



# A Multidisciplinary Approach to Treatment Planning the Single-implant Restoration: Interdisciplinary Coordination

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**ABSTRACT** The purpose of this article is to delineate the sequential thought process involved in a multidisciplinary approach to treatment planning the single-implant restoration. The pertinent issues involving orthodontic, surgical and restorative processes will be discussed comprehensively, with an emphasis on how communication and coordination among specialists influence the manner in which treatment is rendered.

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**A**s the primary care provider for the patient, it is the responsibility of the restorative dentist to serve as a “team leader,” coordinating and integrating the efforts of the various specialists involved in the treatment.<sup>1</sup> Team members include not only the patient, restorative dentist, and implant surgeon, but also the dental laboratory technician and orthodontist. The purpose of this article is to discuss various treatment planning considerations and their impact on formulating a multidisciplinary treatment plan, and to describe how to facilitate communication and coordinate treatment among various team members.

Having input from the restorative dentist to determine the final implant position greatly benefits both surgeon and patient. Likewise, the laboratory technician who appreciates various surgical and biological considerations can better avoid potential problems. For example, an adjacent tooth may present with a favorable crown position but with an unfavorable root angulation interfering with the potential implant site. Relying solely on the cast, without an understanding of the surgical and biologic requirements for successful implant placement, this problem may remain undiagnosed by the laboratory technician, resulting in an improper or unusable implant

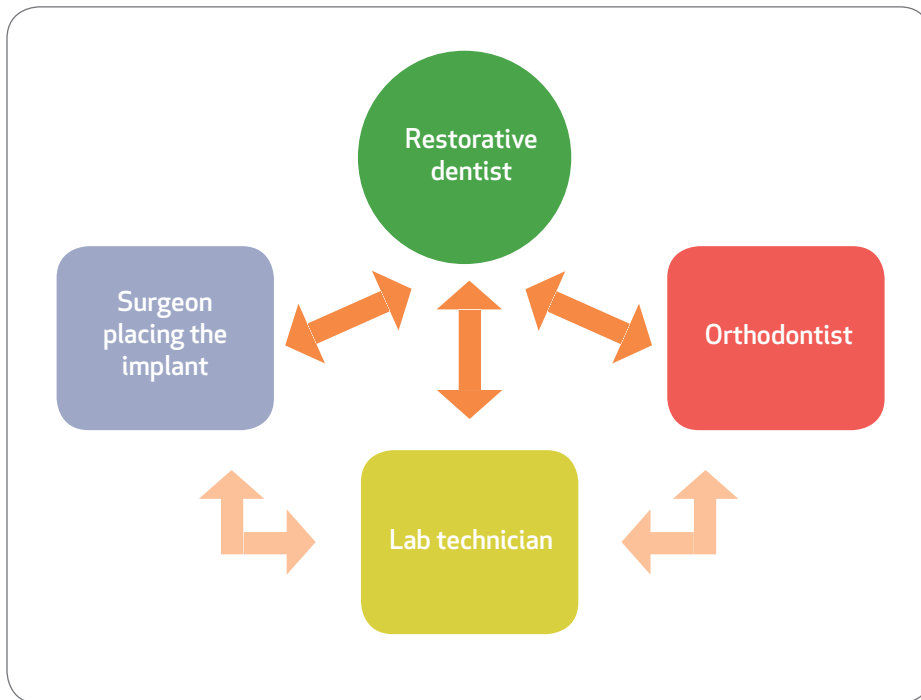


TABLE 1.

angulation in the surgical/radiographic template. An appreciation of surgical procedures also facilitates template designs that do not infringe on flap reflection and surgical instrumentation.

Because each specialist's perspective is somewhat limited to the scope of their particular training, having the restorative dentist tie all aspects of the treatment together maximizes the synergistic benefit of having input from various expertise (TABLE 1).

### The Sequential Organization of Treatment

After completing the diagnostic evaluation, the information must be systematically organized in order to execute a successful treatment. Proper sequencing of adjunctive procedures such as orthodontic movement, hard and soft tissue augmentation procedures, and implant and abutment selection must all be addressed prior to implant placement. Coordination, sequencing, and timing of treatment may vary depending upon a number of factors. An understanding of how each of these factors influences the type of

treatment recommended and sequence in which it is rendered will be discussed. The thought process involved in treatment planning the single-implant restoration is presented and a suggested sequence of treatment is proposed (TABLE 2).

### Orthodontic Treatment Considerations

Once the decision to place an implant has been established and the surgical site evaluated for adequate spacing, the restorative dentist must choose whether or not orthodontic intervention is necessary.

