1

Case Selection and Diagnosis

Part A: Medical Consideration in Implant Dentistry

1 Commonly Ordered Blood Tests in Implant Dentistry[1]

Blood test	Normal	Clinical significance
Hematocrit (Hct)	Female: 36–46% Male: 42–52%	Low values: Anemia; monitor for fatigue, dyspnea, tachycardia, and tachypnea.
Hemoglobin (Hgb)	Female: 12–15 g/dl Male: 14–17 g/dl	Low values: Anemia; monitor for fatigue, dyspnea, tachycardia, and tachypnea.
Red blood cell (RBC) count	Female: 4–5.5 million/mm^3 Male: 4.5–6.2 million/mm^3	Low values: Anemia; monitor for fatigue, dyspnea, tachycardia, and tachypnea. High values: In chronic obstructive pulmonary disease (COPD), this may indicate polycythemia, a compensation for pulmonary dysfunction that makes blood thicker, increases risk of cerebrovascular accident (CVA).
Total white blood cell (WBC) count	5000–10,000/mm^3	>10,000 indicates systemic infection (more than just local colonization).
Platelets and thrombocytes	200,000–500,000/mm^3	30,000–50,000: Risk of internal hemorrhage.
Erythrocyte sedimentation rate (ESR)	Female: 1–25 mm/h Male: 0–17 mm/h	Bad if elevated. Used to diagnose, or follow the course of, inflammatory diseases (e.g., rheumatic conditions).

(*continued*)

Quick Reference to Dental Implant Surgery, First Edition. Mohamed A. Maksoud.

Blood test	Normal		Clinical significance
Creatinine	Female: 0.6–1.2 mg/dl Male: 0.5–1.1 mg/dl		Renal function measure: High values are bad. May indicate nephropathy, or end-stage renal disease.
Potassium (K)	3.5–5.0 mEq/l		Results of low K: Ventricular arrhythmias. Results of high K: Ventricular arrhythmias and asystole.
Calcium (Ca)	8.2–10.2 mg/dl		Results of low Ca: Osteoporosis, muscle spasms or tetany, calcium deposits in tissue, cardiac arrhythmia, and asystole. Results of high Ca: thirst, polyuria, renal stones, decreased muscle tone, tachycardia, cardiac arrhythmia, and asystole.
Sodium (Na)	136–145 mEq/l		Results of low Na: postural hypotension, abdominal cramps, headache, fatigue, and weakness. Results of high Na: edema and tachycardia.
Fasting blood glucose (FBG)	70 to 99 mg/dL		100 to 125 mg/dL: Impaired fasting glucose (pre-diabetes). >126 mg/dL: Diabetes.
Serum c-telopeptide collagen	Adult male 18–29 Years 30–39 Years 40–49 Years 50–68 Years Adult female 18–29 Years 30–39 Years 40–49 Years	 87–1200 pg/mL 70–780 pg/mL 60–700 pg/mL 87–345 pg/mL 60–640 pg/mL 60–650 pg/mL 40–465 pg/mL	High in osteoporosis, osteopenia, and primary hyperthyroidism.
Alkaline phosphates	30–120 IU/L		High values: liver disease, osteoclastic activity, Paget's disease, bone cancer, and osteoporosis.

Blood test	Normal	Clinical significance
Prothrombin time (PT)	1–18 sec	Measures extrinsic clotting of blood. Prolonged in liver disease, impaired vitamin K production, and surgical trauma with blood loss.
Partial thromboplastin time (PTT)	By laboratory control	Measures intrinsic clotting of blood and congenital clotting disorders. Prolonged in hemophilia A, B, and C.
International Normalized Ratio (INR)	Without anticoagulant therapy: 1 Anticoagulant therapy target range: 2–3	Measures extrinsic clotting function. Increased with anticoagulant therapy.
Bleeding time (BT)	1–6 min	Measures quality of platelets. Prolonged in thrombocytopenia.

A Recommendations

1. Low platelet count and abnormal clotting tests in addition to abnormal BT, PTT, or INR value is a contraindication in implant surgery, especially in a sinus grafting procedure, due to the possibility of uncontrolled bleeding.
2. Abnormal c-telopeptide values related to the use of oral or systemic bisphosphonates should be considered prior to implant surgery.
3. Consult with a physician in writing regarding any abnormal values, and attach a copy of the blood test results.

