Comprehensive implant restoration and the shortened dental arch

Roger A. Solow, DDS

The restoration of edentulous space or hopeless teeth with implant-supported restorations can involve extensive time, effort, and financial commitment. This article presents a case of a debilitated dentition that was restored by using the shortened dental arch (SDA) concept in a comprehensive implant restoration. An SDA design was used to replace removable partial dentures with multiple nonsplinted implant-supported crowns extending to the premolars. The results showed an immediate and dramatic improvement in comfort, function, and esthetics while allowing the patient to practice normal oral hygiene.

Received: April 13, 2010
Accepted: June 7, 2010

When the loss of posterior teeth results in bilateral edentulous spaces, dentists have several treatment options. To recommend the best option, the dentist needs to determine if the patient will remain healthy and stable without a restoration, if removable prostheses will improve the status of the entire mouth or be a detriment to the remaining dentition and periodontium, and how many implant-supported restorations should be placed.

A shortened dental arch (SDA) is defined as a dentition that is missing most of the posterior teeth. This is a common condition, as molars are often lost earlier than other teeth due to caries and periodontal disease. Although the minimum number of teeth needed to satisfy functional demands has not been absolutely determined, the masticatory system is adaptable and various authors have proposed that an arch consisting of anterior teeth and premolars is functional and durable.

Molar replacement may not be necessary in terms of dietary demands, but it may be indicated for arch stability and esthetic and psychological reasons. The number of teeth included in the final restoration should be decided for each patient on an individual basis after considering all esthetic, phonetic, functional, emotional, and economic factors. Using an SDA in an existing dentition may avoid the need for restoration with fixed or removable prostheses. In addition, an SDA may preclude the need to place implants in soft posterior bone sites adjacent to sinus and neurovascular anatomy or to perform bone grafting for site development, allowing dentists to avoid the cost of additional implants and crowns. Conversely, an SDA offers less chewing surface area and may increase force due to function or parafunction on the remaining teeth and temporomandibular joints (TMJs).

This article illustrates how the SDA concept was used in a comprehensive implant restoration to treatment plan and restore a debilitated dentition.

Diagnosis

A 72-year-old woman presented with a chief concern of “a recently replaced large composite restoration on a front tooth” and wanted to know what to do “if it was lost again.” A preclinical interview yielded a history of partial denture repairs, which the patient said did not bother her. Her medical history was noncontributory. She was able to, but would not, expose her teeth when asked to smile broadly (Fig. 1).

Clinical examination revealed buccal palpation tenderness apical to tooth No. 8; all other soft tissues were normal, as were muscle palpation, range of motion, and joint palpation. Her Doppler ultrasound classification was a bilateral Piper Class 3B, indicating lateral...
pole disc displacement without reduction. Firm condylar load testing with bimanual guidance produced no discomfort.

The remaining dentition consisted of teeth No. 8–10 and 24–27, with no caries, mobility, or periodontal probes greater than 3 mm. The gingival levels were asymmetrical on teeth No. 8–10. The maxillary and mandibular partial dentures had multiple repairs, no posterior occlusal contact, no retention, and no occlusal rests (Fig. 2). The lower major connector had abraded the root dentin and lingual gingiva of teeth No. 24–26 and lacerated the mucosa apical to these teeth. The maxillary edentulous ridges had good vertical and horizontal dimension (Class I, Division A), and the mandibular edentulous ridges were compromised vertically and horizontally (Class I, Division B).8

After the examination, orthodontic wax (Henry Schein, Inc.) was applied to the major connector of the mandibular partial denture as a spacer, prior to adding a soft liner (HydroCast, Sultan Healthcare). Once the HydroCast was set, the wax spacer was removed and the major connector was elevated off the mucosa (Fig. 3 and 4). Pain relief was immediate.

Full-mouth radiographs revealed a small apical radiolucency on tooth No. 8 and no other pathology (Fig. 5). The vertical height of the edentulous ridges was favorable, as the maxillary sinus and mandibular canals showed no proximity to possible implant sites in the premolar regions.

