Implant Dentistry has evolved dramatically since its inception as an anchor for the fully edentulous patient population. Today, more than ever, implants are being utilized for the partially edentulous patient as segmental or single tooth replacements where long-term function and esthetics are of prominent importance. The dental implant specialist must therefore attempt to work backwards from the restorative-esthetic final goal of therapy to the beginning of the case where the initial decisions are being made. Restorative driven implant based decision making by the surgeon will lead to the correct augmentation and implant selection for the specific needs of the patient. This "reverse pathway" approach is the protocol featured in this article to achieve excellent results and avoid complications.

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Abstract

The Reverse Pathway:
Parameters for the Integration of Function and Aesthetics with Implants

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INTRODUCTION
Contemporary implant dentistry is more than providing a patient with a titanium fixture and restoration. When replacing a missing tooth, patients' expectations are high from an aesthetic, functional and health perspective. Success is achieved in a reverse pathway by working from an aesthetic goal to a healthy, supportive foundation (Figures 1, 1a, 1b, 1c, 1d, 1e).

Knowledge, vision, ability, interdisciplinary treatment and technical support enable us to envision the design of the final prosthesis for patients in the midst of complex problems with sequential solutions as soon as a diagnosis is established.

Before the introduction of the osseointegrated implant, dentists often resorted to heroic measures to maintain teeth with guarded or poor prognoses because quality replace-
ments were not available. Endodontic treatment and prosthetic and surgical techniques such as hemisection and root amputation were employed to preserve tooth function and bone support.1-4 Today implant technology has revolutionized dentistry and improved the quality of life for patients with missing and nonviable teeth by aesthetically restoring function and providing long-term periodontal and peri-implant health.5,6

THE EVOLUTION OF IMPLANTS AND CASE SELECTION

Osseointegrated titanium dental implant technology has made enormous progress since its introduction in the early 1980s.7 A common problem with older implants without anti-rotational properties and even some that used an external anti-rotation hexagon was screw loosening on the abutments, which led to instability of the overlying crown. The develop-
ment of implants with external and internal anti-rotation, improvements in abutment and screw design, abutments with conical seals, and the availability of screw torque devices have enhanced the stability of abutments and prosthetic components.8-10 Surface treatments that promote osteoblast differentiation and new bone formation have shortened the time to osseointegration.11,12 Advances in bone grafting13,14 used to augment supporting bone which often is thin or narrow and osteodistraction techniques used to increase bone height15-18 have expanded prosthetic options and optimized results. In addition, the use of 3-dimensional computed tomography assists in diagnosis and treatment planning, thus reducing surprises during surgery.19

Appropriate case selection is critical to avoid complications and achieve successful osseointegration. Visualizing the final restoration before the treatment commence, allows the dentist to develop a treatment plan that creates the infrastructure necessary for a durable implant prosthesis. Such treatment plans may include orthodontia to supraerupt teeth in order to improve the quality and quantity of bone for the future implant bed.16,20-25 This strategy may reduce the size of the bone graft or eliminate the need for such surgical intervention altogether.

PARADIGM SHIFT FOR OSSEOINTTEGRATION
Minimizing Micromovement and Enhancing Occlusion
A growing trend in implant dentistry is to use an implant immediately after placement, with or without a nonfunctional provisional.26 When immediate use of the implant is planned, the choice of components must be guided by the need to minimize micromovement between the implant and abut-

ment27 while creating a seal that reduces bacterial invasion.28 When evaluating for optimum bone preservation around an implant, we cannot separate from the implant design and its surface treatment its direct correlation to the prosthetic component and connection.29 Furthermore, there are too many variables to conclude that the prosthetic materials selected will have a more favorable or negative impact on the outcome.30,31 Among the variables with the current restorative materials is acrylic, composite, gold, titanium, zirconia and porcelain. It must be also considered the amount of implants, implant position, location and or angulation, length and width, quantity and quality of bone. Understanding patient’s existing occlusion as well as parafunctonal habits could influence on the overall treatment plan and material selection.31

