Dental Implants: Basic Concepts and Techniques (I)

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Dental implants have given the profession and the patient an extremely predictable and effective means of tooth replacement. The partially edentulous patient can now undergo replacement of a single tooth or several missing teeth with implant retained crowns and enjoy the function and esthetics they had with their natural teeth. The completely edentulous patient no longer must live with compromised function and the reduced confidence that traditional full denture wearers have historically experienced.

The history of modern implant dentistry began with the introduction of titanium implants. In the 1950s, Per-Ingvar Brånemark, a Swedish professor of anatomy, had a serendipitous finding while studying blood circulation in bone that became a historical breakthrough in medicine. He coined the phenomenon osseointegration and developed an implant system with a specific protocol to achieve it predictably. The first patient was successfully treated in 1965.

Implant Geometry (Macrodesign)

Since the time of the Brånemark studies, millions of patients have been treated worldwide using variations of implant techniques with implants of different geometries and surface characteristics. Most of these systems were not as successful as endosseous dental implants. Currently, most endosseous implants have a cylindrical or tapered, screwshaped/ threaded design.

The most common implant design being used today is the screw-shaped or threaded cylindrical implant. A **threaded implant** design is preferred because it engages bone well and can achieve good primary stabilization. The (longitudinal) shape of implants may be parallel or tapered. Although most of implants have been parallel walled, the use of a tapered implant design has been advocated because it requires less space in the apical region (i.e., better for placement between roots or in narrow anatomic areas with labial concavities). Tapered implants have also been advocated for use in extraction sockets.

Implant Surface Characteristics (Microdesign)

Implant surface characteristics (microtopography) have been shown to positively influence the healing process. Modifications in surface energy, chemical composition, and surface topography are known to influence cellular activity and tissue responses, leading to enhanced osteogenesis. At the molecular level, modified implant surfaces increase adsorption of serum proteins, mineral ions, and

cytokines, which subsequently promote cellular migration and attachment. Implant surface characteristics can also aid in the retention of a fibrin clot, thus providing a migratory pathway for the differentiating osteogenic cells to reach the implant surface. Today, implants are treated with a variety of technologies to modify surface characteristics (microscale or nanoscale) to enhance bone formation.

Additive Processes

The additive process modifies the microstructure/macrostructure and chemical nature of the implant **surface** by adding materials or chemicals to the existing surface (e.g. inorganic mineral coatings, plasma spraying, biocoating with growth factors, fluoride, and particulates or cements containing calcium phosphates, sulfates, or carbonates). The addition of materials, such as hydroxyapatite, has been shown to enhance or accelerate the initial bone cells adaptation or proliferation. In general, additive surface modifications tend to increase the surface texture greater than subtractive surface modifications, resulting in topographically "rougher" implant. Surface roughness can also be increased by oxidizing or adding an oxide layer.

Subtractive Processes

The subtractive process modifies the microstructure and chemical nature of the implant surface by removing or altering the existing surface (by machining, acid etching, blasting, or a combination of these processes) to enhance the amount or speed of osseointegration. Implant surfaces that are modified at the microscopic level with techniques such as acid etching are thought to promote favorable cellular responses and increased bone formation.

Implant Surface Chemical Composition

There have been unsuccessful trials with oral implants made of carbon or hydroxyapatite due to lack of resistance to occlusal forces led to frequent fractures. The so-called noble metals or alloys, however, do not resist corrosion and have thus been abandoned. Today, most oral implants are made of commercially pure (CP) titanium or titanium alloys. Titanium is a reactive metal that oxidizes within nanoseconds when exposed to air. Because of this passive oxide layer, the titanium then becomes resistant to corrosion in its CP form. Some alloys, such as titanium-aluminum 6%, vanadium 4% (Ti6Al4V), are known to provoke bone resorption as the result of leakage of some toxic components. The oxide layer of CP titanium reaches 10 nm of thickness. It grows over the years when facing a bioliquid. It consists mainly of titanium dioxide (TiO_2).

Hard Tissue Interface

The primary goal in implant placement is to achieve and maintain an intimate bone-to-implant connection. This concept is known as osseointegration. Histologically defined as the direct structural and functional connection between organized, living bone and the surface of a load-bearing implant without intervening soft tissue between the implant and bone. Osseointegration clinically is defined as the asymptomatic rigid fixation of an alloplastic material (the implant) in bone with the ability to withstand occlusal forces.