Diagnostic casts were mounted in centric relation using a marked anterior acrylic platform and bimanual guidance. The lower central incisor of the diagnostic cast must contact the intraoral ink mark of the acrylic platform placed on the maxillary cast to verify that the arc of closure in centric relation is identical to the patient’s.9 The residual ridge relationship was recorded with a polyvinylsiloxane bite registration material (Blu-Mousse, Parkell Inc.) (Fig. 6 and 7). A moderately uneven incisal plane was present, with significant wear facets and exposed incisal dentin on all teeth due to attrition. The interocclusal space on the casts indicated a minimal loss of vertical dimension.
Treatment planning
To visualize the final result, an additive diagnostic wax-up of both arches was performed. The stone teeth were not altered and these casts were duplicated to fabricate surgical guides that would fit accurately when placed on the existing teeth. The stone teeth were then reduced and the diagnostic wax-up was completed to visualize final tooth-to-tooth and tooth-to-ridge relationships (Fig. 8 and 9).

The restorative plan was to place incisal composite restorations on teeth No. 24–27; all-porcelain crowns on teeth No. 8–10; single implanted-supported all-porcelain crowns at the sites of teeth No. 4–6, 11–13, 20–22, 28, and 29; and cantilever pontics on the sites of teeth No. 7 and 23. The SDA meant that the patient could avoid replacing molars; in this case, she showed no esthetic deficit from missing teeth. The patient had the option to restore these areas at a later time if desired. This was the most conservative treatment plan that would restore the patient to the most natural state while avoiding the time and cost required for eight implant-supported molar crowns and site development using sinus or lateral ridge augmentation. Immediate implant placement and provisional restoration into occlusion were planned.

The restorative dentist could now review the information (compiled from the preclinical history, clinical examination, full-mouth radiographs, and diagnostic wax-up) with the periodontist who would place the implants. A detailed surgical plan was made so that the implant spacing, angulation, and z-axis relative to the gingival margin would coordinate with the restorative plan. Surgical guides were fabricated using the fixed position of the pilot drill for maxillary flapless surgery and the variable position of the pilot drill for mandibular flap surgery, since the mandibular residual ridge required crestal reduction to accommodate 4.3 mm implant platforms (Fig. 10–12). These guides were designed to ensure parallel implant alignment to permit the use of straight, stock titanium abutments, thus avoiding the need for angled or custom abutments.

The patient was sent for tomograms to verify the mandibular ridge width (Fig. 13–15); this information was reviewed during the second consultation between the restorative dentist and the periodontist to confirm the treatment plan. The composite resin channels of the surgical guide are markers for the central axis of the planned implant locations when used as a radiographic template.

At the restorative consult, diagnostic casts, wax-ups, radiographs, and tomograms allowed for a thorough discussion of all problems, solutions, and goals with the patient. She received a one-page written summary of problems, solutions, fees, and future concerns. Surgical correction of the asymmetric gingival levels of teeth No. 8–10 was not recommended, since these areas were not visible during an exaggerated smile. She was referred to the periodontist for the implant consult.
The diagnostic wax-ups were lubricated (Separator, Great Lakes Orthodontics Ltd.) and a duplicate stone model was fabricated so that the wax-up was preserved. An impression was taken of the stone duplicate model, using a clear vinylpolysiloxane (Memosil 2, Heraeus Kulzer Inc.), to create a matrix for the provisional restorations. The stone teeth then were reduced 1 mm on all surfaces to create space for the provisional material. Composite resin (Epic-TMPT, Parkell Inc.) was placed in the intaglio of the matrix and the matrix was seated completely on this lightly prepared cast (Fig. 16). The composite resin was polymerized (Optilux 501, Kerr Dental) for one minute through the clear matrix. The composite resin shells then could be relined with an auto-polymerizing acrylic resin during surgery to create the provisional restorations (Fig. 17).11

**Treatment**

Prior to implant surgery, endodontic treatment of tooth No. 8 was completed by the endodontist. Endodontics should be scheduled prior to surgery to prevent any possible apical peri-implantitis. The periodontist placed regular and wide
platform implants (Replace Select, Nobel Biocare USA), using flapless surgery in the sites of teeth No. 4–6 and 11–13 and flap surgery in the sites of teeth No. 20–22, 28, and 29. All implants had good primary stability and were torqued past 35 ncm. The surgical guide ensured parallelism and spacing derived from the diagnostic wax-up, so the restorative dentist used stock, straight titanium abutments (Replace Select) torqued to 35 ncm (Fig. 18–20).

