Current Protocols for
Posterior Single Implant-supported Restorations

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ABSTRACT

Current options for posterior single implant-supported restorations allow for shorter treatment times and earlier restorative care for patients. For all protocols, careful treatment planning is critical, and is aided by the use of CT and/or CBCT imaging as well as software that helps the clinician with the identification of relevant structures and with overall treatment planning. Primary implant stability, osseointegration, and soft-tissue contouring are all affected by the surgical phase, and soft tissues are affected by the restorative phase. Careful consideration should be given to these aspects for all stages of implant therapy.

EDUCATIONAL OBJECTIVES

The overall goal of this article is to provide the reader with information on posterior implant-supported restorations. After completing this article, the reader should be able to:
1. Describe anatomical and other considerations during implant treatment planning;
2. Review the use of software during implant treatment planning;
3. List and describe aspects of implant design that affect primary implant stability; and
4. Delineate abutment and retention options and the evidence for these.

TREATMENT OPTIONS

Treatment options for the replacement of missing teeth have expanded substantially since the introduction of modern, root-form endosseous dental implants, which offer excellent long-term outcomes with suitable case selection and clinical care. The standard protocol 2 decades ago for all indications required that implants were only placed in healed sockets (ridges) and submerged to remain undisturbed during osseointegration (two-stage surgical technique). Since then, implants have been developed and protocols evaluated that offer more rapid and less invasive treatment without compromise or possibly even with improvements by becoming less invasive and more precise.

Current protocols for posterior single implants

Current protocols for posterior single implants include immediate, early, or delayed implant placement relative...
to the time of tooth removal; submerged two-stage procedures or one-stage procedures using a healing abutment and avoiding the second surgery (required to uncover submerged implants); and immediate, early, or delayed temporization and/or loading. Single, implant-supported posterior restorations offer high survival and success rates with these protocols when the individual case is carefully selected.

**Treatment Planning for Posterior Dental Implants**

Case selection is important to avoid failures. There are few systemic health contraindications to implant therapy, and research supports treatment in patients with diabetes mellitus (unless uncontrolled), cardiac disease, or osteoporosis. Although smokers have been found to experience greater marginal bone loss than nonsmokers, smoking tobacco is also not considered a contraindication. A full medical history is essential to consider all potential absolute and relative contraindications. Local contraindications must be considered, including but not limited to anatomical structures, lack of bone, and parafunctional habits. Anatomical considerations are critical when planning mandibular and maxillary implants.

**Mandibular Implants**

The inferior alveolar nerve is the most critical anatomical landmark, and poor treatment planning can result in iatrogenic nerve injury during implant placement with outcomes that include paresthesia, a complete absence of sensation, or pain. Although 2-dimensional radiographs have historically been used to assess anatomical structures and bone prior to implant placement, these cannot produce an accurate 3-dimensional assessment. Risk assessment using computerized tomography (CT scans) has shown that <6 mm of bone separated the inferior alveolar canal from teeth in 73% and 53% of mandibular second and first molars respectively, and 65% of second bicuspids. The inferior alveolar canal including an anterior loop, as well as the position of the lingual and sublingual arteries, must be considered. Undercuts and/or anatomical concavities in the lingual area of the lower mandible may present a risk for lingual plate perforation. Based on CBCT (virtual) and CT scan studies, the greatest risk is at mandibular second molar sites and at least three times greater than other posterior sites. It is important for the clinician to understand the relative position of arteries such as the submental artery to avoid very rare but important-to-understand complications. A small proportion of the population has an incisive branch of the mental nerve. This should be isolated on CT and discussed with the patient prior to surgery. Lastly, posterior ridge resorption has implications for the final occlusion in addition to increasing the risk to anatomical structures—as the ridge resorbs, it typically leads to a crossbite setup, especially if maxillary ridge resorption also occurs.

It is generally recommended that a minimum of 2 mm of bone height be preserved as a safety margin between the inferior alveolar nerve on the one end and between the site preparation drilling and the implant on the other. If this would not be possible, alternatives include bone grafting and delayed implant placement, the use of short implants (or highly invasive specialist nerve repositioning), or providing an alternative treatment.