2 ASA Classifications

- ASA Physical Status 1: A normal healthy patient.
- ASA Physical Status 2: A patient with mild systemic disease.
- ASA Physical Status 3: A patient with severe systemic disease.
- ASA Physical Status 4: A patient with severe systemic disease that is a constant threat to life.
- ASA Physical Status 5: A moribund patient who is not expected to survive without the operation.
- ASA Physical Status 6: A declared brain-dead patient whose organs are being removed for donor purposes.

A Recommendations

- ASA Status 1 and 2 can be treated in a dental office.
- ASA Status 3 and 4 should be treated in an in-patient facility.

3 Medical Conditions[1]

A Scleroderma

1. A multisystem disorder characterized by inflammatory, vascular, and sclerotic changes of the skin and various internal organs, especially the lungs, heart, and gastrointestinal tract.
2. Typical clinical features in the facial region are a masklike appearance, thinning of the lips, microstomia, sclerosis of the sublingual ligament, and indurations of the tongue.
3. The symptoms cause the skin of the face and lips as well as the intraoral mucosa to become taut, thereby hindering dental treatment and complicating or even preventing the insertion of dental prostheses.
4. No controlled studies were found for scleroderma to demonstrate any positive or negative effects on the outcome of implant therapy.

B Oral Lichen Planus (OLP)

1. A common T-cell-mediated autoimmune disease of unknown cause that affects stratified squamous epithelium exclusively.
2. OLP has been considered a contraindication for the placement of dental implants possibly because of the altered capacity of the oral epithelium to adhere to the titanium surface.
3. OLP as a risk factor for implant surgery and long-term success cannot be properly assessed.

C Ectodermal Dysplasia (ED)

1. A hereditary disease characterized by congenital dysplasia of one or more ectodermal structures.
2. Common extra- and intraoral manifestations include defective hair follicles and eyebrows, frontal bossing, nasal bridge depression, protuberant lips, hypo- or anodontia, conical teeth, and generalized spacing.
3. Most search results for ED were case reports demonstrating treatment success with dental implants.
4. A few larger case series report survival and success rates of implants in such patients. All studies reported significantly lower survival and success rates in the maxilla than in the mandible.

D Sjögren's Syndrome (SS)

1. A chronic autoimmune disease affecting the exocrine glands, primarily the salivary and lacrimal glands. The etiology of SS is far from being understood.
2. The most common symptoms of SS are extreme tiredness, along with dry eyes (keratoconjunctivitis sicca) and dry mouth (xerostomia).
3. Xerostomia can eventually lead to difficulty in swallowing, severe and progressive tooth caries, or oral infections.
4. Currently, there is no cure for SS, and treatment is mainly palliative.

5. Literature on implant performance in patients with SS is scarce. There are no controlled studies available, and only one case series study with eight patients included was found. The eight patients in this study were all women receiving a total of 54 implants (18 in the maxilla and 36 in the mandible) with a machined surface. Seven of these implants (12.9%) were found not to be osseointegrated at abutment connection. During the first year of function, two additional implants in the mandible were lost, resulting in an implant-based failure rate of 16.7% (the patient-based rate was 50%; four patients out of eight lost at least one implant).

E Crohn's Disease

1. An idiopathic chronic inflammatory disorder of the gastrointestinal tract that may also involve the oral cavity.
2. The disease process is characterized by recurrent exacerbations and remissions.
3. The literature regarding the performance of dental implants in patients with Crohn's disease is scarce. In a retrospective study with observation up to 1 week after second-stage surgery, two of three patients with Crohn's disease had implant failures (3 out of 10 inserted implants were lost). The authors speculated that the presence of antibody–antigen complexes might lead to autoimmune inflammatory processes in several parts of the body, including the bone–implant interface. However, in both of these patients with early implant failures, other medical and local risk factors were also present: claustrophobia, smoking, and poor bone quantity. In a follow-up study, patients treated from 1982 to 2003 were evaluated to assess the influence of systemic and local factors on the occurrence of early implant failures. Crohn's disease was significantly related to early implant failure. Unfortunately, the authors did not provide the exact number of patients with Crohn's disease treated or the number of implant failures in these patients. In a recent prospective study from the same group, the influence of various systemic and local factors on the occurrence of early failures was once more evaluated. This time, the implants had a modified, oxidized titanium surface. Between November 2003 and June 2005, 11 of 12 implants placed in patients with Crohn's disease integrated successfully.