The osseointegration process observed after implant insertion can be compared with bone fracture healing. Implant site osteotomy preparation (bone wounding) initiates a sequence of events, including an inflammatory reaction, bone resorption, release of growth factors, and attraction by chemotaxis of osteoprogenitor cells to the site. Differentiation of osteoprogenitor cells into osteoblasts leads to bone formation at the implant surface. Extracellular matrix proteins, such as osteocalcin, modulate apatite crystal growth.

For osseointegration to occur in a predictable fashion, several important factors are required:

1. A biocompatible material (the implant)

   Titanium is the material of choice for dental implants. Titanium is biologically inert and therefore does not elicit a foreign body rejection reaction from host tissue.

2. Atraumatic surgery to minimize tissue damage.

   Atraumatic technique in an aseptic environment is critical to minimize mechanical and thermal injuries to bone. This involves using sharp, precision osteotomy drills run at slow speed with high torque while maintaining gentle, intermittent pressure and providing copious irrigation. Irrigation can be accomplished either externally or internally using special handpieces and burrs with internal ports. The goal is to maintain bone temperatures below 47°C during implant site preparation. If temperatures exceed 47°C, it is likely to cause bone necrosis and failure of osseointegration.

3. Implant placement in intimate contact with bone.

   The implant site must be prepared with a precise technique. All implant systems have specially designed drills that are used in a specific sequence to remove

bone as atraumatically as possible. The drill sizes are matched to the size and shape of the implant being placed, creating the precision necessary for developing initial bony contact and stability.

4. Immobility of the implant, relative to bone, during the healing phase

   Initial stability of the implant must be achieved and maintained for formation of bone at the implant surface. Stability at the time of placement can be predicted by the volume and quality of bone that intimately contacts the implant as well as the length and diameter of the implant. During the time required for osseointegration to occur, it is imperative that immobility of the implant be maintained. A mild inflammatory response enhances the bone healing, but moderate inflammation or movement above a certain threshold is detrimental. When micromovements at the interface exceed 150 μm → impair differentiation of osteoblasts and fibrous scar tissue will form between the bone and implant surface. Therefore, it is important to avoid excessive forces, such as **occlusal loading**, during the early healing period.

New bone formation follows a specific sequence of events. Woven bone is quickly formed in the gap between the implant and the bone; it grows fast, up to 100 μm per day, and in all directions. Characterized by a random orientation of its collagen fibrils, high cellularity, and limited degree of mineralization, the biomechanical capacity of woven bone is poor. Thus, any occlusal load should be well controlled or avoided in the early phase of healing. After several months, woven bone is progressively replaced by lamellar bone with organized, parallel layers of collagen fibrils and dense mineralization. Contrary to the fast-growing woven bone, lamellar bone formation occurs at a slow pace (only a few microns per day).

Clinically, both primary stability and secondary stability of an implant are critical to success. **Primary stability**, achieved at the time of surgical placement, depends on the implant geometry (macrodesign), as well as the quality and quantity of bone available for implant anchorage at a specific site. Studies using resonance frequency analysis (RFA) have reported decreased implant stability in the early weeks of post-insertion healing. **Secondary stability**, achieved over time with healing, depends on the implant surface (microdesign), as well as the quality and quantity of adjacent bone, which will determine the percentage of contacts between the implant and bone.

"For example, areas such as the anterior mandible have dense cortical bone and provide rigid primary

stabilization and good support throughout the healing process. Conversely, areas such as the posterior maxilla have thin cortical bone, and large marrow spaces provide less primary stability (lower success rates). Once osseointegration is achieved, implants can resist and function under the forces of occlusion".

Soft Tissue–Implant Interface

This subject has become a major focus in of interest in implant dentistry because of the need for **satisfactory esthetics** as well as maintenance of a **soft tissue seal** or barrier against bacterial invasion.

Peri-implant and periodontal soft tissues do share several **similarities** and only subtle differences. Each emerges from alveolar bone through soft tissue. Soft tissue consists of connective tissue covered by epithelium, which is continuous with an epithelium-lined gingival sulcus, the apical- most portion being lined with junctional epithelium forming an attachment. From that point down to the level of alveolar bone, both types of soft tissue possess a zone of dense connective tissue → maintaining a stable interface between soft tissue and the implant + acts as a seal to oral environment.