**Maxillary Implants**

The most obvious anatomical landmark to consider is the position of the maxillary sinus. This tends to pneumatize once the tooth has been extracted. If the sinus drops too much, then bone grafting may be required to provide adequate bone for primary implant stability. If bone grafting is required, it is prudent to assess the patency of the ostium (the entrance and exit point of the sinus entering into the middle meatus of the nasal cavity). Other areas of interest include the buccal undercut in the anterior maxilla; this area can be palpated or reviewed using 3D images to plan implant angulation and depth. Lastly, maxillary bone density may be a concern. The bone has a thinner cortex and a larger spongy bone area than the mandible, which enhances blood supply to osteotomy sites but also may compromise the stability of the bone.

**Treatment Planning, Anatomical Structures and Software**

In addition to CT/CBCT, digital dentistry is now improv-
ing the diagnostic and planning phases of implant treatment. Software is available that guides clinicians through the whole treatment planning process after patient details and images have been uploaded. This software helps the clinician inspect the anatomy using panoramic views, 3-D digital reconstructions of the arch, thin slices, and cross-sectional slices from any point along the arch. For example, mapping out the path of the inferior dental nerve using these tools leads to a more accurate understanding of its position as well as the mental foramen and mental nerve. In addition the software can now use a fusion technique to bring a digital scan of the wax-up and model into the CT/CBCT software to plan the implant placement based on the final prosthodontics. This software can further produce a surgical template that enables the surgeon to place the implant at the ideal depth and angulation based on fusion of the X-ray and the model used in the planning process.

**Bone Height, Width, and Length**

Besides maintaining adequate safety margins for structures at risk of injury, ideally there should be 2 mm of bone on the buccal and lingual surfaces of the ridge and 1.5 mm of space from the implant to adjacent teeth (Table 1). In the absence of sufficient buccal and lingual ridge width, perforation of the plate may occur, the bony wall may be so thin that bone fenestration occurs post-placement, or implant positioning may not meet biologic width requirements and result in poor gingival form. (It may be necessary to do bone grafting many months prior to implant placement to have ideal width of bone around the implant.) Care also must be taken to ensure that the implant does not impact roots due to a general or local lack of mesio-distal width. A substantial lack of adequate

| TABLE 1. Dimensional recommendations for implant and bone |
|---|---|
| Bone between implant and key anatomical structures | At least 2 mm |
| Bone lingual to the implant | At least 2 mm |
| Bone buccal to the implant | At least 2 mm |
| Bone between implant and adjacent teeth | At least 1.5 mm |

**Implant Depth and Angulation**

It is important to pre-operatively determine implant depth and angulation necessary to provide the inter-arch and intra-arch prosthetic space required for restoration and adequate long-term strength. Although less critical in the posterior region, the distance from the proposed restorative contact point to the crestal bone should be considered. A distance of more than 5 mm results in poor papillary form. Implant angulation is determined by the best combination of safely utilizing available bone and soft tissue.
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relative to the planned tooth cervical emergence from the implant and axial trajectory toward the occlusal surface.

Nonsplinted implants should be placed such that they will be loaded axially over the implant body, as any angulation would be detrimental and magnify the forces on nonsplinted implants. The position of the screw channel is also impacted by implant angulation. Ideally, the screw channel should be in the central fossa of a screw-retained crown. In addition, if the restoration will be cement-retained, it is desirable to have an abutment screw channel that could be accessed by cutting a channel through the implant crown if the abutment screw were to loosen.

With digital software, it is possible to view 3D models and cross-sections, showing the anatomical dimensions and angulation of an implant diagrammatically and virtually (Figures 1 and 2). Prosthetic planning can be enhanced by using "smart fusion" technology. Clinicians can now scan models and wax-ups of the patient’s arch in order to fuse these with a dicom-based CT scan. The fusion of the digital X-ray with the digital models shows the clinician the virtual problems and concerns prior to surgery, and the implant team can see the proposed relative position of the implant to the final crown/bridge. This enables the planning team to place the implant so that the final outcome is ideal based on both occlusion and bone volumes. Once the plan has been created, a stereolythic surgical template can be fabricated to aid placement of the implant in the ideal position, controlling both depth and angulation. During surgery the guide helps the surgeon place the implant in the position created on the planning software. Anatomical landmarks such as the nerve and sinus can be visualized using this technology.