F Transplantation (Heart, Liver, and Renal Transplant)

1. Patients receiving transplanted organs generally undergo long-term immunosuppressive therapy, usually consisting of cyclosporine combined with steroids, which have anti-inflammatory properties. Several animal studies have demonstrated that cyclosporine may negatively influence bone healing around dental implants and may even impair the mechanical retention of dental implants previously integrated in bone.
2. In human studies, there is no information available in the literature addressing heart or renal transplantations and the performance of subsequently placed or already present dental implants. There is one case report describing the placement of two implants 6 months after liver transplantation, providing anecdotal evidence of stability 10 years after insertion.

G Diabetes or Insulin Therapy or Glucose Intolerance

1. Type 1 (insulin-dependent) diabetes mellitus is caused by an autoimmune reaction destroying the beta cells of the pancreas, leading to insufficient production of insulin. Type 2 (non-insulin-dependent) diabetes mellitus is viewed as a resistance to insulin in combination with an incapability to produce additional compensatory insulin. Type 2 diabetes is often linked to obesity and is the predominant form, notably in the adult population in need of implant therapy.
2. Diabetes is associated with various systemic complications, including retinopathy, nephropathy, neuropathy, micro- and macrovascular disturbances, and impaired wound healing.
3. In the oral cavity, xerostomia, caries, and periodontitis have been linked to diabetes. The increased susceptibility to periodontitis is thought to be due to a negative influence of diabetes on inflammatory mechanisms and apoptosis, resulting in a deregulated host defense, deficits in wound healing, and microvascular problems.

H Osteoporosis or Osteoporotic

1. This is a decrease in bone mass and bone density and an increased risk and/or incidence of fracture. However, it has been noted that subjects without fractures also may have lost a significant amount of bone, while many patients with fractures display levels of bone mass similar to those of control subjects. Thus, definitions of osteoporosis based on reduced bone mass or nonviolent fracture are not perfectly synonymous. In addition, the relationship between skeletal and mandibular or maxillary bone mass is limited.
2. The World Health Organization has established diagnostic criteria for osteoporosis based on bone density measurements determined by dual energy X-ray absorptiometry: A diagnosis of osteoporosis is made if the bone mineral density level is 2.5 standard deviations below that in a mean young population.

I Bisphosphonates

1. Bisphosphonates reduce or even suppress osteoclast function and can therefore be used in the treatment of various disorders causing abnormal bone resorption, including malignancies affecting the bone, such as multiple myeloma and bone metastases of breast and prostate cancer.
2. Patients receiving systemic bisphosphonates combined with steroids are not good candidates for implant treatment due to lack of trabeculation.

4 Recommendations for Medical Consideration in Implant Dentistry

Medical condition	Surgical consideration	Recommendations
Diabetes mellitus	Hypoglycemia due to lack of food intake	• Supplemental antibiotics • Adjust insulin dose • Steroids
Osteoporosis	Possible jaw fracture due to lack of ossification	Assess severity of bone loss through blood Ca level

Medical condition	Surgical consideration	Recommendations
Vitamin D deficiency	Reduced bone trabeculation	Assess severity of bone loss through blood Ca level
Hyperthyroidism and fibrous dysplasia	Affect trabecular pattern Ground glass appearance	• Maximize the number and length of implants • Conservative surgical approach • Longer osseo-integration period • Progressive loading • Bone and sinus augmentation (to ensure graft viability, augment using a higher percentage of autogenous graft than allograft and xenograft)
Paget's disease and multiple myeloma	Cotton wool appearance Increased Serum Alkaline Phosphatase and Blood Calcium Level	No implants
Scleroderma	Microstomia Taut intraoral mucosa	No implants
Oral lichen planus	Autoimmune inflammation of the mucosa	No implants
Sjögren's syndrome	Xerostomia	No implants
Crohn's disease	Autoimmune inflammation of the mucosa	No implants
Liver, kidney, and pancreatic transplant	Cyclosporine taken as an immunosuppressant affects implant-to-bone healing	No implants
Cardiovascular disease	Blood thinners	Monitor and adjust
HIV	Immunocompromised and xerostomia	No implants
Systemic bisphosphonates combined with steroids	Lack of bone trabeculation	No implants

Part B: Radiographic Examination and Imaging Modalities[2–4]

1 Imaging Strategies

Several radiographic examinations are used for preoperative assessment of dental implant sites. Each examination has specific indications, advantages, and disadvantages; however, a perfect imaging examination for dental implant treatment planning does not exist.

