), photographic records, maxillomandibular records, and an acrylic resin diagnostic arrangement of the future tooth arrangement, were made. A 1-piece all-ceramic zirconia fixed partial denture substructure (Procera; Nobel Biocare AB) was designed using the diagnostic prescription, established from the provisional prosthesis. An acrylic resin substructure replica was subsequently fabricated in the laboratory and sent to a Nobel Biocare facility in Stockholm, Sweden, for scanning and fabrication of a 1-piece zirconia fixed partial denture substructure (Fig. 5). Currently, this can be accomplished at the local dental laboratory level with an appropriate scanner. The maxillary canine and first premolar tooth preparations were scanned locally, and this information was sent via modem to the production facility in Sweden for the fabrication of the zirconia substructures for the single unit crowns.

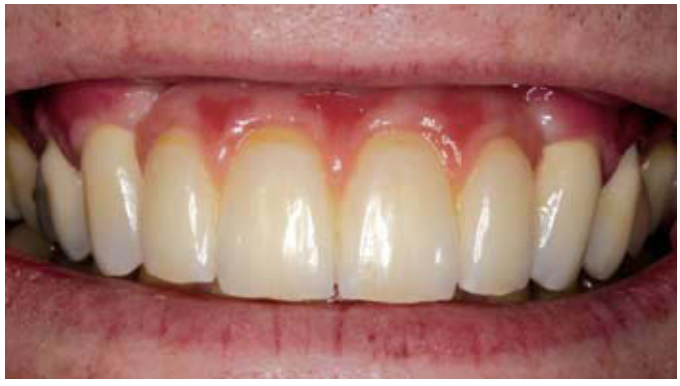
At a subsequent appointment, the 1-piece zirconia framework was assessed intraorally, along with the single unit copings, and verified for accuracy of fit. Periapical radiographs were made to confirm the passive seating of the fixed partial denture substructure. A ceramic trial insertion was undertaken 3 weeks later without the prosthetic pink porcelain, and contour and shade modifications were noted. Further photographic records were made (Fig. 6). A pink porcelain shade guide was then used to define the pink porcelain (Nobel Rondo; Nobel Biocare AB) esthetic prescription. A further ceramic trial insertion was then completed 1 week later, including the prosthetic pink replacement tissue, and the parameters of soft tissue interface, cleansability, lip support, occlusion, speech, and overall esthetics were assessed. Following final refinements and modifications, the single unit zirconia crowns (Procera; Nobel Biocare AB) for the maxillary canine and first premolar teeth were luted using resin-modified glass-ionomer cement (FujiCEM; 3M ESPE, Seefeld, Germany). The 1-piece zirconia implant-supported fixed par-



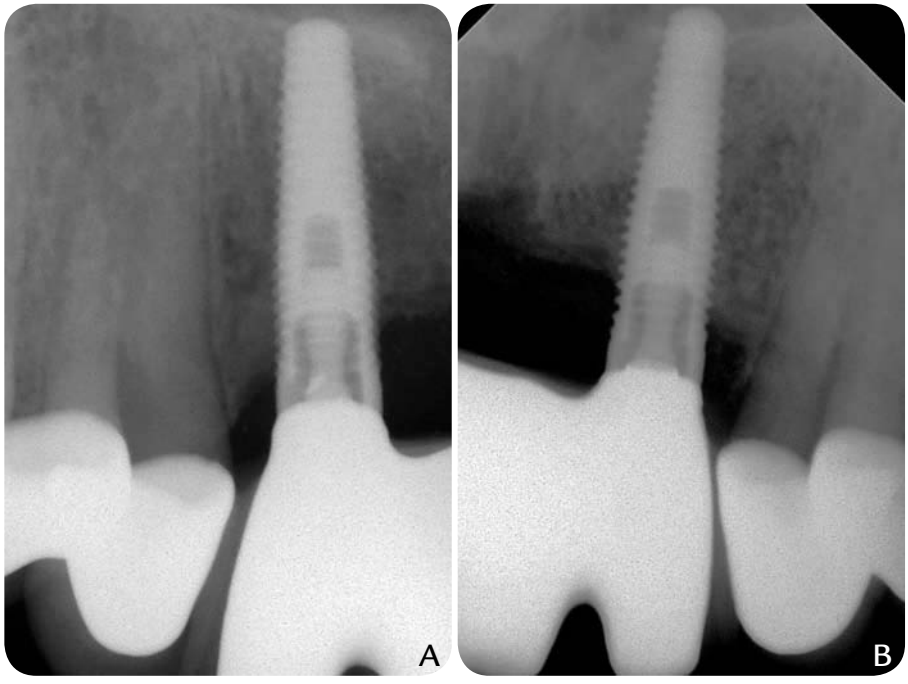
5 A, Facial view of completed all-ceramic zirconia fixed partial denture, prior to insertion. B, Palatal view demonstrating screw-retained, Procera zirconia substructure to implant level.



6 Facial view of all-ceramic zirconia fixed partial denture, prior to addition of gingival porcelain.



7 Completed implant-supported, screw-retained, fixed partial denture and gingival porcelain, with all-ceramic zirconia single unit crowns for both canine and first premolar teeth.