Adjustments can be made in the software virtually until the optimal solution is found for a successful surgical and restorative outcome. Software also may allow the clinician to perform a “virtual extraction” and examine the shape and dimensions of the resulting “virtual socket.” Implants can then be virtually selected and placed in these sockets to determine implant size and suitable depth, bone height, width and volume, and implant angulation.

Immediate vs Delayed Implant Placement

Three protocols regarding the timing of implant placement relative to the occurrence of tooth extraction are supported for posterior implants:
- Delayed implant placement, waiting 6 months for the alveolar ridge to completely heal
- Immediate-delayed implant placement, waiting 2 months post-extraction before implant placement
- Immediate implant placement at the time of tooth extraction.

In a 2010 Cochrane review, based on 2 randomized controlled clinical trials with implant in function for at least 1 year, no statistically significant differences in failure rates, complications, peri-implant bone levels, or esthetic outcomes were found when comparing immediate versus delayed implant placement. A more recent review by Lang et al of 46 prospective studies with a mean follow-up of 2 years (minimum 1 year) estimated an average 2-year survival rate of 98.4% (range 97.3% to 99%) and an average 97.5% 4-year survival rate (p<0.05) for immediately placed implants. These rates are similar to those observed with delayed placement. Ridge preservation bone grafting has been recommended to help preserve the alveolar ridge following extractions in delayed placement cases, with some studies showing reduced alveolar bone loss in grafted vs nongrafted sites. For ridge preservation, bone grafting typically takes 5 months to heal prior to implant placement.

Immediate implant placement at the time of extraction reduces the number of surgical interventions, the length of time before the patient has a functional loaded implant, and reduces patient discomfort. It has been suggested that immediate implant placement reduces crestal bone loss. Based on a recent review of clinical trials, however, no statistically significant differences in crestal bone levels were found in short-, medium-, or long-term follow-up studies.

When a tooth is extracted, the implant is usually smaller and in a different position than the original tooth. For example, in the anterior the implant is placed in a lingual position leaving a buccal jump gap anterior to the implant. It has been recommended that this space be bone grafted to prevent collapse of the buccal plate. Bone grafting is recommended if the space between the implant and the socket wall is more than 2 mm. Whether immediate implant placement may help limit buccal mucosal recession
is debatable. Outcomes from available studies are mixed with findings of no statistically significant differences at 2 years,\textsuperscript{15} less recession buccally than lingually in a 5-year study,\textsuperscript{16} and conclusions from one review that there were no statistically significant differences long-term.\textsuperscript{13} Lee et al found a 0.5 mm to 1 mm reduction in vertical and horizontal bone 4 to 12 months after immediate implant placement, correlated to the thickness of the buccal plate.\textsuperscript{17}

**The Importance of Biotype**

Facial mucosal recession was reported at a 2009 consensus conference to be a greater risk with immediately placed implants, with risk factors including a thin biotype, thin or damaged facial bony wall, and positioning of the implant too far buccally.\textsuperscript{18,19} Crestal bone loss has been found to be greater where thinner buccal bone plate is present ($\leq$1 mm) or where the jumping distance is $\leq$1 mm.\textsuperscript{20} There is some evidence that if the thickness of the mucosal tissue is $<2.5$ mm more bone loss is likely than with a thicker biotype. Linkevicius et al concluded in their study that thinner soft tissue at the crestal bone level significantly influences crestal bone stability, especially when $<2$ mm thick where $>1$ mm of crestal bone loss may then occur compared to thick biotype sites.\textsuperscript{21}

**Peri-apical Pathology**

Immediate implant placement in sites with peri-apical pathology has historically been debated. In a recent review, it was determined that this is not a contraindication if the site is curetted prior to implant placement.\textsuperscript{22} Two separate large retrospective studies by Fugazzotto\textsuperscript{23} and Bell\textsuperscript{24} were conducted. Fugazzotto placed 418 implants in sites with peri-apical pathology with a 97.8% survival rate and a mean follow-up of more than 5 years;\textsuperscript{23} Bell found a survival rate of 97.5% for 655 implants. No differences in survival rates were observed between sites with or without peri-apical pathology.\textsuperscript{24} The ability to achieve primary implant stability is still a prerequisite, and curettage of the site prior to implant placement and post-operative antibiotics are recommended.