A Plain-Film Radiography

1. This term refers to projection images obtained with a stationary x-ray source and area detector.
2. Plain-film images represent the entire volume through which the x-ray beam is transmitted and is subject to differential magnification, geometrical distortion, and anatomic superimposition.

Intraoral radiography

1. Periapical intraoral radiography provides images of limited dentoalveolar regions that have excellent contrast resolution with minimal distortions.
2. Images are taken using film-holding devices to allow regional visualizations of vertical and anteroposterior bounds of residual alveolar ridges and identifications of adjacent anatomical structures.
3. The technique is the most widely available, inexpensive, and common initial dental radiographic examination for implant site assessment. The technique, however, is highly operator dependent and requires a moderate level of patient compliance to provide images with minimal geometrical distortions.
4. The greatest limitation of this strategy is the lack of cross-sectional information to access bone volume.
5. Occlusal radiography provides information on the general shape of the residual dental arch and maximum buccolingual dimension of the alveolar ridge; also, occlusal radiography has been proposed as a supplement to periapical radiography for implant assessments. Occlusal radiography, however, provides no information in addition to that provided by dental study models, and its use is not, therefore, justified for implant site assessments.

Cephalometric radiography

1. Cephalometrics includes two-dimensional lateral representations of the anteroposterior and vertical relationships of the maxillary and mandibular dental arches. Edentulous spaces in the midline are represented as cross-sectional images that can be calibrated to provide accurate measurement of buccolingual as well as vertical bone dimensions of the anterior residual alveolar ridge. Equipment for cephalometric radiography is readily available, and cephalometric images are relatively easy to obtain and of low cost.

2. The use of these images is limited, however, in that they provide uniformly magnified images of midline structures only. Although oblique, lateral cephalograms are used to image anterolateral segments, the alveolar process is often obscured by the superimposition of teeth adjacent to the edentulous alveolus.

B Rotational Panoramic Radiography

1. Panoramic radiographs provide information on the inferior alveolar canals and maxillary sinuses, and they may show pathologic conditions not demonstrated on complete, intraoral radiographic examinations.
2. Panoramic radiography is commonly available, is relatively low cost, provides information on both dental arches, and is useful in the initial diagnostic phase of implant planning.
3. By calculating the ratio between image dimensions and known dimensions of radiopaque markers on a radiographic stent, estimates of the available vertical distances between the alveolar crest and anatomic structures can be estimated at specific positions in a panoramic image.
4. Many factors, however, limit the accuracy and reliability of this calculation. These include patient-positioning errors, inherent distortions related to equipment differences, discrepancies between the shape of the dental arch and focal trough, and beam angulation.
5. A major limitation of panoramic radiography is that buccolingual assessments cannot be made. Because of its inherent limitations, panoramic radiography is considered unsuitable as a single imaging source for dental implant site assessment.

C Cross-sectional Imaging Techniques

1. Cross-sectional imaging techniques produce in-focus, thin-section images. Cross-sectional images can be produced with conventional tomography, panoramic-based scanography and tomography, cone beam computed tomography (CBCT), and computed tomography (CT).
2. CT scanners are most commonly used in medical radiology departments and hospitals.
3. Tomographic images can also be obtained with magnetic resonance (MR) imaging.
4. Tomographic techniques produce multiple, contiguous image sections (slices), with minimal distortions and uniform thicknesses and magnifications. In addition, images can be reconstructed such that they are perpendicular to each other.
5. The main advantage of tomographic images for implant dentistry is that they minimize or eliminate anatomic superimposition.

Conventional tomography

1. In conventional tomography, the x-ray source and the receptor move in synchrony and in opposite directions to each other about a fixed fulcrum, and this results in the blurring of structures outside the image plane, which is at the level

of the fulcrum. For implant dentistry, this provides uniformly magnified images in two dimensions, usually sagittal and coronal (cross-sectional). A limitation of this technique is that it produces images of limited regions (a few teeth) of a single dental arch.