It is the orientation of the connective tissue fibers adjacent to an implant that **differ** from a natural tooth. This zone of connective tissue has been measured to be 1 to 2 mm in height. Clinically this becomes important when examining the health of peri-implant soft tissue. Probing depths in a healthy implant would be approximately 1 to 2 mm less than the total measured dimension from the crest of the sulcus to the alveolar bone crest. **The other obvious difference** between teeth and implants is that teeth have a periodontal ligament with connective tissue fibers that suspend teeth in alveolar bone. The implant, however, is in direct contact with bone without any intervening soft tissue. This difference has a dramatic impact on the biomechanics, proprioception, and prosthetic consideration for implants versus natural teeth. Because an implant, unlike a tooth, does not have cementum, most connective tissue fibers run in a direction more or less parallel to the implant surface.

Questions emerged decades ago, as it did for the natural dentition, about the need for **keratinized tissue to surround implants**. Keratinized mucosa tends to be more firmly anchored by collagen fibers to the underlying periosteum than non-keratinized mucosa, which has more elastic fibers and tends to be movable relative to the underlying bone. In clinical studies evaluating intraoral implants, with or without peri-implant keratinized mucosa → no clinically significant difference. However, when there is a lack of keratinized tissue, patients tend to complain

about pain and discomfort while performing oral hygiene procedures or other functions in the area. The symptoms are alleviated by increasing the amount of keratinized (firmly bound) tissue around the implant(s) via soft tissue grafting.

Biomechanical Considerations

Once the implant is properly placed, the long-term success is heavily dependent on restorative biomechanical factors— that is, how the stresses imposed on the functioning implant or prosthetic unit, or units will be controlled or distributed. The axiom is simple: The load-bearing capacity of the integrated implant must be greater than the anticipated load during function. If not → mechanical failure, biologic failure, or both.

Mechanical failure may present simply as porcelain fracture or as a loosened or fractured prosthetic screw (the screw that attaches the abutment or framework to the implant). The most devastating mechanical failure occurs when the force is destructive enough to fracture the implant fixture. A **biologic failure** can occur when the functional load exceeds the load- bearing capacity of the implant-bone interface. This initially presents as *bone loss* around the platform of the implant. If the loss is severe enough and the provocation is long enough, the bone loss may progress around the entire implant → complete failure of the implant.

The clinician must remember that an implant-retained restoration lacks the "shock absorbing" **periodontal ligament**. The periodontal ligament allows slight physiologic movement of teeth → adapt to the forces without pathologic bone loss. This, however, is not possible with an osseointegrated implant.

The **load-bearing capacity** of implants is qualified by several **factors**, including the number and size of the implants, the arrangement and angulation of the implants, and the volume and quality of the bone-implant interface. The same factors that maximize initial implant stability in hard tissue continue to be important.

"Thick cortical bone and dense trabecular bone surrounding a long, wide-diameter implant that is positioned to be in line with the functional load, would offer the greatest load-bearing capacity and the best prognosis for long-term success. Conversely, a short, narrow- diameter implant placed in an area of thin cortical bone and less dense trabecular bone and in an off-axis angulation would have far less load- bearing capacity and a poorer prognosis for success".

Angulation; Loads directed through the long axis of the implants are tolerated very well. Slight off-axis loads are usually not clinically detrimental, but loads applied at angles greater than 20 degrees or more can result in load magnification and

initiate bone loss at the implant-bone interface → if persist → bone loss → potential implant failure.

Number of implants; affects the load-bearing capacity of the implanted prosthesis.

"If there is a three-tooth edentulous span, the fixed prosthetic options would be to place three implants with three splinted crowns, three implants with three single-unit crowns, two implants as terminal abutments for a three-unit fixed partial denture, or two adjacent implants with a fixed partial denture with a cantilevered pontic. The load-bearing capacity decreases with each successive option".

Arrangement; Straight-line or linear arrangement of multiple implants should be avoided as this provides the least biomechanical advantage and is the least resistant to torquing forces caused by off-center occlusal and lateral loads. Implants should be placed in a more curvilinear or staggered fashion.

Connecting **implant to natural tooth** with a fixed partial denture will effectively create an excessively loaded cantilever situation because of the immobility of the implant compared with the mobility of the natural tooth. This can create stresses at the implant abutment junction up to two times the applied load on the prosthesis. Additional problems include: breakdown of osseointegration, cement failure on the natural abutment, screw or abutment loosening, and possible prosthetic components failure of implant.