With no evidence based on the best occlusal design and restorative material to be selected for the implant supported prosthesis and due to the lack of a periodontal ligament, we must also consider factors that could negatively affect the long term success and bone preservation of the implant-prosthetic unit such as: occlusal design, occlusal forces to prevent overloading, large cantilevers, premature contacts.32

Preserving Bone
Postoperative bone preservation is key to implant success and must be continually evaluated both clinically (demonstrated by healthy, stable tissue) and radiographically. Contributors to bone preservation include the use of implants with external microthreads,33-35 loading of the implant to a conical sealed abutment,36,37 and use of a narrower abutment-crown to implant connection38 which directs the loading forces closer to the center of the implant and away from the exter-
nal and most coronal threads, thereby helping to reduce implant-abutment micromovement.\textsuperscript{27}

**Implant Spacing: 3 mm versus 2 mm**

Since the introduction of the Branemark implant,\textsuperscript{7} bone loss at the uppermost coronal threads has been the norm, particularly for implants with flat-to-flat connections versus those with internal conical seals.\textsuperscript{37} To address one variable in this problem, there has been consensus in the literature that the recommended distance between 2 implants is 3 mm (Figure 2). This distance is sufficient to prevent implant encroachment and subsequent bone loss at the top threads (Figure 3).\textsuperscript{37} In addition, the 3 mm distance provides sufficient subgingival tissue support for the creation of papillae\textsuperscript{39-41} regardless of the gingival biotype (thick or thin) surrounding the implants.\textsuperscript{42,43} When implants are placed more than 3 mm apart, over-contouring of the crowns is necessary to provide papilla support (Figure 4). Even with such contouring, the resultant papillae will have a flatter architecture and will be in a more gingival location. On
the other hand, spacing implants closer than 3 mm may be advantageous in some scenarios. When the implants used provide optimal bone preservation at the upper threads and, thus, achieve an excellent soft tissue response, a 2 mm distance between implants may be acceptable (Figure 5). Short-term results suggest that 2 mm spacing does not compromise papillae formation and offers excellent function and aesthetics. The 2 mm distance is also recommended when replacing missing anterior teeth. Considering the options of restoring two missing

Figure 5: Radiograph showing implants replacing the mesial and distal roots on a first molar. While the interproximal placement is ideal, the implants could have been positioned an additional 1-2 mm subgingival. Implants placed by Dr. Nolen L. Levine.

Figure 5a: Initial occlusal view of a lower right first molar with a vertical fracture.

Figure 5b: Initial periapical radiograph.

Figure 5c: Radiograph showing extraction of the first molar due to a vertical fracture. Note the anatomic landmark of the original roots in the bone.
anterior teeth with two implants and two crowns versus one implant and two crowns, avoiding the cantilevered crown will enhance support without compromising the aesthetic result. When one implant is supporting two crowns and one is cantilevered, following guidelines for proper papillae support will yield a more predictable result.\textsuperscript{39}

**Retaining or Removing Molars**

The decision to retain or remove a molar is based on several factors: anatomy, periodontal, endodontic, and occlusal status, tooth position, quality...
and quantity of the remaining tooth structure including existing microfractures, the ability to create a ferrule effect during tooth preparation, the crown-to-root ratio, cost, and the anticipated longevity of the tooth compared with that of an implant (Figures 5a, 5b, 5c). When a molar is missing or must be extracted, anatomical differences between the implant and the natural tooth influence treatment planning. The design of all implants resembles a single root, whereas upper and lower molars generally have multiple roots. Furthermore, the burs used to prepare the implant bed typically produce cylindrical shapes with parallel or tapered walls. Consequently, in some instances a missing lower molar is best replaced with 2 implants to better fit the extracted mesial and distal roots (Figure 5). The mesial-distal dimensions of the lower molar require that the size of each implant be sufficiently thick to withstand occlusal forces while respecting the distance from the implant to a natural tooth and from implant to implant.41,42