**Primary Implant Stability**

Primary implant stability is an important factor for osseointegration. Research has led to the conclusion that implant micromotion should ideally be limited to 100 $\mu$m and that implant micromovement in excess of 150 $\mu$m can result in fibrous encapsulation and failure to osseointegrate, while immediate implants can withstand micromovement in the 50 $\mu$m to 150 $\mu$m range.\textsuperscript{25-28} As a point of reference, the lateral movement of natural teeth in a healthy dentition ranges from 56 $\mu$m to 108 $\mu$m.\textsuperscript{29} For nonsplinted implants it is important to ensure that the implant has nonfunctional loading – this implies no occlusal contact in CR, CO, MI, or in excursive movements. To achieve primary stability in extraction sockets, the osteotomy site should extend 3 mm apical to the socket or there must be 3 mm of bone contact with the walls of the extraction site.\textsuperscript{28,30} This highlights the importance of atraumatic extractions and selection of an implant with dimensions suitable for a given extraction site.

**Implant Design and Primary Stability**

Implant designs have been modified over time to help increase primary implant stability. Thread designs have been adjusted for width, depth, and pitch – a reduced pitch distance and increased thread compactness decreases micromotion.\textsuperscript{31,32} In an implant design with a variable pitch, also incorporating variable thread angle depths, primary stability was increased with fewer threads. The increased thread pitch increases stability because the threads are deeper and variable.\textsuperscript{33} Variable-thread implant designs, including with immediate loading in healed sites, was assessed after 36 months of loading, by Arnhart et al. They found a survival rate in evaluable subjects ($n=127$) of 97.7% for internal and 96.3% for external connection designs, with no statistically signifi-

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<th>TABLE 2. Factors improving primary implant stability</th>
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cant difference and stable bone levels after initial healing. In patients receiving implants with variable-thread designs, in partially edentulous mandibles and maxillae, the cumulative survival rate was 97.7%. Additional factors influencing primary implant stability are discussed below (Table 2).

**Primary loading (insertion) torque**

There is a strong correlation between lower initial insertion torques and implant failures. In one study using ISQ measurements to assess primary implant stability, it was found that stability may be lower for immediate implant placement but that this difference was lost over time and did not affect outcomes. Research also supports immediate loading if a primary loading torque of 40 Ncm to 45 Ncm can be achieved during implant placement. Thread design influences the primary loading torque that can be achieved.

**Immediate, Early, and Delayed Loading**

Traditionally, implants were loaded 3 to 8 months after placement (i.e., following osseointegration). Immediate and early loading of implants (1 week to 2 months post-placement) has been recommended to decrease treatment times. High survival and success rates have been observed with immediate loading. In a review of 19 studies, an overall 95.5% survival rate after 12 months was observed, with no statistically significant differences in survival rates for immediate, early, or delayed single implant placement. A 2012 review of immediately loaded implants in 9 studies (including single, FPDs, and removable restorations) cited an implant survival rate range from 95.8% to 100%, and success rates for mandibular implants of 79% to 100%. The researchers concluded that immediate loading was predictable for mandibular implants. Esposito et al reviewed clinical trials with different loading times and occlusal vs nonocclusal loading, and found no clinically relevant differences for implant survival rates, prosthesis failure rates, or loss of crestal bone.

Immediate loading protocols are supported in the literature if the implant has a minimum stability of 35 Ncm when challenged with further rotation and the healing structure is non-functionally loaded. If the implant is splinted to another implant, then the loading capabilities can sometimes be full functional load.

**Implant Surface**

Roughened implant surfaces were developed based on the concept of increasing the available surface area for osseointegration. Several types of roughened surfaces have been shown to offer successful outcomes for immediate, early, and delayed loading including in the posterior mandible and to increase osseointegration. A 10-year study on implants with a porous oxidized microtexture surface (TiUnite®, Nobel Biocare) found a cumulative survival rate of 98% for evaluable implants in healed sites and 96.5% for immediate implant placement, with stable marginal bone levels and a total mean marginal bone loss of 1.93 mm and 1.98 mm respectively. This surface has a high crystallinity and phosphorus ceramic-like qualities and micropores for high osteoconductivity and fast anchorage of newly formed bone, with the objective of decreasing healing times. Microtextured rough surfaces are also suitable for the promotion of osseointegration in immediate implant placement cases involving lower quality, soft bone as demonstrated by outcomes in a 7-year study with a cumulative implant survival rate of 97.1% where 76% were placed in soft bone and the majority were posterior implants.