Detrimental forces can be applied iatrogenically by **placing non-passive, ill-fitting frameworks on implants**. When the screws are tightened to seat the ill-fitting framework, compressive forces are placed on the implant-bone interface →bone loss → potential implant failure.

Preoperative Assessment and Treatment Planning

The goal of dental implant therapy is to satisfy the patient's desire to replace missing tooth or teeth in an esthetic, functional manner with long-term success. To achieve this goal, clinicians must comprehensively assess the dentoalveolar condition as well as the overall physical and mental well-being of the patient.

Chief Complaint

What is the problem or concern in the patient's own words? What is the patient's goal of treatment?

The patient will measure implant success according to his or her personal criteria:
1- The overall comfort and function of the implant restoration

2- satisfaction with the appearance of the final restoration
3- impact of treatment on the patient's quality of life; did the treatment helped them to eat better, look better, or feel better about themselves?

The clinician could consider an implant and the retained prosthesis a success using standard criteria of
1- symptom-free implant function,
2- implant stability, and
3- lack of peri-implant infection or bone loss.

Therefore, it is critical to inquire, as specifically as possible, about the patient's expectations before initiating implant therapy. It is helpful to invite patient's spouses or family members to the consultation visits to add "trusted" observer to the discussion of treatment options.

Medical History and Medical Risk Assessment

Absolute contraindications There are only a few absolute medical contraindications to implant therapy, limited primarily to patients who are **acutely ill** and those with **uncontrolled metabolic disease**. These contraindications can be limited in duration; once the illness resolved, the patient may become candidate for implant therapy.

Relative contraindications are concerned with medical conditions that affect bone metabolism or the patient's ability to **heal**. These include conditions such as diabetes, osteoporosis, immune compromise (HIV), medications (e.g., bisphosphonate), and medical treatments such as chemotherapy and irradiation.

absolute or relative contraindications Some psychological or mental conditions depending on their severity. Patients with psychiatric syndromes (e.g., schizophrenia, paranoia) or mental instabilities (e.g., neurosis, somatic symptom disorder), those who have mental impairment or are uncooperative, or those who have irrational fears, phobias, or unrealistic expectations may be poor candidates for implant treatment.

Potential contraindications Certain habits or behavioral considerations such as smoking, tobacco use, substance abuse (e.g., drugs and alcohol), and parafunctional habits (bruxing and clinching. Smoking has been documented as a significant risk factor resulting in decreased long-term stability and retention of implants.

Dental History

The individual's previous experiences with surgery and prosthetics should be discussed. If a patient reports numerous problems and difficulties with past dental care, including a history of dissatisfaction with past treatment, the patient may have similar difficulties with implant therapy. It is essential to identify past problems and to elucidate any contributing factors.

Intraoral Examination

Is performed to assess the current health and condition of existing teeth, as well as to evaluate the condition of the oral hard and soft tissues. All oral lesions, especially infections, should be diagnosed and appropriately treated before implant therapy.

Additional criteria to consider include the patient's habits, level of oral hygiene, occlusion, jaw relationship, temporomandibular joint condition, and ability to open wide.

After intraoral examination, the clinician evaluate potential implant sites:

1- Measure the available space in the bone for the placement of implants (The mesial-distal and buccal- lingual dimensions of edentulous spaces can be approximated with a periodontal probe), and
2- The dental space for prosthetic tooth replacement, and
3- The orientation or tilt of adjacent teeth and their roots (There may be adequate space between roots, but the coronal aspects of the teeth may be too close→ orthodontic tooth movement may be indicated).

Ultimately, edentulous areas need to be precisely measured using diagnostic study models and imaging techniques.

How Much Space Is Required for Placement of One or More Implants?

Alveolar Bone

Assuming an implant is 4 mm in diameter and 10 mm long, the minimal width of the jawbone needs to be 6 to 7 mm, and the minimal height should be 10 mm (minimum of 12 mm in the posterior mandible, where an additional margin of safety is required over the mandibular nerve). This dimension is desired to maintain at least 1 to 1.5 mm of bone around all surfaces of the implant after preparation and placement.

Interdental Space

The minimal mesial-distal space for an implant placed between two teeth is 7 mm.

The minimal mesial-distal space required for the placement of two standard-diameter implants (4-mm diameter) between teeth is 14mm. For example, the minimal space needed for the placement of an implant 6 mm in diameter is 9 mm (7 mm + 2 mm).