Creating a Tissue Profile
The tissue profile emerging from the implant is often created with a healing cap (Figure 5d) or an abutment (Figures 5e and 5f). Modification of the profile with a provisional may be necessary, and the final impression should not be taken until the correct soft tissue profile is created.
Impression Accuracy
Impression techniques and proper material selection are critical in order to accurately reproduce on a model the position of the osseointegrated implant(s). While no significant differences are described between polyether and vinyl polysiloxane materials, the polyether material provides superior detail reproduction in the presence of moisture, the direct impression technique is preferable to the indirect one as well as the polyether impression material being the most precise with the direct impression technique.

Connecting Implants
The decision to connect implants prosthetically is determined by the quality of the bone, the characteristics of the implant, the patient’s occlusion, occlusal habits, existing restorations, and oral hygiene. When implants are connected prosthetically, it is essential that a passive fit be verified clinically and in the laboratory. This is more easily accomplished if only one screw is used (Figures 5g and 5h). The assessment can be done clinically unless the crowns have subgingival margins, in which case radiographic verification is necessary. Figures 5i and 5j show the completed treatment, with the two premolars of the implant restoration replacing one natural molar.

Whether to connect implants and natural teeth
is controversial.\textsuperscript{57,58} Such connection can be accomplished by using attachments, cementation or screws. Connecting natural teeth to an implant-supported fixed partial denture with a cemented restoration or semi-precision attachments may result in separation and intrusion from the tooth (Figure 6).\textsuperscript{59} To avoid these complications, the natural tooth can have a crown accepting a lingual screw\textsuperscript{60} or must have a milled telescopic crown permanently cemented (Figure 7), and the fixed partial denture should be screw-retained onto the telescopic crown and onto the implant abutments (Figure 7a, Figure 2). By retaining the implant supported prosthesis with a screw, the need for using a cementation technique is eliminated, thus sustaining evaluation for over 14 years the hypothesis that such prosthetic designs can prevent intrusion of the natural tooth/teeth.\textsuperscript{58}

**CONCLUSION**

Osseointegrated dental implants have dramatically advanced dental care by aesthetically restoring function in patients with missing and nonviable teeth. Implant success is influenced by appropriate case selection, visualizing the final result before the treatment begins, and adherence to established parameters designed to reduce complications, maximize bone preservation, and achieve durable restorations. As experience accumulates and implant technology evolves, paradigms are shifting.

**Disclosure**

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Optimum Esthetics and Retention with Cast-to Abutments

Progress and technological evolution is something we should all embrace since such attributes allow us to provide patients with improved care. But when is it appropriate to consider proven materials and techniques outdated and when should one move forward with the promise of better product(s) along with superior outcomes?

When reflecting on giving up a comfort zone of predictability and long-term success, is the risk at hand worthwhile? It is then when proven research and reliable development is needed to jump the hurdle and to take action for clinical implementation with the confidence that the given laboratory results will support such a decision.

When considering essential aspects of the implant traits such as improved bone preservation, enhanced occlusal loading of the crown-abutment-implant unit and faster integration could be compromised by achieving earlier and improved esthetics; one might argue if such compromise is worth the risk. However, this is not the case when utilizing the Astra Tech OsseoSpeed™ Implant with the MicroThread™ and Conical Seal Design™, which offers the combination of marginal bone preservation with its soft tissue response and no screw loosening, thus setting higher standards and expectations for dental professionals, patients and manufacturers.

Case Presentation 1: Cement-retained
The need to extract fractured, untreated teeth (1a) is not an unusual occurrence and replacing them with implants is a more conservative approach than creating a three-unit bridge. The options to place an implant immediately after the tooth has been extracted or implement a delayed technique vary depending on each case being treatment planned. A benefit of immediate implant placement is bone preservation as well as avoiding a second surgical procedure. Once the implant is integrated and an impression is taken, using a Cast-to Abutment allows for customization, thus providing a crown with the best possible retention (1b).