As part of the preliminary treatment, lack of spacing, excess spacing, or unfavorable root angulation must be addressed. When too much space is available interproximally, one solution to correct the excess space is to overcontour the proximal surfaces of adjacent teeth. Although this option may be a valid option, it requires restorative treatment of the adjacent teeth and has the potential risk of developing poor emergence profiles. On the other hand, if a retained deciduous tooth is wider mesial-distally than the permanent tooth such as in primary mo-

lars, narrowing the interproximal tooth structure to the ideal permanent tooth size may be done prior to orthodontic consolidation of the excess space created.<sup>2</sup>

If the implant is to be placed in the esthetic zone, it may be better to conceal excessive space more distally. For example, if a space is too large to be closed orthodontically, the implant may be placed mesially in the ideal position, compromising the space distally in a less noticeable esthetic area.<sup>3</sup> Another useful indication for orthodontic treatment might be extrusion of an endodontically treated tooth with a hopeless periodontal prognosis.<sup>4</sup> This can favorably position the final position of the residual ridge crest more coronally by minimizing the extent of a vertical periodontal defect prior to extraction.

Another important consideration is adequate restorative interocclusal space. If the opposing tooth is supraerupted, compromises in the occlusal plane may result in unfavorable vectors of force due to excursive interferences, lack of interocclusal space for implant restorative components, and compromises in abutment height leading to lack of resistance and retention form in cemented restorations. Orthodontic intrusion of the opposing tooth may be an option if the tooth cannot be occlusally adjusted<sup>5</sup> (FIGURE 1).

Communication between the restorative dentist and the orthodontist should be very specific with regard to the desired tooth positions and angulations. In addition to study casts, a "work order" similar to those typically used for laboratory technicians, but outlining implant crown and implant fixture space requirements and very specific, precise measurements of desired tooth movement and direction may be utilized. Radiographs indicating desired root position may also be appropriate as part of this "work order" when root proximity and angulation impacts implant placement.

**IDENTIFY THE ISSUES/ANALYZE AND ASSESS THE SITUATION:****EVALUATE IMPLANT POSITION:**

- Angulation
- Spacing requirement
- Bodily position

**HARD TISSUE ASSESSMENT:**

- Bone width buccal-lingually
- Bone height on adjacent teeth
- Quality/density

**SOFT TISSUE ASSESSMENT:**

- Quality of tissue: biotype/amount of keratinization
- Adjacent gingival levels
- Papilla height

**ADJACENT TEETH/OPPOSING OCCLUSION:**

- Position/contours/contacts
- Angulation/root angulation
- Prognosis of adjacent teeth

**IDENTIFY THE OVERALL GOALS:****SURGICAL**

- Implant surface treatment
- Implant design
- Bone level versus tissue level
- Tapered versus parallel
- Internal versus external
- Length, diameter
- Immediate versus delayed placement
- Grafting/bone augmentation
- Immediate versus delayed provisionalization

**RESTORATIVE**

- Abutment selection
- Direct UCLA versus platform
- Prefabricated versus custom
- Material (zirconia, gold-coated, etc.)
- Type of restoration
- Cement versus screw
- Occlusal considerations

**ORTHODONTIC**

- Appropriate spacing
- Correction of adjacent teeth
- Intrusion/extrusion

**TABLE 2.****Orthodontic Treatment Sequencing**

Depending upon a variety of factors, implant placement may be performed prior to, during, or following completion of orthodontic treatment.

Although rarely needed in the case of single-tooth implant restorations, implant placement prior to orthodontic treatment may be indicated in those situations where tooth movement may be facilitated

by additional anchorage. Implants utilized for additional orthodontic anchorage may be of either a temporary type designed to be removed following completion of orthodontic treatment, or a definitive type to be utilized to support a final restoration. Planning for implants to be utilized to support final restorations presents a particular challenge as the implant position must be planned to accommodate

the anticipated final restorative position of the teeth. A diagnostic cast, sectioned to allow a wax-up anticipating planned orthodontic tooth movement is made and duplicated. The ideal implant position is determined on this duplicate cast. Teeth that do not require orthodontic movement are utilized as reference points to transfer the proposed implant position back onto the preorthodontic cast for



**FIGURE 1.** A patient presented with a retained deciduous maxillary left canine and insufficient restorative space. In this case, orthodontic intrusion alone was not adequate esthetically. Although more difficult, the decision to minimally open the vertical dimension of occlusion by orthodontic extrusion of the adjacent posterior segments in conjunction with intrusion of the opposing mandibular canine was elected.

radiographic/surgical template fabrication. Appropriate radiographs are taken utilizing the template and the template is then utilized for implant placement prior to initiation of orthodontic treatment.

Commonly, implant placement is performed following completion of orthodontic treatment and stabilization of final tooth position. Although the outcome is more predictable, performing orthodontic then surgical procedures sequentially does add to the total treatment time. In addition, orthodontic retention is needed that does not interfere with implant surgical procedures to avoid relapse while waiting for osseointegration. An advantage of waiting until final orthodontic treatment is completed prior to dental implant placement is that the removed brackets and archwires will not interfere with implant placement.