The mandibular surgical guide replicated the prosthetic outline without the restriction of the pilot drill on the maxillary guide. After crestal bone reduction (Fig. 21), pilot drill indents were placed in bone and proper spacing and parallelism were maintained (Fig. 22).

The composite resin shells were relined with an autopolymerizing acrylic resin (Snap, Parkell Inc.) and cemented (IRM, Dentply International). The provisional restorations were organized into two or three tooth segments. The maxillary incisal plane was refined to optimize esthetics and “f” and “v” phonetics and adjusted to accommodate smooth lateral, protrusive, and crossover excursions (Fig. 23 and 24). The maxillary palatal surfaces were shaped in coordination with the composite
bonding of the mandibular anterior teeth to provide smooth anterior guidance. Channels were placed in the sclerotic dentin (without anesthesia) to provide mechanical retention, and the enamel was bevelled prior to adhesive bonding with microhybrid composite resin (Renamel, Cosmedent, Inc.) (Fig. 25 and 26).

Smooth anterior guidance was shown by continuous marked lines from a 20 µ inked ribbon (Accufilm, Parkell Inc.) on the central incisors and canines in excursive movements. Simultaneous point contacts on the provisional premolars in closure and all excursions created mandibular stability without the adverse lateral torque that stresses crestal bone (Fig. 27 and 28). Patient feedback concerning the form and comfort of the provisional restoration was solicited until all details were refined. Her response was extremely positive.

Due to the ceramist’s illness, final impressions were not taken until 4.5 months after implant placement (Fig. 29 and 30). Gingival response and occlusal stability were confirmed at that time, judging by the lack of inflammation, patient comfort, and retention by provisional cement. The patient chose a lighter shade for the porcelain compared with the provisional restorations. Casts of the provisional restorations were equilibrated to centric relation, these casts were mounted cast-to-cast and sent to the ceramist so that the master die casts could be cross-mounted with a centric relation record on the same model of articulator. Both solid and removable die casts were used to ensure predictable interproximal contacts (Fig. 32 and 33).

Final porcelain restorations were guided by the contours of the provisional restoration casts (Fig. 34 and 35). The porcelain was refined intraorally to match the occlusal scheme of the provisional restorations (Fig. 36 and 37). The gingival
response and the esthetic and phonetic results were predictable, since they were programmed by the provisional restorations that had been tested over time (Fig. 38–40). A maxillary occlusal bite splint was fabricated with this same detailed occlusion to comfortably protect the porcelain surfaces from wear or fracture during possible nocturnal bruxing (Fig. 41). Postoperative occlusal refinement was checked after several weeks to refine any details and address any concerns. The patient described the result as “life-changing.” The implants and restoration have been completely stable for two years.

Discussion
Restoring a patient with fixed prosthetics and a full-arch design (including molars) in optimal occlusion represents the ideal treatment for many patients. Fulfilling each patient’s goals for function, esthetics, phonetics, and occlusal stability may not require this ideal treatment and the significant complexities involved.12 The SDA is a practical way to simplify comprehensive implant-supported restorations. Masticatory performance is an objective measurement of chewing efficiency and decreases as arch length is reduced.13-16 Although the SDA compromises chewing ability, this compromise may not be apparent to patients or affect their diet.17-20 Patients with limited ability to
tolerate extensive dental procedures and those who are comfortable with an existing SDA may not want to increase their arch length. Financial limitations may also dictate the extent of restorative dentistry.