**Platform Switching**

Platform switching has been proposed to help preserve crestal bone.

One review found no significant differences in crestal bone preservation for switched and non-switched platforms, and a small study of 32 implants found no differences in the presence or level of inflammatory cells and biomarkers associated with bone loss after prolonged intraoral exposure of abutments. In contrast, a pilot study using CBCT scans found greater crestal bone loss at the abutment-implant interface level in a separate study. The conclusion from the systematic review and meta-analysis by Atieh et al, based on 10 studies with 1,239 implants, was that there was statistically significantly less crestal bone loss associated with platform-switched implants than non-platform-switched implants (p<0.0001). A recent study yielded a 100% survival rate, with statistically significantly less marginal bone loss with internal connection platform-switched than non-platform-switched external connection implants.
A minimum vertical thickness of 2.5 mm of soft tissue is recommended for an adequate soft-tissue seal.

**Emergence Profile**

The goal is to have an emergence profile that is not too wide so that the buccal bone plate architecture is ideal, while also creating a soft-tissue seal to maintain bone. The emergence buccal lingually is often the limiting factor for implant size since the width of the bone narrows after tooth loss, while the mesial distal length is typically not problematic. An emergence profile shaped like a wineglass with the shape leaving the implant platform and reaching the contact point on a smooth angle similar to the posterior tooth anatomy achieves these objectives. Using a wider implant helps to create this ideal emergence. The implant should be submerged sufficiently to maintain a minimum 2.5 mm depth from the anticipated soft tissue crest to the implant platform to provide adequate soft tissue volume and create an emergence profile that prevents food entrapment. If the implant is not placed deeply enough, then the emergence profile leads to food impaction.

**Abutment Design and Placement**

Stock abutments were originally available as straight abutments, and angled abutments were introduced that gave more flexibility for implant placement to meet anatomical demands and restorative requirements. One concern is the lack of customization impacting the ability to have crown margins at an appropriate level for esthetics as well as for cement cleanup at insertion. CAD/CAM ceramic custom abutments have increased treatment options and improved esthetics.

The fit/seal between abutments and implants is critical, as is lack of rotation to prevent screw loosening. Abutment screw loosening was found to be uncommon in a review of 12 studies and 586 single implant restorations with “complication-free” success rates of 97.3% for external connections. For internal connections (1,113), this was 98.6%. There are various internal connections used today. Many implant systems have used the conical connection design to maximize the tight fit of the abutment to the implant and minimize any potential complications due to bacterial leakage at this interface. Microgaps result in microleakage, and represent a risk for peri-implantitis. Ensuring use of components with a tight fit is essential. The implant and abutment also share a mating hexagon at the base of the conical connection. This is available for indexing purposes to enable orientation transfer between clinical and laboratory components and restorations.

Contentious debate has arisen over screw-retained vs cement-retained options. Wilson found that patients with peri-implant disease often had cement trapped under the abutment areas of implants. Eighty-one percent of the patients with peri-implant disease had residual cement. Once the cement was removed, in 74% the peri-implant disease resolved.

In the past, if the implant was angled to the facial aspect, then a typical screw-retained option through the occlusal surface was not possible. An abutment had to be fabricated and then a crown was made to cement over the screw channel exiting through the facial aspect.

Recently, angulated screw channels (ASC) have been designed to provide zirconia-based solutions allowing more flexibility in securing the abutment. In the posterior region, this is particularly advantageous when limited working space is available. ASC abutments have improved the conical internal implant-abutment interface by having a titanium adapter that supports the zirconia abutment. One of the most important benefits is the strength of the material while reducing the cost. For porcelain-fused-to-gold restorations the cost of the gold can be very high since the restoration is not merely a shell but rather places the tooth and some bone as a solid core. Since gold is a commodity, the price vs zirconia can be quite a bit more. The zirconia has a yttrium stabilized structure with a 1400 MPa tensile strength which is higher than for the gold alloys used in porcelain-fused-to-metal restorations. Furthermore many companies are moving towards monolithic zirconia which eliminates the porcelain layering technique. The case presentation below demonstrates the use of a single implant-supported platform-switched and screw-retained posterior restoration.