Whenever the available space between teeth is greater than 7 mm and less than 14 mm, only one implant, such as placement of a wide-diameter implant, should be considered. Two narrow diameter implants could be positioned in a space that is 12 mm. However, the smaller implant may be more vulnerable to implant fracture.

Interocclusal Space

The restoration consists of the abutment, the abutment screw, and the crown. This restorative "stack" is the total of all the components used to attach the crown to the implant. The minimum amount of interocclusal space required for the **restorative "stack"** on an **external hex**-type implant is 7 mm.

Diagnostic Casts and Photographs

Both contribute significantly to the assessment and treatment planning. Elements that can be evaluated from mounted models:

1. Occlusal relationships
2. Arch relationships
3. Inter-arch space
4. Arch form, anatomy, and symmetry
5. Preexisting occlusal scheme
6. Curve of Wilson and curve of Spee.
7. Number and position of the existing natural teeth.
8. Tooth morphology.
9. Wear facets.
10. Edentulous ridge relationships to adjacent teeth and opposing arches.,
11. Measurements for planning future implant locations
12. Visualizing force vectors, both present and planned.

Medicolegally, mounted models are preserved as a reference of preoperative condition.

Intraoral photographs allow evaluation of the patient's soft tissue (e.g., quantity, quality, location, texture, color, symmetry). Extraoral photographs help to assess:

1. Facial form
2. Facial symmetry
3. Patient's degree of expression and animation
4. Patient's appearance (e.g., facial features, facial hair, complexion, eye color)
5. Smile line.
6. Incisal edge or tooth display
7. Buccal corridor display
8. Potential esthetic demand

Hard Tissue Evaluation

A visual examination can immediately identify deficient areas. Clinical examination of the jawbone consists of

- Palpation to feel for anatomic defects and variations in the jaw anatomy, such as concavities and undercuts.
- With local anesthesia probe through the soft tissue (intraoral bone mapping) to assess the thickness of the soft tissues and measure the bone dimensions at the proposed surgical site.

It is possible that an adequate dimension of bone is available in the anticipated implant site, but that the bone and thus the implant placement might be located too lingual or too buccal for the desired prosthetic tooth replacement → Bone augmentation done to facilitate the placement of an implant in an acceptable prosthetic position despite the availability of an adequate quantity of bone (i.e., natuaral bone is in the wrong location).

Soft Tissue Evaluation

Areas with minimal or no keratinized mucosa may be augmented with gingival or connective tissue grafts. Frenum attachments that pull on the gingival margin, should be thoroughly evaluated.

"Keratinized mucosa is typically thicker and denser than alveolar mucosa (nonkeratinized). It forms a strong seal around the implant with a cuff of circular (parallel) fibers around the implant, abutment, or restoration that is resistant to retracting with mastication forces and oral hygiene procedures."

Radiographic Examination

Multiple factors influence the selection of radiographic techniques (PA.OPG, CBCT, etc.). Such factors as cost, availability, radiation exposure, and the type of case must be weighed against the accuracy of identifying vital anatomic structures within a given bone volume and being able to perform the surgical placement without injury to these structures. Areas of study radiographically include the following:

1. Location of vital structures
   - Mandibular canal
   - Anterior loop of the mandibular canal
   - Anterior extension of the mandibular canal
   - Mental foramen
   - Maxillary sinus (floor, septations, and anterior wall)
   - Nasal cavity
   - Incisive foramen
2. Bone height
3. Root proximity and angulation of existing teeth
4. Evaluation of cortical bone
5. Bone density and trabeculation
6. Pathology (e.g., abscess, cyst, tumor)
7. Existence of anatomic variants (e.g., incomplete healing of extraction site)
8. Cross-sectional topography and angulation (determined by CBCT)
9. Sinus health (best evaluated by using CT and CBCT)
10. Skeletal classification (best evaluated with lateral cephalometric images)

"Radiographic images allow for quantifying dimensions or for taking measurements. Traditional radiographs must be calibrated for potential magnification. Digitally acquired periapical, panoramic, lateral cephalometric images and CT and CBCT scans have bundled software applications that allow for very accurate measurement".

Critical measurements specific to implant placement include the following:
- At least 1 mm inferior to the floor of the maxillary and nasal sinuses
- Incisive canal (maxillary midline implant placement) to be avoided.
- 5 mm anterior to the mental foramen
- 2 mm superior to the mandibular canal
- 3 mm from adjacent implants
- 1.5 mm from roots of adjacent teeth

CT and CBCT image allow the diagnosis and treatment planning processes to be more accurate with regard to measurements and dimensions. Critical anatomic structures can be visualized in all three coordinate axes so that their exact locations can be identified.