If orthodontic treatment does not interfere with ideal implant placement and position, the two procedures may be performed concurrently. However, unless implant placement is needed in order to provide additional anchorage to facilitate orthodontic treatment, it is preferable to perform implant placement during the stabilization phase of orthodontic treatment, immediately following final tooth movement (**FIGURE 2**). Having an integrated implant fixture ready to restore at the completion of



**FIGURE 2.** During the final stages of orthodontic treatment, the implant was placed immediately at the same surgical appointment the deciduous canine was extracted.

orthodontic treatment, immediately after bracket removal, reduces overall treatment time and may improve patient satisfaction.

Once orthodontic treatment is initiated, it is beneficial for the orthodontist to provide periodic diagnostic casts to the restorative dentist to monitor progress. This becomes particularly helpful to finesse the final tooth position as the patient nears the end of orthodontic treatment, ensuring a final result compatible with ideal implant position. Following completion of tooth movement, but prior to removal of brackets and archwires for stabilization, an impression is made in order to fabricate the surgical/radiographic template.

Coordination with the orthodontist is necessary to temporarily remove archwires and to deliver a temporary removable space maintainer, such as a vacuum-formed matrix to stabilize the arch just prior to implant surgery. Immediately following implant surgery, archwires may be replaced in lieu of the removable appliance while awaiting maturation of the implant-bone interface and stabilization of tooth position. In addition to enhancing patient comfort, this eliminates pressure over the surgical site by the removable appliance and obviates the necessity for multiple adjustments to accommodate for post-operative swelling. Reliance on patient compliance to wear a removable appliance is eliminated, reducing the possibility of orthodontic relapse following implant placement and prior to restoration.

In order to decrease the time, cost, and inconvenience of repeated removal and replacement of archwires for stage I and stage II implant surgeries, a one-stage implant surgical procedure may be considered when orthodontic treatment overlaps implant placement time. In addition, anticipating the clearance needed for surgical template seating, flap design, and surgical instrumentation when planning bracket placement and archwire design to facilitate implant placement may eliminate the need for repeated archwire removal and replacement altogether.

Whether implants are placed before, during, or at the end of orthodontic treatment, evaluation of diagnostic casts by the restorative dentist made prior to bracket removal will avoid the inconvenience and potential embarrassment of bracket replacement should further tooth movement be needed to optimize results.

## Surgical Treatment

Prior to any treatment, the surgeon and restorative dentist must determine which implant system to place during the presurgical discussion. Implant configuration (tapered versus parallel) and implant connection (internal versus external) should be restoratively driven and decided prior to surgery. The approximate length and diameter can be determined by radiographic evaluation, however, the exact implant length and diameter are variable factors that are definitively made at the time of surgery.

### Implant Selection Criteria

#### SURFACE TREATMENT

Deciding on an implant system based on surface technology is not as significant a factor today since all current major implant systems have shown integration with high levels of success.<sup>6</sup> Over the years, manufacturers have attempted to enhance their implant surfaces. From the tradition-

al machined, smooth surfaces, the newer roughened surfaces have consistently proven themselves to be superior in terms of quality of osseointegration as well as time of osseointegration.<sup>6</sup> These enhanced surfaces are more bio-reactive and thus may also lend themselves to earlier loading protocols than the original machined-surface implants.<sup>7</sup> Selecting a major manufacturer can be beneficial since it is more likely that a reputable business will still exist if, and when, components need replacement.

#### IMPLANT DESIGN

Most manufacturers now offer both a bone and tissue level implant. Because tissue level implants potentially run the risk of showing the metal collar through thin biotypes, there is a trend toward placing collarless bone level implants, which are advantageous in esthetic applications.

Another implant characteristic is the configuration of the body, which can either be tapered or parallel-sided. Due to the configuration of tapered implants, they can be used in sites with compromised bone width or in close proximity to adjacent roots. These implants are, however, more technique-sensitive because of the need to place them at the precisely drilled depth in order to engage all of the implant threads.<sup>8</sup> Parallel walled implants are less technique-sensitive and changes in vertical position or angulation can be made more easily. In extraction sites, parallel implants will engage the socket walls more effectively, providing added primary stability.<sup>8</sup>

With regard to the implant-abutment interface, the type of connection plays a significant role in stability of the abutment. Potential problems such as screw loosening and fracture are also influenced by this connection. In the past, screw loosening has been observed up to 40 percent in prospective studies with single molar implant restorations being the

most common.<sup>9,10</sup> Because of this, implant manufacturers have focused their marketing attention on connection design. Two such implant-abutment interface designs are the internal and external connections.