**Case Presentation**

The patient was a 63-year-old man in excellent general health and with good periodontal health. He presented with
a lower first molar with failed endodontic therapy and an abscess, as well as excessive occlusal loading (Figure 3). The tooth was deemed to be nonrestorable and it was decided that it would be extracted, followed by immediate implant placement. The CT scan revealed adequate bone and it was determined that it would be possible to achieve primary implant stability.

Treatment planning was restoratively driven, aided by digital software. This lets the clinician see many key treatment planning points in 3D views. Fusion of the scanned model over the CT image aids planning of the depth and angulation of the implant based on the prosthetic position of the final crown, letting the clinician see the ideal posi-
tion of the screw channel, thickness of the soft tissue, bone dimensions, and position of the inferior alveolar nerve relative to the available space (Figures 4a and 4b). Once these structures are visualized a surgical guide can be made using stereolithography, and used during surgery to guide the implant into the ideal angulation and depth.

Following atraumatic extraction, the bone socket was debrided using a curette and then irrigated with saline (Figures 5 and 6).

A 2.0 mm guided pilot drill was used in the surgical guide to establish the position of the tip of the implant in the extraction site (Figure 7). Once the drill was placed to depth, the guide was removed and the depth was measured using the free gingival margin as the reference point by placing a 2 mm drill back in the osteotomy and placing a drill guide on the drill. Once this depth was determined the site was widened using other twist drills (keeping in mind that the osteotomy preparation needs to be undersized to establish initial stability of the implant in the bone beyond the extraction socket). Next, a 2.4-2.8 diameter twist drill was used to establish the full depth of the osteotomy. Note that the osteotomy was prepared to full depth with drills <4.0 mm diameter and then just the first entry point to the bone was prepared to 4 mm diameter since the tip of the implant is also 4 mm. It is important to widen only the top of the site with this drill sufficiently to provide an entry purchase point to insert the apical tip of the implant. Once the implant begins to engage, the objective is for seating...
to continue in the preserved 2.8 mm diameter channel and ultimately the 2.4 mm diameter apical site preparation for final seating. An undersized osteotomy is a key strategy for achieving implant stability of greater than 35 Ncm.

A 5.5 mm diameter, 13 mm length implant (NobelActive Wide Platform, Nobel Biocare) was placed into the osteotomy, establishing the apical tip into a minimum of 3 mm depth of bone while staying a minimum of 2 mm away from the nerve (Figure 8). The 5.5 mm wide implant has a widely spaced and deep dual thread with a progressively increasing vertical thread profile design. This thread design, the 4 mm wide implant tip, and the TiUnite® rough surface are designed to enhance initial implant stability, and its efficacy has been shown for immediate implant placement at time of extraction followed with stable bone remodeling, including for single implants that were immediately temporized and in function.33,57 The widest part of this implant is intended to be placed below the bone crest and the implant then has a reverse taper ending with a 5.1 mm platform. The combination of this back taper and platform shift abutment design emerging within this reduced diameter allows for more soft tissue volume between adjacent implants or with an adjacent tooth. By increasing implant diameter from the standard 4.3 mm, fatigue strength is doubled (580 N vs. 290 N). After seating to the desired depth, the implant resisted further rotation or insertion when 70 Ncm was applied to confirm initial stability.

A periapical radiograph was taken to confirm the implant position and a healing abutment was placed (Figures
9 and 10). Allograft bone particles were then used to fill the remaining socket to the top of the implant. The healing abutment was placed before the allograft to prevent allograft particles from entering the internal screw channel of the implant.

Next, a polyetheretherketone (PEEK) healing abutment with a 4 mm height was placed to shape the soft tissues and help create the emergence profile from the time of surgery (Figure 11). The soft tissue was sutured both anterior and posterior to this healing abutment, after which vinylpolysiloxane impression material was placed to cover the screw channel opening. The patient had started a course of antibiotics (amoxicillin 500 mg, 3 times a day) 24 hours before the
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Treatment and would continue taking these 3 times per day for 7 days postoperatively. Osseointegration was allowed to occur for 3 months after the implant and PEEK healing abutment were placed before fabrication of the crown restoration began.