8 A and B, Periapical radiographs indicating implant/zirconia fixed partial denture interface.

tial denture was then inserted, verified radiographically for accuracy and passive fit, and the fixation screws were torqued to 35 Ncm. The screw access openings were then sealed with composite resin (Filtek Supreme XT; 3M ESPE). The occlusion was subsequently assessed and adjusted (Fig. 7), and final radiographs were made (Fig. 8). The occlusion was designed and adjusted for contact in clenched centric occlusion only, with immediate lateral guidance from the palatal inclines of both canine crowns. Protrusive guidance was gained from the

palatal inclines of the 4 incisor crowns of the fixed partial denture; however, the deep vertical overlap made this guidance very steep. In consideration of the occlusal scheme, especially with respect to the vertical overlap, a maxillary night guard was constructed from heat-polymerized, clear acrylic resin (Vertex Rapid Simplified Heat Cure, clear; Vertex-Dental BV, Zeist, The Netherlands). The patient was instructed in oral hygiene procedures, especially in the use of both floss (Super Floss; Oral-B; Belmont, Calif) and a water irrigating device (Oxyjet; Oral-B).

The patient has been followed for 18 months following insertion of this zirconia fixed partial denture. The prosthesis has been removed and clinical and radiographic examinations have been performed, including individual assessment of each implant. Bone levels are stable and no signs or symptoms of failure were observed for any implant. The underlying soft tissues around the pontic areas and periimplant areas show no signs of inflammation, and the intimate relationship between the prosthetic pink flange and soft tissues appears stable. The patient is pleased with both the appearance and function of his reconstruction, and, to date, no maintenance procedures have been performed apart from examination, occlusal monitoring, and hygiene treatment.

DISCUSSION

There has been a steady and increasing trend toward the use of all-ceramic technologies in dentistry. Further, the profession now has available a biomaterial with the strength and other physical attributes to compare more than favorably with the historic gold standard: cast precious metal alloys.

The production of the Procera zirconia framework involves relatively uncomplicated clinical and laboratory procedures. This technology dramatically reduces laboratory time, costs, and complexity by eliminating the need to wax a substructure using a premachined or burnout component (to register the implant interface), along with investing, casting, pickling, possible post soldering, finishing, and opaquing. Furthermore, the dental ceramist has the opportunity to create a more natural and esthetic restoration using a highly accurate, passively fitting, strong, tooth-colored framework.

This clinical report highlights the use of technologies to overcome surgical deficiencies that can often occur, especially in the esthetically demanding maxillary anterior region. In determining the most appropriate treatment approach, the clinician should balance and assess the cost/risk/time benefits of any treatment option, as well as consider the patient's preferences. The use of the 1-piece zirconia fixed partial denture framework in this situation involved the "worst case" scenario of having to replace the prosthesis with a metal ceramic construction. The concerns with the use of this new technology include: the accuracy of fit of the milled zirconia substructure, the accuracy of the implant interface connection, the flexural and compressive strength of the framework itself, the use of zirconia veneering porcelains (both strength and esthetics), and the long-term survival of the veneered prosthesis. Not all of these concerns can be addressed at this stage with the use of this technology, and further studies and long-term assessment are required.

Specifically, in this situation, there was minimal soft tissue height above the implant shoulders, and further, significant negative space issues, which, if not addressed, would have resulted in the appearance of overly long teeth with large interdental spaces. The ability to use a ceramic framework to the implant level significantly improved the emergence profile and reduced the ridge lap required for the prosthetic soft tissue replacement. Zirconia-supported, soft tissue-colored, zirconia-compatible veneering porcelains were used as a technical solution to the esthetic issues created by these soft tissue deficiencies. The ceramist has an extensive palate of pink hues available to create natural-looking soft tissue prosthetic replacements upon the prescription of the clinician.

CAD/CAM design and fabrication of crown and fixed partial denture substructures has revolutionized laboratory procedures. The advantages of industrialized, reproducible, and consistent manufacture, largely eliminating human performance inconsistencies, have significantly improved the accuracy, cost effectiveness, and reliability of dental prosthetics. Currently, there are several options for the fabrication of 1-piece implant fixed partial denture substructures, including copy milling and CAD/CAM options.

The Procera Zirconia Implant Bridge (Nobel Biocare AB) is one of the options, using a scanned replica to produce a zirconia implant fixed partial denture substructure for either external hex or internal connection implant interfaces (for most of the popular implant designs) via CAD/CAM manufacture. While there are many advantages of using a 1-piece structure to the implant level, with ease of retrievability being a significant consideration, sometimes, due to implant angulation issues, custom zirconia abutments may be required in combination with a luted zirconia fixed partial denture to achieve an ideal solution.

SUMMARY

The use of a new 1-piece zirconia fixed partial denture, to implant level, along with new generation veneering porcelains, provides the clinician with greater flexibility, potentially decreased costs, and the ability to achieve improved esthetic and biological treatment outcomes. When there is sufficient bone and soft tissue dimension, excellent functional and esthetic results may be recreated,

but occasionally, for various reasons, there are deficiencies of either or both tissue types, resulting in compromise of the definitive restorative solution. Use of high strength all-ceramic zirconia fixed partial dentures, to implant level, offers the possibility to more easily address these issues, as compared to conventional methods. This technology provides opportunities for the restoration of more extensive implant situations using all-ceramic technologies. However, at this stage, long-term data for its application are required prior to the adoption of its use in mainstream prosthodontics.

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