Furthermore, a taper on the internal aspect of the abutment connection provides a more intimate “slip joint” connection.<sup>11</sup> This Morse taper actively engages the internal walls of the implant creating a tight seal to prevent the ingress of bacteria as well as potential screw loosening.<sup>12</sup>

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The internal conical design has shown to increase the resistance to bending moments at the implant-abutment interface when compared to a standard external hexed butt joint. This was observed in the original ITI system (Institut Straumann AG) with an 8-degree conical interface as well as Astra’s Conical Seal design (Astra Tech AB) which had an 11-degree taper.<sup>13</sup> Both tapered designs allowed forces to be absorbed by the implant-abutment connection and transferred to the implant-bone interface. Unlike the external connection where abutment screw and preload are the determining factors in stability of the connection, the internal tapered connection creates a frictional lock protecting the abutment from excursive lateral forces. With regard to stress concentrations at the implant-abutment connection, the internal

connection is preferred over the external type for single-tooth restorations.<sup>14</sup>

In terms of anti-rotation, the presence of a hex on either the internal or external connections is ideal for single-tooth restorations.<sup>15</sup> Additionally, a larger and broader interproximal contact area of the final restoration may further assist in terms of its rotational resistance.

#### IMPLANT DIMENSION

Implant dimension is somewhat constrained by anatomic limitations. Ideally, an implant at least 10 mm long should be used since shorter implants have been shown to have a lower success rate.<sup>16</sup> Apart from a biomechanical advantage the implant diameter choice is esthetically more essential.<sup>17</sup> The diameter of the selected implant should ideally correspond to the emergence profile of the tooth being restored. A maxillary lateral incisor would require a regular or narrow platform while a molar tooth would benefit from a wide platform implant. This should be selected based on the width of the edentulous space and the desired emergence profile of the restoration. Wide diameter implants will have greater surface area and improve stress distribution to bone.<sup>18</sup> Usually, 5 mm diameter implants are indicated in molar areas, 4 mm in premolar and anterior regions, and narrow implants (3 mm to 3.5 mm) may be used in sites with limited space, such as maxillary lateral incisors and mandibular incisors.

#### IMMEDIATE IMPLANT PLACEMENT

The decision to place an implant immediately following a tooth extraction should be made on a case-by-case basis depending on whether or not the extraction site is free of acute infection and where the proper diameter implant will engage enough of the extraction site to achieve primary stability. With regard to survival rates, the short-

term clinical outcomes have been comparable for both immediate and delayed implant placement.<sup>19</sup> However, the long-term success involving peri-implant health, bone loss and esthetic outcomes seem to be inconclusive from lack of data.<sup>20</sup> As such, immediate implant placement continues to be a somewhat controversial topic in implant dentistry. Proponents of immediate placement do however cite shorter treatment times and greater patient satisfaction as advantages compared to a delayed protocol.<sup>21</sup>

#### COORDINATION OF HARD AND SOFT TISSUE GRAFTING PROCEDURES

During the implant placement, grafting procedures may be indicated to increase bone volume and augment sites so that implant can be placed in the most favorable restorative position.<sup>22</sup> The decision to simultaneously place a graft and the implant depends on the extent of grafting required as well as the amount of primary stability of the implant.<sup>23</sup> The decision to graft should be made with the patient after thorough discussion of the risks and benefits of the proposed procedures. Detailed evaluations and hard tissue grafting options will be further discussed in the article on hard tissue considerations.

Once an adequate amount of bone is present to place the implant, the quantity of bone must be assessed for soft tissue support. Since soft tissue architecture is dictated by the underlining hard tissue anatomy, the need for adjunctive hard tissue grafting procedures may be indicated for apparent soft tissue deficiencies.

If soft tissue grafting is required, the decision needs to be made as to the timing of the grafting. It may be performed at the time of implant placement or at second stage. One advantage to delaying soft tissue grafting procedures until second stage is to allow time for osseointegration to occur and any bone grafting procedures

to properly remodel. Once the hard tissue contours are stable, the need for soft tissue augmentation can be achieved more predictably. At the time of implant placement, the surgeon should make an index to register the position of the implant once it is placed and before proceeding with primary closure of the tissues. The restorative dentist/lab can then fabricate a custom healing abutment or a provisional restoration that can now be used at the second-stage surgery and grafting procedure. The graft is allowed to heal and mature against a more anatomically shaped emergence profile, instead of a standard healing abutment.

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#### IMMEDIATE IMPLANT PROVISIONALIZATION

From the patient's perspective, immediate placement of a provisional restoration at the time of implant placement offers a number of distinct advantages. It provides for an immediate provisional restoration that portends the final fixed restoration and eliminates the potential negatives of wearing a removable prosthesis. From a surgical/restorative perspective, an advantage of the immediate provisional restoration is that by mimicking the contours of the proposed restoration, it acts as a soft tissue scaffold, its emergence profile helping to maintain or recreate ideal soft tissue architecture.<sup>24</sup> Factors determining whether it is advisable to immediately provisionalize an implant at the time of

placement include the degree of primary implant stability and the ability to minimize loading. It is critical that patients are advised to eat a soft diet and to avoid directly functioning on the provisional restoration during the healing period.