Removable prostheses may be a less expensive option than implant-supported crowns for increasing arch length, although they may not provide patients with the same chewing ability or level of satisfaction.21-24 Removable partial dentures can be detrimental to the supporting teeth when plaque retained on the prosthesis also accumulates on the teeth, increasing the risk of decay and bone loss. Compromise of the prosthesis against the residual ridge during chewing may cause bone loss that can change the fit of the prosthesis on the residual ridge and increase stress at the clasp-tooth interface.25 The bulk of the prosthesis also accumulates on the teeth, increasing the risk of decay and bone loss. Compromise of the prosthesis against the residual ridge during chewing may cause bone loss that can change the fit of the prosthesis on the residual ridge and increase stress at the clasp-tooth interface.25 The bulk of the prosthesis and its attachment to adjacent teeth prevent it from being the most natural method for restoring lost tooth structure. A 1999 study by Kuboki et al found that some patients do not use their removable prosthesis and are more comfortable with an SDA.26

The absence of molars is a clinical concern, since it could place more force on the remaining dentition and TMJs during tooth contact. The level of potential increased force may be an individual response, depending on the duration and intensity of tooth contact from oral habits and nocturnal or diurnal bruxing. Severe bruxers may display significant tooth wear, fracture, mobility, or migration not seen in non-bruxers. If teeth have little contact, no deleterious effect from excessive force would be expected. Some of the effects of lost molar support on the teeth and TMJs, as reported in the literature, are described below.

Absence of molar contact has been shown to decrease electromyographic (EMG) activity of the elevator muscles during clenching on an anterior tooth bite splint compared to a full-arch bite splint.27,28 Canine guidance during lateral excursion contact on a bite splint was shown to reduce elevator muscle EMG activity compared to group function, where more posterior teeth make contact.29-31 Equilibration of the natural dentition to avoid posterior teeth contact during lateral excursions was shown to reduce abnormal elevator muscle EMG activity if these teeth are lost. This decreased muscle activity would be less detrimental to the remaining teeth.

Histopathology of the TMJs was demonstrated in rats whose molars had been extracted.35-37 Granados studied human skull specimens and attributed flattened articular eminences to increased forces from edentulism and attrition.38 Human skull studies have correlated the number of teeth lost with the severity of change in condylar form.39-41 Conversely, Hodges found that TMJ osteoarthrosis was not correlated with loss of molar support when age was considered as a variable, since the frequency of both tooth loss and osteoarthrosis increases with age.42

Radiographic remodeling of the condyle has been described as a functional adaptation to mechanical stress.43 Kopp and Rockler reported an association between radiographs indicating reduced joint space and subcortical sclerosis and a loss of molar support.44 Hansson et al found a correlation between radiographic structural bone change and same-side loss of molar support; they attributed these changes to increased biomechanical loading of the TMJ.45 Cadaver studies showed a correlation between missing teeth and the amount of bony remodeling and articular disc alteration while also showing that the risk of osteoarthritic changes is increased in patients who have lost several teeth or are edentulous.46-48

Multiple patient studies show that the concern over increased force to the dentition and TMJs of an SDA may not be a clinical problem, as neither decreased patient comfort nor increased tooth wear and mobility were reported.49 Hattori et al recorded the pressures generated from clenching on two bite splints of different designs, one full-arch and one SDA.49 The authors used finite element analysis with these clinical data to determine the resulting forces at the TMJ. During maximum voluntary clenching, SDAs produced smaller TMJ loads compared to a complete dentition design. The SDA never caused overloading in the TMJ, as the clenching strength was limited by the neuromuscular regulatory system via the periodontal receptors.50

In a 1967 study, Franks evaluated the effect of missing teeth on mandibular dysfunction and found that patients with three to five missing teeth formed the largest symptomatic group; as the number of missing teeth increased, the incidence of dysfunction decreased.51 More recently, Holmlund and Axelsson evaluated 60 patients with chronic, painful locking of the TMJ and found no difference between the fully dentate and reduced molar occlusion groups in terms of signs, symptoms, and arthroscopic diagnoses. The authors’ results did not support the concept of molar replacement to prevent TMJ osteoarthrosis.52 However, Kopp reported significantly greater loss of molar support among patients with osteoarthrosis compared to
those with mandibular dysfunction, concluding that long-term loss of molar support was a factor in crepitation, osteoarthrosis, and an increased severity of mandibular dysfunction.53

These skull, cadaver, and patient studies do not show whether a patient with an SDA risks structural breakdown of the dentition or TMJs due to tooth loss alone or from parafunction that may have contributed to that tooth loss.