The PEEK healing abutment was removed and an open tray impression was performed using a flared impression coping to pick up the soft tissue emergence that was created using the PEEK healing abutment (Figure 12a). Prior to the impression an X-ray was used to confirm the seating of the impression coping (Figures 12b and 12c). The remaining tissue emergence was picked up with the impression coping and polyether injected around the impression coping. A color was selected using the 3D Vita shade master guide and a “Vita easyshade compact” tool. The lab technician poured the stone model using a soft-tissue material around the replica (Figure 13). This enables the technician to remove the soft tissue scan during scanning. The model was multiple-scanned using the scanner (NobelProcera). The technician scans the position of the replica as well as the soft-tissue profile. This ensures that the emergence of the PEEK healing abutment is visualized on the scanned digital model. The technician used software (NobelProcera) to create a 3D model.

Restoration had been planned using a one piece screw-retained porcelain-to-zirconia restoration attached directly to the implant. This provides a robust restoration with full control over emergence profile and eliminates the use of a separate abutment with a separate cemented crown.

For this patient, an Angulated Screw Channel zirconia abutment (NobelProcera) was used. This abutment provides the capability to insert and fasten abutment screws to proper torque specifications (35 Ncm) through a screw channel that can be angled up to 25 degree from the straight center axis. A screwdriver and abutment screw interface designed for this purpose (Omnigrip™, Nobel Biocare) enables the abutment screw to be fully seated within the implant while being inserted through a channel that may be designed for approaches at angles of up to 25 degrees from the implant center axis. Using the SmartFusion™ process, such correction may not be required though it still may be useful for finess in aligning a screw access hole precisely, for example, to avoid an opposing cusp.

This abutment includes a titanium insert extending from the implant conical connection and serving as a precise friction-fit pedestal base for the zirconia abutment. This adds strength by using titanium instead of zirconia for the internal connection that could be subjected to flexural forces, while preserving biocompatibility. The precision fit of the zirconia/titanium adapter interface does not use or require a luting agent, thereby eliminating the breakdown of an adhesive bond as a potential risk.

The clinician can choose layered porcelain over the zirconia or monolithic zirconia, which means that the complete crown is fabricated in one solid core of zirconia. When veneering porcelain is desired, the complete crown/abutment is designed as full contour and then a cutback is made for the veneering porcelain only.

Since the channel is in zirconia it is easier to disguise when the restorative resin is placed compared to the darkness observed with metal substructures. By using the ASC crown, the technician could move the channel to the ideal position. Once the final crown is designed, the dental technician uses a software tool to reduce the overall dimension by 1 mm. The final design was sent via private secure internet (NobelConnect) to the centralized milling center (Figures 14a and 14b). The abutment was milled on a CNC milling machine and returned to the technician. The technician added the porcelain and delivered the final contoured crown to the dental office for final delivery (Figure 15).

At the crown delivery appointment, the healing abutment was removed. The porcelain-veneered zirconia crown/abutment with adapter was inserted into the implant as one piece and fastened using the Omnigrip™ Clinical Screw and Screwdriver.

The result was an esthetic and functional single lower first molar implant restoration (Figure 16). The patient was given oral hygiene instructions and an appointment made for both a 1-week check and a 3-month implant maintenance visit.

Conclusions

Posterior single implant restorations have proven to be successful and desirable treatment options. Current protocols give the clinician and patient options with respect to the length of treatment, timing of phases, whether an immediate replacement will be provided at the time of extraction, and
what restorative materials will be used. With suitable case selection, high survival and success rates are found for this therapy. Esthetic restorations that respect biological and functional requirements in the posterior region offer excellent solutions for patients.