However, simply informing the patient to avoid biting on the implant can be unpredictable. Occlusal forces must be controlled, in order for the restorative dentist to place a provisional the same visit that the implant is placed. Although lateral forces on anterior teeth can be more significant, overall occlusal loads are less compared to posterior teeth therefore favoring immediate provisionalization in the anterior region. To prevent detrimental forces during the early stages of osseointegration, the provisional restoration is adjusted so no centric or eccentric occlusal contacts exist. In addition, contacts on adjacent teeth can favorably protect the implant from excursive interferences. It may also be wise to have a back-up removable provisional prosthesis such as an Essex stent in case primary stability of the implant cannot be achieved at the time of surgery and the implant provisional cannot be delivered.

#### Restorative Treatment Considerations

During the initial phase of the restorative treatment, the provisional implant restoration is evaluated for esthetics and function. Adjacent contours of hard and soft tissue are allowed to stabilize prior to fabrication of the definitive restoration. This can be particularly critical in the esthetic zone. Once the provisional implant restoration has had sufficient time to mimic the shape and esthetics of the final restoration, an impression can be made to aid the laboratory technician. This is one of the most predictable ways to facilitate transition into the final restoration.

### Abutment Selection

The restorative dentist must be aware of the various prosthetics components that are available for the different systems that the surgeon may be utilizing. The implant system used should be dictated by the restoring dentist as there may be subtle differences between the systems that may be beneficial to the particular case.

For example, one design philosophy incorporates the use of an abutment that is slightly narrower than the implant platform such that the abutment-implant interface occurs medially to the implant axial surface. Frequently referred to as “platform switching” (3i), “conical seal” (ASTRA) or “platform shifting” (Nobel Biocare), this concept supposedly keeps the bacterial inflammatory response found at the abutment-implant junction or micro-gap, away from the bone interface. One study has shown maintenance of crestal bone at its initial position instead of remodeling to the first or second thread.<sup>25</sup> Application of this concept may be more critical in areas exhibiting thin interproximal bone adjacent to the implant site. If the restorative dentist wishes to prescribe to this philosophy, the decision should be communicated with the surgeon to ensure the correct choice of implant system.

With the growing number of implant manufactures and restorative material, the abutment choices may seem vast and confusing. There are standard prefabricated abutments or custom abutments, both of which may have a straight or angled profile.

In the single-tooth implant, direct UCLA “cast-to” abutments can be less complex than multiunit standard abutments by simplifying the number of components. If an implant is placed restoratively in the ideal position, the access channel should exit through the occlusal portion of posterior teeth and the cingulum or incisal edge of anterior teeth.

When angulation issues are a concern, prefabricated angled and preparable abutments will provide a limited degree of correction. “Cast-to” UCLA-type abutments can have greater flexibility in angulation adjustment through the use of a custom abutment. However, the additional coping will be an added cost to the lab fee. This should be a main concern for the restoring dentist since poor angulation issues in implant placement can restoratively be a financial burden.

Also gaining popularity, are the CAD-CAM custom abutments meant

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for cement-retained restoration. Made from titanium or zirconia, they are milled from blocks, after scanning and designing it on a computer system. Abutment material is a function of both esthetics and strength. For its superior esthetic qualities, the use of zirconia has increased in popularity. However, in the anterior region of esthetically demanding patients, thin periodontal biotype and limited occlusal forces, zirconia abutments are a favorable choice, as they are nonmetallic in color, and do not produce a grayish appearance through the tissues. In the posterior regions, conventional gold nitride-coated titanium or high noble cast abutment can provide adequate strength with sufficient esthetics.

### Type of Restoration

Originally, implant restorations were all screw-retained. Screw-retained restorations are easily retrievable if adjustments or repairs are needed. Restorations that came loose could be re-torqued as well. The cement-retained restoration was originally designed to mimic conventional crown and bridge procedures simplifying treatment for the restorative dentist. Cemented restorations are more ideal in controlling occlusal contacts and situations where esthetics may be compromised with the use of a screw access channel. With cement-retained restorations, occlusal forces can be directed more vertically down the long access of the crown rather than axially around the screw access. Even in cement-retained restorations, there is an abutment screw in the system that has an equal chance of coming loose as the one holding the screw-retained restoration. Whether a cement-retained, or screw-retained restoration is utilized, the abutment screw should be tightened utilizing a torque driver to deliver the torque specified by the manufacturer. The introduction of the torque driver has allowed quantitative consistency in tightening of screw joints in addition to increasing contact forces between implant and abutment components.<sup>26</sup>

However, with better internal connection implants and the more predictably reduced incidence of screw loosening, the cement-retained restorations have gained more popularity amongst practitioners. When encountering a patient with a known parafunctional habit and the dentist anticipates a potential problem with a higher anticipated load and porcelain fracture, a screw-retained restoration would be favored. This will allow for a predictable removal of the restoration for repair.