2. Only objects within the specific region of interest are in focus. Usually, stents with radiopaque markers are needed to confirm the positions of imaged sites.
3. Because of blurring outside the region in focus, it is often difficult to identify structures and interpret the images.

Panoramic-based tomography

1. Some panoramic units use x-ray beam motions and area receptors to produce planar or curved (scanogram) tomographic images. Units vary markedly in the anatomic localization methods used, the number and thickness of tomographic slices, and the resultant image magnifications.
2. Images are often extremely wide compared with the area under study, may not cover the region of interest sufficiently, and suffer from blur, making interpretation of images difficult. Although this technique can be helpful in preliminary evaluations of specific implant sites, the technique is time-consuming, and multiple inter- or intra-arch implant site assessments require multiple exposures.

Computed tomography

1. Mostly uses fan-beam radiation and multiple detector arrays. Usually, one source of fan-beam radiation is used. The user makes selections to define the spatial resolution, field of view (FOV), and image sharpness. From the volume of data that is collected, mathematical formulas are used to reconstruct volumetric and/or multiplanar images. The multiplanar reconstructions can have various image thicknesses (several millimeters to tenths of millimeters) and be in any image plane (sagittal, coronal, axial, or any plane in between). Images are undistorted, are calibrated for dimensional accuracy, and have high soft tissue and hard tissue contrast resolution.
2. CT is relatively expensive, and it is usually available in hospitals and medical imaging centers only.

Cone beam computed tomography

1. CBCT differs from CT in that it uses a single x-ray source that produces a cone beam of radiation (rather than a fan beam, as with CT). CBCT uses a single, relatively inexpensive, flat-panel or image-intensifier radiation detector.
2. CBCT imaging is performed using a rotating platform to which the x-ray source and detector are fixed. The x-ray source and detector rotate around the object being scanned, and multiple, sequential, planar projection images are acquired in an arc of 180° or greater and are mathematically reconstructed into a volumetric dataset.
3. Many CBCT devices are now multimodal, providing panoramic and cephalometric imaging. Most have a low footprint suitable for dental office placement,

are technically as easy to operate as panoramic units, allow collimation of the beam to the region of interest to reduce patient radiation exposures, and produce submillimeter-resolution images of high quality. Although CBCT images have high spatial resolution, the data from which images are created contains considerable noise caused by scattered radiation.

4. Both CT and CBCT volumetric datasets can be exported in DICOM (Digital Imaging and Communications in Medicine) format and imported into third-party software that is specifically designed for implant treatment planning. With such software, various three-dimensional and cross-sectional images can be created. It is also possible to create virtual image-displays and simulated implant placement, and to use the software for computer-guided surgery.
5. In comparison with conventional dental imaging, volumetric datasets provide additional information that can be used for more sophisticated analyses and expanded, treatment-planning options that result in higher likelihoods for achieving satisfactory prosthetic results.
6. For use in implant dentistry, a major advantage of CBCT compared with CT is that CBCT equipment is usually far less expensive than CT equipment. Another advantage is that CBCT software for use in planning implants is usually much easier to use and far more useful than is software available with CT. The primary disadvantages of both CT and CBCT are their relatively higher effective radiation exposures and additional costs compared with plain, panoramic, and some other cross-sectional radiographic methods.

Advantages of CBCT	**Disadvantages of CBCT**
Multiplanar reconstruction.	Limited soft tissue visualization.
Significantly less radiation compared with other 3D advanced imaging modalities (e.g., medical CT).	Some CBCT machines produce an increased radiation exposure compared with selected intraoral and panoramic radiographs.
Fast, efficient, in-office modality.	Limited bone density measurements.
Interactive treatment planning.	Artifacts created by metal subjects (e.g., porcelain fused-to-metal [PFM] crowns, dental implants).
Adequate for bone-grafting assessment.	Third-party software applications and 3D models are additional expenses.
Computer-aided surgery.	Liability and extra cost.

MR imaging

1. With MR imaging (which does not use ionizing radiation), cross-sectional images (suitable for dental implant treatment planning) can be created.
2. The limitations of these images for dental implant imaging are the increased imaging scan times, dentists' unfamiliarity with MR images, and higher costs.