References


2. Froum S, Cassarino S, Byrne S, Cho SC. Risk assessment before extraction for immediate implant place-


1. Current protocols for posterior single implants include _________.
   a. immediate, early, or delayed implant placement
   b. nonsubmerged or submerged osseointegration
   c. immediate, early, or delayed temporization and loading
   d. all of the above

2. Local contraindications include ____________.
   a. lack of adequate bone
   b. parafunctional habits
   c. proximity to anatomical structures
   d. all of the above

3. Implants should be placed such that they will be loaded ______________ over the implant body.
   a. axially
   b. mesially
   c. buccally
   d. diagonally

4. Less than 6 mm of bone separated the inferior alveolar canal from the mandibular first molar in __________ of cases in one study.
   a. 43%
   b. 53%
   c. 63%
   d. 73%

5. A review by Lang et al estimated an average 4-year survival rate of __________ for immediately placed implants in the mandible and maxilla.
   a. 95%
   b. 95.5%
   c. 97.5%
   d. 99.5%

6. The __________ must be considered during implant treatment planning.
   a. lingual mandibular undercut
   b. anterior loop of the inferior alveolar canal
   c. inferior alveolar nerve
   d. all of the above

7. Ideally, there should be 1.5 mm of space from the implant to ____________.
   a. adjacent teeth
   b. metal surfaces
   c. adjacent implants
   d. the buccal bone plate

8. Software also may allow the clinician to ____________.
   a. assess implant angulation and depth
   b. perform a virtual extraction
   c. examine a virtual socket
   d. all of the above

9. Linkevicius et al concluded in their study that thinner soft tissue at the crestal bone level significantly influences crestal bone stability, especially when ____________, where >1 mm of crestal bone loss may then occur compared to thick biotype sites.
   a. <2 mm thick
   b. >2 mm thick
   c. <4 mm thick
   d. >4 mm thick

10. With respect to the presence of peri-apical pathology, _________.
    a. post-operative antibiotics are recommended
    b. the ability to achieve primary implant stability is still a prerequisite
    c. curettage of the site prior to implant placement is required
    d. all of the above
CEQuiz

11. To achieve primary stability in extraction sockets ____________.
   a. the osteotomy site should extend 3 mm apical to the socket
   b. there should be 4 mm lateral to the socket
   c. there must be 3 mm of bone contact with the walls of the extraction site
   d. a or c

12. __________ improve primary stability.
   a. Rough implant surfaces
   b. Variable thread designs
   c. Higher bone densities
   d. all of the above

13. Immediate loading protocols are supported in the literature if the implant has a minimum stability of ___________ when challenged with further rotation and the healing structure is non-functionally loaded.
   a. 25 Ncm
   b. 30 Ncm
   c. 35 Ncm
   d. 45 Ncm

14. Microtextured rough surfaces ____________.
   a. promote osseointegration
   b. are suitable for immediate implant placement cases involving lower quality, soft bone
   c. are designed to decrease healing times
   d. all of the above

15. Atieh et al concluded in their systematic review and meta-analysis that there was statistically significantly less crestal bone loss associated with ____________.
   a. non-platform-switched implants
   b. platform-switched implants
   c. immediate loading
   d. delayed placement

16. __________ is a concern with stock abutments.
   a. Lack of customization
   b. Lack of compatibility
   c. Cost
   d. all of the above

17. Microgaps result in microleakage and represent a risk for ________.
   a. caries
   b. periodontal disease
   c. peri-implantitis
   d. none of the above

18. For cement-retained restorations, an abutment screw channel that could be accessed by cutting a channel through the implant crown if the ___________ were to loosen is desirable.
   a. implant
   b. abutment
   c. abutment screw
   d. restoration

19. A fusion technique can be used to bring a digital scan of the wax-up and model into the CT/CBCT software to plan the implant placement based on _________.
   a. surgical procedures
   b. the final prosthetics
   c. bone tolerance
   d. none of the above

20. A stereolythic surgical template can be fabricated to ____________.
   a. aid placement of the implant in the ideal position
   b. control depth
   c. control angulation
   d. all of the above

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EDUCATIONAL OBJECTIVES
1. Describe anatomical and other considerations during the treatment planning process
2. Review the use of software during implant treatment planning
3. List and describe aspects of implant design that affect primary implant stability
4. Delineate abutment and retention options and the evidence for these.

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2. A B C D
3. A B C D
4. A B C D
5. A B C D
6. A B C D
7. A B C D
8. A B C D
9. A B C D
10. A B C D
11. A B C D
12. A B C D
13. A B C D
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