### Occlusal Considerations

When designing the occlusion of the restoration, it is important to analyze the existing occlusion and guidance pattern prior to restorative treatment. Guidance in excursive movements should preferably be on natural teeth due to their added mechanoreceptive feedback. If a canine tooth is being replaced by an implant and canine guidance is desired, the excursive contacts should be distributed on adjacent teeth such as the first premolar or lateral incisor during lateral movement. This concept of group function will allow a more favorable allocation of forces over the implant. In a case where the length of a restoration will fulfill the esthetic requirements but unfavorably load the implant, the authors suggest that a concept observed in natural dentition may be utilized and guidance should be adjusted so that only the critical last 1 mm of closure is contacting in excursive movements.<sup>27</sup>

Implants tend to accommodate axial loads better than non-axial loads.<sup>28</sup> Unlike natural teeth, implants are ankylosed to bone and do not display the level of resiliency imparted by the periodontal ligament. Thus the occlusion of the restoration must be carefully adjusted to compensate for the forces being absorbed by the visco-elastic properties of the surrounding bone. If the occlusion is not adjusted correctly, there is a risk of overloading the implant, which may lead to crestal bone loss and potential implant failure.<sup>29</sup>

One potential method of dealing with the difference in visco-elasticity between dentition and implants is to develop light centric contact in maximum intercuspal position and no eccentric contacts on lateral movements. When the patient occludes lightly, the occlusion is adjusted so that a 12 microns shim stock is able to just pass over the implant restoration without tearing while being held firmly by the

adjacent teeth. Upon forceful closure, this allows improved tactile mechanoreception on the natural teeth. According to the literature, there is currently no evidence-based research to support a specific concept of implant occlusion. However, based on clinical experience and existing literature, guidelines may be recommended for optimal implant occlusion and management of complications related to implant occlusion.

The occlusal table of the restoration should be kept as minimum as possible.<sup>30</sup> Since the mesial-distal width cannot be changed much, as the restoration needs to achieve a contact area, the buccal-lingual

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dimensions may be narrowed slightly. This allows for a smaller occlusal table and minimizes the risk of developing an interference and implant overload.<sup>30</sup>

### Communication Is Key

Good communication between all specialists involved including the patient is essential for a successful treatment. Communication will facilitate the management of cases and reduce the risk of complications. The restorative dentist should be the primary individual sharing information between specialties and conveying their objectives and requirements to one another. This section provides the practitioner with suggestions as to how to best communicate pertinent information to each implant team member (TABLE 3).

### Facilitating Communications With the Implant Surgeon

Communication with the implant surgeon is probably the most crucial step in implant planning. Once the implant is placed, its position cannot be altered or removed without causing further complications. The restoring dentist and implant surgeon must decide on the ideal angulation and bodily position before requesting a radiographic scan. The scan should be as recent as possible to currently reflect the anatomical boundaries.

Restoratively speaking, the two crucial constraints that need to be conveyed to the surgeon in the surgical guide are the proposed CEJ level which dictates implant depth 2-3 mm apical and the restoration contours that determine angulation such that the restoration will be loaded down the long axis, and the access will allow for a favorable exit if screw retention is desired. In addition, the surgeon should recommend any guide modifications that will facilitate easier surgical access. For example, since the implant's restorative occlusal anatomy on the surgical guide provides little clinical value, the occlusal cusps can be reduced to facilitate easier surgical access.

However, this should be done carefully as to not adversely misinform the surgeon of the restorative contours. If during the surgical procedure a soft tissue flap is reflected, it must not interfere with the seating of the guide. Lastly, where the surgical guide rests on adjacent teeth, an occlusal notch can be made to conveniently verify complete seating on the teeth.

During implant placement, the fewer adjustments needed to accommodate the surgery, the more smoothly the treatment will proceed. A prearranged agreement between the surgeon, restorative dentist, and patient may be made to avoid indecision when changes in planned implant po-



TABLE 3.

sition or angulation must be made to accommodate conditions found at surgery. Protocols for deciding whether implant angulation should be changed and to what extent, or ideal position maintained with simultaneous grafting procedures should be worked out prior to surgery.