Modality	Mode of action	Magnifications and distortion	Radiation	In-office or out-of-office facility	Advantages and disadvantages in implant dentistry
Periapical	X-ray head	None Single tooth area	Light	In office	Only in single implant cases
Panoramic	Panorex	Distorted image Overlap of syloid process of the mandible on maxillary sinuses Overlap of the cervical vertebrae on the anterior teeth	Moderate	In office	For diagnostic purposes only
Occlusal	X-ray head	None Limited to occlusal plane view	Light	In office	No benefits
CT	Multiple x-ray heads produce fan-beam projections Slices staked to form 3D image	None	High	Out of office	High-radiation dose with scattered radiation High cost and patient inconvenience
CBCT	Single x-ray head produces cone beam projections 3D image sliced	None	Low	In office	Low cost Convenient Less radiation exposure
MR imaging	Magnetic resonance imaging	None	None	Out of office	No benefits
Cephalometric	X-ray head	Yes	High	In office	No benefits

A Terms Used in Digital Radiography

Pixel	The smallest controllable element of a picture represented on the screen in a two-dimensional grid.
Voxel	The smallest controllable element of a picture represented on the screen in a three-dimensional grid.
DICOM	Digital Imaging and Communication in Medicine.
FOV	Field of view.
6-inch FOV	Produces an image of teeth sextants or an arch.
9-inch FOV	Produces an image of dentition and orbit.
12-inch FOV	Produces an image of the whole skull.

B Indications of CBCT in the Maxillofacial Region

- Evaluation of the jaw bones to assess the feasibility of placing dental implants at specific sites in the jaws. This ensures that every possible precaution has been made to reduce the risk of involvement of the nerves in the lower jaw, and the sinuses and nose in the upper jaw.
- Evaluation of the status of previously placed implants.
- Evaluation of the hard tissue (bones) of the temporomandibular joint (TMJ).
- Evaluation of abnormalities (pathology) in or affecting the bones.
- Evaluation of the extent of alveolar ridge resorption.
- Assessment of relevant structures prior to orthodontic treatment, such as the presence and position of impacted canine and third molar teeth.
- Assessing symmetry of the face (cephalometrics).
- Assessing the airway space (sleep apnea).
- To permit 3D reconstructions of the bones or the fabrication of a biomodel of the face and jaws.
- Assessing the mandibular nerve prior to the removal of impacted teeth, especially the lower wisdom teeth.

C CBCT versus Dental X-Ray

CBCT	Dental X-Rays
Cone beam CT images provide undistorted, or accurate, dimensional views of the jaws. *Distortion* is the unequal magnification of different parts of the same image.	Panoramic images, by contrast, are both magnified and distorted. Magnification by itself is not a problem, as long as one knows or can calculate the magnification factor.

In addition, CT images can provide cross-sectional (buccolingual), axial, coronal, sagittal, and panoramic views. With CT, it is possible to separate the various structures, for example the left condyle from the right one.	Due to distortion, panoramic images are notoriously unreliable to use for making measurements. A panoramic film provides an image of only one dimension, namely a mesio-distal or antero-posterior perspective. In a panoramic image, all the structures between the x-ray tube and the image detector are superimposed on one another.

D CBCT Compared to Tomography

CBCT	Tomography
CBCT can be performed within a 10–40 sec range, depending on the region being imaged and on the desired quality of the image. CBCT also provides stronger indication of bone quality. The equipment is substantially lighter and smaller. Cone beam CTs have better spatial resolution (i.e., smaller pixels). No special electrical requirements are needed. No floor strengthening is required. The room does not need to be cooled. Very easy to operate and maintain; little technician training is required. Some cone beam manufacturers and vendors are dedicated to the dental market. This makes for a greater appreciation of the dentist's needs. In the majority of cone beam CTs, the patient is seated, as compared with lying down in a medical CT unit.	Tomography, on the other hand, provides direct (as opposed to reconstructed) cross-sectional, sagittal, and coronal views. The disadvantage of plain-film tomography is that it requires much more chair time than CT. Thus, it can be especially difficult to perform on patients who are unable to sit or hold still for a period of time. Cost of equipment is approximately 3–5 times less than that of traditional medical CT. Plain-film tomography has lower contrast resolution, which means less discrimination between different tissue types (i.e., bone, teeth, and soft tissue).