Unrestored SDAs generally are stable, although they can display some tooth migration and interdental spacing without the mesial vector of force that results from molar root inclination.54-56 In the present case, restoring premolar sites with implants provided mandibular stability during closure and eliminated the possibility of tooth migration.

The present case used multiple nonsplinted single implant-supported crowns to restore the lost teeth. Oral hygiene was simplified, as the patient can maintain all areas using only a regular brush and floss.

Historically, early implant restorations splinted posterior crowns together, similar to placing a periodontal prosthesis restoration on compromised periodontal support. Splinting requires pointed brushes and floss threaders for interproximal cleaning. Porcelain fracture or bone loss on a site due to peri-implantitis might require replacing the entire splinted prosthesis. A nonsplinted design limits these problems to a single tooth site.

Today, improved stability with higher placement torque and rough surface implants with increased surface permit a more natural nonsplinted design.57 Cantilever pontics are hygienic and avoid the need for additional implants in small tooth sites.

Maintenance of existing teeth with a healthy periodontium preserves their proprioceptive capability (which is approximately 10 times greater than that of implants).58-60 This proprioception is compromised by replacing all teeth with complete dentures, implant-retained overdentures, or a hybrid implant-supported fixed restoration. When tooth-to-tooth and tooth-to-implant contact were compared, Mericske-Stern et al reported a decrease in maximal chewing force and pressure sensitivity.61

Patients may perceive that decreased proprioception prevents the restoration from feeling as natural as original teeth. Implant-supported restorations provide superior function and patient satisfaction compared to the less expensive removable prosthesis.62,63 Multiple nonsplinted implant-supported crowns using the SDA concept eliminate the hygiene and implant framework fit problems of the original Branemark design (a cantilever fixed hybrid restoration).64

The SDA in the natural dentition may be an appropriate design for patients who do not select to treat a complete arch.1,2,4-6,25 Long-term clinical studies are needed to evaluate the effects of an SDA with this type of comprehensive implant-supported restoration.

Summary
This case report demonstrates the use of the SDA design for a comprehensive implant-supported restoration. Removable partial dentures were replaced with multiple nonsplinted implant-supported crowns extending to the premolars. The molars were not replaced. The SDA design avoided the complexities and costs associated with implant placement near the maxillary sinus and atrophic mandibular residual ridge. The patient could perform normal oral hygiene while comfort, function, and esthetics improved immediately and dramatically.

Acknowledgements
The author would like to express his appreciation to Michael Seda, DMD, MS, for planning and placing the implants and to Mindy Buoncristiani, DDS, for the endodontic treatment.

Author information
Dr. Solow is in private practice in Mill Valley, California and is a visiting faculty member at the Pankey Institute, Key Biscayne, Florida.

References
2. Kayer AF. The shortened dental arch: A thera-
3. Helkimo E, Carlson GE, Helkimo M. Chewing efficiency and state of dentition. A methodolog-
6. de Sa e Frias V, Toothaker R, Wright RF. Short-
7. Drotter JR. An orthopaedic approach to the diag-
nosis and treatment of disorders of the tempro-
10. Solow RA. Simplified radiographic-surgical template for placement of multiple, parallel im-
11. Solow RA. Composite veneered acrylic provi-
12. Ramford SP, Ash MM. Occlusion, ed. 4, Phila-
13. Witter DJ, Crawminkel AB, van Rossum GM, Kayer AF. Shortened dental arches and masti-
14. Yurkstas AA. The effect of missing teeth on masti-
17. Aukes JN, Kayer AF, Felling AJ. The subjective ex-