Appropriate timing of provisional restoration delivery should be coordinated between the surgeon and restorative dentist. Due to the uncertainty of immediate provisionalization until the time of

implant placement, the restorative dentist should be ready to deliver an alternative provisional restoration. If initial stability is established, a provisional can be delivered facilitating soft tissue adaptation and the patient's esthetic satisfaction. However, if poor initial stability is present, delivery of a custom healing abutment can be an alternative method of achieving soft tissue adaptation without risk of occlusal loading (FIGURE 3).

Soft tissue augmentations, such as

keratinized free gingival grafts, should be accomplished during the second stage when the implant is uncovered and provisional delivered. This approach allows the provisional restoration to mold soft tissue contours appropriately. The need for hard tissue augmentation should be decided upon by the surgeon at time of implant placement or decided at the treatment planning stage.

Although not always possible, if the implant shows adequate stability, a



**FIGURE 3.** A custom healing abutment following the contours of the extracted canine was fabricated to maintain the scalloped architecture. The height of the abutment was just above the tissue level away from any occlusal contacts. A provisional denture tooth was then bonded to the archwire.



**FIGURE 4.** After orthodontic treatment was completed on the upper arch and the implant allowed to fully osseointegrate, veneers were prepared on Nos. 6-10 and provisionalized with a splinted restoration to stabilize the arch. At this time, the implant was also loaded with a provisional restoration.

surgical index may be taken at the time of surgery to fabricate a provisional. Whether the implant is stable will dictate whether the provisional is delivered. If initial stability cannot be achieved at the time of implant placement, a surgical index will at least permit delivery of a provisional restoration at a later date.

#### *Facilitating Communications With the Orthodontist*

When orthodontic treatment is required, it helps to show the orthodontist proposed teeth positions through a diagnostic wax-up. Providing exact spacing requirements minimizes confusion and error. If spacing is an issue, the dentist should specify where to ideally position the teeth prior to implants. In addition to the desired crown position, correction of adjacent root angulation needs to be addressed if they interfere with the proposed implant site.

Minimum space requirements for implant placement must be specific to avoid confusion. For example, requirements for root spacing must be measured at the crestal bone level, root surface-to-root surface, and not at the level of the crown's interproximal contacts. The fixture form will determine necessary inter-root space requirements at the apical root level.

Depending on the implant system, the orthodontist should be informed of the necessary interocclusal space in determining whether orthodontic intrusion extrusion or occlusal adjustment is necessary

for the opposing tooth. If extrusion is decided upon to orthodontically augment the ridge, occlusal adjustments must be coordinated with the restorative dentist during concurrent extrusive movement.

The method of provisionalization must be decided by the restorative dentist after implant placement. If orthodontic treatment is still in progress, a denture tooth can be bonded to the archwire. Alternatively, a removable interim prosthesis can be worn. If the adjacent teeth require restorative treatment, splinted provisional restorations can also be used to maintain spaces. (FIGURE 4).

In order to facilitate anticipated surgical implant procedures, the orthodontic brackets and archwires should be designed and placed in such a manner as to not impede these surgical procedures. This negates the necessity to remove brackets and archwires to accommodate implant surgical procedures. This also somewhat decreases the logistical burden of coordinating visits between the restorative dentist, orthodontist, and implant surgeon every time the surgeon or restorative dentist needs to get access to the implant site.

In addition to accommodating implant surgical procedures, it is often beneficial if the archwires can be placed in such a manner as to facilitate any needed radiographic surveys such as a CT scan along with the concomitant radiographic/surgical template. Although conventional dental periapical radiographs should be taken to assess root angulation and

proximity prior to bracket removal, if the CT scan can be taken with the brackets and radiographic template in place, should a problem with root angulation become apparent in the CT scan, further orthodontic corrections can be made without the inconvenience of having to replace prematurely removed brackets.

As such, it is critical that the progress of orthodontic treatment is carefully monitored by the restorative dentist with adequate opportunities to check on osseous and soft tissue contours and adjacent crown and root positions relative to the proposed implant site prior to bracket removal. Although archwire removal can sometimes facilitate some implant surgical procedures, bracket removal should not be done by the orthodontist until it is certain that orthodontic treatment has met all the goals of treatment and is complete, and with the specific approval of the restorative dentist. Needless to say, this avoids some potentially serious patient management complications should further orthodontic treatment is deemed necessary to optimize treatment results.

#### *Facilitating Communications With the Laboratory Technician*

Good communication with the lab technician is just as important as with the other specialists involved. This entails a thorough laboratory prescription with all the necessary information to assist the technician without having them rely on their own judgment. A successful treatment always begins with a diagnostic wax-up. Although provided by the lab technician, the restoring dentist should be able to evaluate, critique, and relay import information from this diagnostic tool and radiographs to the surgeon and orthodontist. The wax-up will help the restoring dentist decide if orthodontic movements are necessary and later duplicated for fab-

rication of the surgical guide. That is why it is essential to communicate the exact position of the proposed CEJ and restoration contours in the diagnostic wax-up.