CBCT virtually eliminates claustrophobia and greatly enhances patient comfort and acceptance.

The upright position is also thought by many to provide a more realistic picture of condylar positions during a TMJ examination.

The lower cost of the machine may be passed on to the patient in the form of lower fees.

Both jaws can be imaged at the same time (depending on the specific cone beam machine).

Radiation dose is considerably less than with a medical CT.

3 Principles of Imaging for Dental Implant Assessment, with Recommendations

1. Images should have appropriate diagnostic quality and not contain artifacts that compromise anatomic-structure assessments.
2. Images should extend beyond the immediate area of interest to include areas that could be affected by implant placements.
3. Practitioners should have appropriate training in operating radiographic equipment and competence in interpreting images from the modality used. This training and competence should be maintained through continuing dental education courses. Such training should include a thorough review of normal maxillofacial anatomy, common anatomic variants, and imaging signs of diseases and abnormalities. This is particularly important for CT and CBCT imaging because of the complexity of structures within the expanded FOVs.
4. The goal of radiographic selection criteria is to identify appropriate imaging modalities that complement the goals at each stage of implant therapy. The use of specific imaging is based on professional judgment. Professional judgment varies depending on the skill, competence, knowledge, and experience of the clinician.
5. Specific considerations must include clinical and anatomic complexity, potential risks of complications, and esthetic outcomes.

A Initial Examination

The purposes of the initial radiographic examination are to assess the overall status of the remaining dentition, to identify and characterize the location and nature of the edentulous regions, and to detect regional anatomic abnormalities and pathologies.

Recommendation 1.	**Recommendation 2.**	**Recommendation 3.**
Panoramic radiography should be used as the imaging modality of choice in the initial evaluation of the dental implant patient.	Use intraoral periapical radiography to supplement the preliminary information from panoramic radiography.	Do not use cross-sectional imaging, including CBCT, in an initial diagnostic imaging examination.

B Preoperatively

1. Establish the morphologic characteristics of the residual alveolar ridge (RAR). The morphology of the RAR includes considerations of bone volume and quality. Vertical bone height, horizontal width, and edentulous saddle length determine the amount of bone volume available for implant fixture placement. This information is necessary to match the available bone dimensions with the number and physical dimensions of the implant(s). Moderate deficiencies in horizontal and vertical bone may be corrected by augmentation procedures at the time of the osteotomies and fixture placements, whereas severe deficiencies require prior surgical procedures, such as ridge augmentations.
2. Similarly, excessive or irregular vertical alveolar bone may require preprosthetic or simultaneous alveoloplasty.
3. Bone quality is considered good when there is enough cortical and trabecular (cancellous) bone to hold the implant securely (which is required for osseointegration), and it is considered poor when there is inadequate oral bone to hold the implant securely. The most commonly used classification system for assessing oral-bone quality for implant placement was introduced in 1985 and uses four radiographic oral-bone classes that are based on visual assessments of the amounts of cortical and trabecular bone. Better assessments of bone quality may influence surgical technique, implant selection (i.e., length, diameter, and type), and the loading protocol.
4. Determine the orientation of the RAR. The orientation and residual topography of the alveolar–basal bone complex must be assessed to determine whether there are variations that could compromise the alignment of the implant fixture with the planned prosthetic restoration. This is particularly important in the mandible (e.g., submandibular gland fossa) and anterior maxilla (e.g., labial cortical bone concavity).
5. Identify local anatomic or pathologic conditions restricting implant placement. In the maxilla, these include the incisor region (nasopalatine fossa and canal, and nasal fossa), canine region (canine fossa and nasal fossa), and premolar/molar region (floor of the maxillary sinus). In the mandible, these include the incisor region (lingual foramen), canine/premolar region (mental foramen), and molar region (submandibular gland fossa, and inferior alveolar [mandibular] canal containing the neurovascular bundle).

6. Match imaging findings to the prosthetic plan. Successful implant treatment planning involves both surgical and prosthetic considerations. Radiographic images are not only used for prosthetic planning but also used to construct templates to guide surgical procedures and implant placements. The use of guided surgery for implant placement is increasing because of a number of clinical advantages, including increased practitioner confidence and reduced operating time. Guided surgery requires imaging capable of providing DICOM data (either CT or CBCT). These data are imported into software programs where interactive surgical and prosthetic tools can provide complex implant "simulations" within a virtual patient.