The final crown can be permanently or temporarily cemented, depending on the patient's overall dental health and dentist's preference \(^{1,2}\) (1c, 1d, 1e).
Case Presentation 2: Screw-retained

Teeth with existing restorations and, in some instances, with root canal treatment, are weaker than untreated teeth and therefore more susceptible to fracture (2a). The reasons for a tooth (or teeth) requiring extraction are numerous but with careful diagnosis, treatment planning and meticulous implementation, the ability to regenerate the lost bone and sustain it with an implant is no longer a miracle but a clinical reality23 (2b).

Furthermore, with Astra Tech implants, bone preservation at the most coronal thread of the implant is not a process that occurs only seldom but routinely. In order to provide for optimum recreation of the anatomical crown, the implant must be properly positioned in sound bone while respecting the surrounding anatomical boundaries (2c). The bone preservation influences the soft tissue health and contours and it is critical to have the implant with adequate depth to allow the crown to emerge from the implant with the correct profile (2d).

While on multiple implants it is preferred to take an impression with an open-tray for greater accuracy; when a single implant impression is taken, a closed-tray technique is also acceptable. Once the impression is taken, there are multiple prosthetic options but they can be broken down into two main categories: cemented or screw-retained. If the restoration is a single crown, often a cement-retained technique is preferred because of its similarity to traditional crown and bridge. In some situations however, cement removal and possible damage of the crown when loosening may dictate a screw-retained restoration. Screw-retained restoration offer the advantages of: (i) retrievability; (ii) no need for cement removal; and (iii) accuracy. The occlusal anatomy is preserved with a lingual screw-retained crown, but may be compromised when screw-retained occlusally.

While the Cast-to Abutment is more commonly used for cement-retained restorations, in cases where a cement-retained restoration is not ideal, the Cast-to Abutment can also be used to provide the capability to design and customize the optimum shape, including lingual tapping, to accommodate for a screw-retained crown (2e). The tapping is preferably done on the mesial lingual area to facilitate its placement and removal (2f). Any slight ledge between the crown and the lingual screw should be smoothed down in the mouth with a #4 round bur followed by a brownie rubber point (2g). The previously described advantages of the screw-retained crown are very important with the key benefit being the ability to recreate the ideal occlusal anatomy without concern for the location of the abutment screw (2h).

Of all the previously described concepts, most important is the need to preserve the coronal bone around the implant for long-term support, stability and peri-implant soft tissue health (2i).

Implants can also act as excellent anchorage for orthodontic movement, especially if the patient desires to proceed with the orthodontic treatment after the implant-supported crown has been completed. If the crown is screw-retained, one has the ability simply to unscrew it and utilize a provisional with the implant in order to avoid damage to the crown. In situations where a treatment option such as Invisalign™ orthodontics is utilized and no buttons are placed on the crown, the crown does not need to be removed (2j, 2k).

2a. Lower left molar with fractured roots.

2b. Occlusal view of implant-healing cap replacing a lower left molar.

2c. Buccal view of implant replacing the roots on the lower left molar.

2d. Occlusal view showing the soft tissue emergence profile created by the healing cap.

2e. Lingual view of custom abutment tapped to accommodate a lingual screw and prevent displacement of the crown.

2f. Insertion of lingual screw through the crown onto the abutment to prevent its displacement.

2g. Lingual view of the crown with the retaining screw in place. Sharp edges to be smoothed down with a #4 round carbide bur and brownie polishing point.

2h. Buccal view of a screw retained crown preserving and recreating the occlusal anatomy. Laboratory work by Fujiki Toshi, RDT

2i. Radiograph of the implant supported crown showing excellent bone preservation. Implant placed by Ken Peskin DDS, Oral Surgeon.

2j. Occlusal view showing final implant supported crown on lower left molar. Note the existing crowding on the lower anterior teeth.

2k. Lower anterior teeth straightened with Invisalign™ having used the final implant supported crown as additional anchorage. Dentistry by Sergio Rubinstein DDS