In the anterior esthetic region, capturing tissue architecture is critical in achieving a predictable outcome. Minimizing the amount of soft tissue changes while transitioning from provisional to definitive restoration will result in a more predictable treatment. Therefore, it is best to provide the technician with an impression of the soft tissue in its most stable state. This can be achieved through the use of either custom-made impression copings that mimic the exact subgingival emergence profile of the provisional restoration or using the actual provisional if time allows.

When requesting the impression to be poured, a type IV low expansion die stone should be specified. In addition, the use of a silicone soft tissue cast around the implant analogs can be useful in fabricating slightly overcontoured restorations to carefully manipulate the gingiva and can easily be removed to verify the seating of the restoration on the master cast (FIGURE 5).

If the lab is to fabricate a provisional, information regarding contours to shape the soft tissue is necessary. If attempting to guide papilla regeneration, specify the addition of material to be displaced mesial-distally. Or if the facial tissue is thin, it is recommended that facial contours be slightly flatter than the adjacent natural tooth contours in order to minimize apical displacement of the free gingival margin.<sup>31</sup>

Communicating proper esthetics is even more crucial when working in the anterior region. The more information one can provide the technician, the better the outcome. In addition to taking a shade, information regarding translucency, specific characterizations, contours, and surface

texture should also be conveyed. Multiple photos with at least two shade tabs next to adjacent teeth should be included. Diagrams with shade mapping can ensure an accurate description is provided for the technician. Other useful techniques include printing out intraoral photos and drawing out the actual changes that need to be made directly on the paper or the addition of a different colored wax added to the porcelain showing exact contour modifications.

**WITH REGARD TO THE single-tooth implant restoration, perhaps the most critical aspect of communication with the patient is predicting the expected esthetic result.**

#### *Facilitating Communications With the Patient*

Avoiding misunderstandings with patients regarding the timing, sequencing, cost, and expected treatment outcomes is a critical aspect in the success of any patient treatment.<sup>32</sup> Advances in implant dentistry techniques have led to increased predictability, enhanced functional and esthetic results. Understanding patient expectations is crucial to determining the most appropriate treatment.

Advertisements that tend to minimize the complexity of the multitude of factors that need to be taken into consideration in order to obtain optimal, long-lasting esthetic results may sometimes mislead patients as to what is actually involved in replacing the single missing tooth with a dental implant restoration. This may be true regarding not only the time needed for treatment, the cost of treatment,

but also for the necessary prerestorative steps needed to prepare the site for optimum esthetic and functional results.

For this reason, it is critical that an initial plan, outlining all anticipated procedures along with sequencing of those procedures, is presented to, thoroughly discussed with, and understood by the patient prior to the initiation of treatment. As previously stated, as implant placement is restoratively driven, it is usually the restorative dentist who becomes the central figure in coordinating the various aspects of dental implant treatment. It is also the restorative dentist who becomes the primary resource for answers to the patient's questions regarding their treatment, and the individual who the patient looks to for guidance and support throughout these procedures.

With regard to the single-tooth implant restoration, perhaps the most critical aspect of communication with the patient is predicting the expected esthetic result, particularly with regard to issues regarding gingival balance, apparent gingival root prominence, and papilla contour. Based upon the understanding of the biologic parameters that determine sustainable gingival contours (interproximal bone height, distance to the interproximal contact, and the implant/tooth interproximal bone width), one should be able to give the patient a realistic expectation prior to initialing treatment of what the final gingival contours should be.

Based on the particular parameters the patient presents with, a diagram or photograph illustrating the expected result should be shared and discussed with the patient. Particularly in the esthetic zone, failure to meet patient expectations can lead to "failure" of treatment and patient dissatisfaction, even in light of generally favorable results.



**FIGURE 5.** An impression was made with a soft tissue cast to allow for minimal overcontouring of the restoration if the tissue architecture needed modification.



**FIGURE 6A.** Delivery of the definitive veneers Nos. 6-10 and provisional implant restoration on No. 11. Patient was satisfied with the esthetic results and maintenance of the soft tissue architecture.



**FIGURE 6B.** Given the outcome of having the screw access through the incisal edge, either a prefabricated angled abutment or custom abutment with a cement-retained restoration is indicated. An anterior group function occlusal scheme was designed to control the guidance in excursive movements.

## Conclusion

If the dentist can reliably anticipate the outcome of treatment, patients will be more likely to accept care. In order to have predictable results, long-term objective goals must be envisioned prior to the start of treatment. In relation to the single-tooth implant restoration, these objectives can be broken down into surgical, orthodontic, and restorative requirements. Understanding the sequential thought process and addressing the pertinent issues are only part of the treatment. Good communication with all specialties including the patient will ensure greater confidence and a more successful treatment (FIGURES 6A-B). ■■■■

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