Surgical Treatment Planning Considerations

After evaluating all the previously described information, the surgeon must determine the prognosis of implant placement based on specific limitations as a result of

- Anatomic variations
- Bone quality.
- Bone quantity.

} In different areas of the jaw

The **anterior mandible** is usually tall enough and wide enough to accommodate implant placement. Bone quality is usually excellent, typically the densest of any

area in the two arches. Primary surgical concerns in this area include proper angulation of the implants and avoiding the mental foramen and mandibular canal. Implants should be placed at least 5 mm anterior to the most anterior portion of the mental foramen, avoiding the anterior loop of the mandibular canal.

The **posterior mandible** limits the length of the implants based on the position of the mandibular canal. Ideally, the tip of the implant should be at least 2 mm from the inferior alveolar nerve (IAN). It is important to consider the buccolingual position of the nerve as well. If the nerve is located very near the buccal cortex, a longer implant could be placed, with the implant extending lingual to the IAN, even though the implant extends vertically past the nerve. CT or CBCT can be helpful in making this determination. The mandibular canal also precludes any posterior implants from engaging the inferior cortical plate, which could lessen the initial primary stability of the implant.

The attachment of the mylohyoid muscle helps maintain the bony width along the superior aspect of the ridge, although this can often be deceiving because a deep lingual depression, "the lingual undercut," usually is present immediately below this attachment. This is a critical area to be examined and palpated during the clinical examination.

"In planning the implant placement, if primary stability is questionable, increased time for osseointegration may be considered. The clinician may also want to consider "over-engineering" the case by using more implants (e.g., three implants replacing three teeth, vs. two implants replacing three teeth)".

The posterior maxilla poses two specific concerns. The **first** is the quality of bone in this area. Bone quality in the posterior maxilla is typically the poorest of any area, limited by thin cortical bone at the ridge crest and the least dense trabecular bone → less primary stability → more time (6 months or longer) may be required for osseointegration. The **second** concern is the proximity of the maxillary sinus. Often bone resorption and increased pneumatization of the sinus, causes limited height of bone remains for implant placement. Implant should be placed, leaving 1 mm of bone between the sinus and the implant. If there is inadequate bone height, then either a "sinus bump" or "sinus lift" procedure would be necessary.

The **anterior maxilla**, even though it is the most surgically accessible area, may be one of the most difficult regions for implant placement. This area, even when healthy teeth are present, usually has a thin buccal plate. After tooth loss, the resorption of the ridge follows a pattern of moving apically and palatally → ridge that is narrow and angulated such that ideal implant positioning may be impossible and the esthetic outcome may be compromised.

The nasal cavity and the incisive canal are vital structures that also define the anatomic limitations of anterior implant placement. Implants should be placed 1 mm short of the nasal floor and should not be placed in the maxillary midline.

Final Treatment Planning

The final stage of treatment planning involves consolidating all the clinical and radiographic information in combination with surgical options and limitations to produce the best result of the prosthetic treatment. To facilitate ideal implant placement, surgical guides are frequently utilized. The **surgical guide template** is a critical factor in an esthetically important area because even slight variations of angulation can have large effects on the appearance of the final restoration. The surgical guide is nearly indispensable in patients for whom it is necessary in anterior esthetic zone → correct emergence profiles. The four **objectives of using a surgical template** for the **partially** edentulous patient are as follows:
(1) delineating the embrasure,
(2) locating the implant within the tooth contour,
(3) aligning the implants with the long axis of the completed restoration, and
(4) identifying the level of cementoenamel junction or tooth emergence from soft tissue.

This template can be constructed by

1- using a diagnostic wax-up over the preoperative cast to construct a clear resin template with a guide hole. This provides the surgeon ease of access to bone and uninterrupted visual confirmation of frontal and sagittal positions and angulation. Although underlying bone may dictate some minor variation, the surgeon must stay as close as possible to the template during implant placement. With the aid of computer technology, accurate "virtual" treatment planning can be accomplished.
2- CBCT data are used to produce a three-dimensional reconstruction, which offers the ability to view anatomic structures in cross-section. The ideal prosthetic position can be simulated, and the position and angulation of the implant determined. A computer-generated splint can then be constructed with guide sleeves matched to implant drill sizes → precise placement of the implant in bone + maintaining best angulation.