Recommendation 4.
The radiographic examination of any potential implant site should include cross-sectional imaging orthogonal to the site of interest.

Conventional tomography provides cross-sectional information, but it is technique sensitive and the images are more difficult to interpret than CBCT images. CBCT usually results in lower patient exposures to ionizing radiation than does CT.

Recommendation 5.
CBCT should be considered as the imaging modality of choice for preoperative cross-sectional imaging of potential implant sites.

As with any type of imaging, a patient should be exposed to the least amount of ionizing radiation that is needed to produce CBCT images of acceptable diagnostic quality. This is achieved by careful selection of exposure parameters and FOV. Although the FOV should be limited to the area of interest, the FOV may extend beyond the implant site to include the maxillary sinus or opposing dental arch. CT may be considered when CBCT is unavailable; however, dose-sparing protocols must be used.

The use of CBCT before bone grafting helps define both the donor and recipient sites, allows for improved planning for surgical procedures, and reduces patient morbidities. CBCT is best for the evaluation of volumetric and topographic changes of the restored residual alveolar ridge.

Recommendation 6.
CBCT should be considered when clinical conditions indicate a need for augmentation procedures or site development before placement of dental implants: (1) sinus augmentation, (2) block or particulate bone grafting, (3) ramus or symphysis grafting, (4) assessment of impacted teeth in the field of interest, and (5) evaluation of prior traumatic injury.

Recommendation 7.
CBCT imaging should be considered if bone reconstruction and augmentation procedures (e.g., ridge preservation or bone grafting) have been performed to treat bone volume deficiencies before implant placement.

C Postoperative Imaging

1. The purpose of postoperative imaging after dental implant placement is to confirm the location of the fixture at implant insertion.
2. Later in maintaining implant treatment, imaging is used to assess the bone–implant interface and marginal peri-implant bone height.

Recommendation 8.
In the absence of clinical signs or symptoms, use intraoral periapical radiography for the postoperative assessment of implants. Panoramic radiographs may be indicated for more extensive implant therapy cases.

Recommendation 9.
Use cross-sectional imaging (particularly CBCT) immediately postoperatively only if the patient presents with implant mobility or altered sensation, especially if the fixture is in the posterior mandible.

Recommendation 10.
Do not use CBCT imaging for periodic review of clinically asymptomatic implants. Finally, implant failure, owing to either biological or mechanical causes, requires a complete assessment to characterize the existing defect; plan for surgical removal and corrective procedures, such as ridge preservation or bone augmentation; and identify the effect of surgery or the defect on adjacent structures.

Recommendation 11.
Cross-sectional imaging, optimally CBCT, should be considered if implant retrieval is anticipated.

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Recommendation 12.
The decision to order a CBCT scan must be based on the patient's history and clinical examination, and justified on an individualized needs basis that demonstrates that the benefits to the patient outweigh the potential risks of the patient's exposure to ionizing radiation, especially in the case of children or young adults and large FOV scans. Because the 3D information obtained with CBCT cannot be obtained with other 2D imaging modalities, it is virtually impossible to predict which treatment cases would not benefit from having this additional information before obtaining it.

Based on the available evidence and the type of information acquired with 3D imaging modalities, the consensus panel suggests that the use of CBCT should be considered as an imaging alternative before cases where the proposed implant receptor or bone augmentation site(s) are suspect, and conventional radiography may not be able to assess the true regional 3D anatomical presentation as indicated here:

- Computer-aided implant planning and placement, including flapless techniques (e.g., interactive treatment planning software applications, surgical guides, and navigation systems).
- Implant placement in a highly esthetic zone or where concavities, ridge inclination, inadequate bone volume or quality, undeterminable proximity to vital structures, and/or insufficient inter-radicular spacing are suspected.

Recommendations 13.
The use of CBCT requires a specific skill set that until recently has not been taught in dental schools at either the undergraduate or postgraduate levels. Therefore, it is also recommended that clinicians who are providing dental implant procedures for their patients become knowledgeable in 3D diagnosis and treatment planning concepts, and become familiar with interactive treatment planning software applications.

Protocols. 3D imaging technology does not supersede sound surgical and restorative/prosthetic fundamentals.

Clinicians should understand that the scan process often starts before the scan itself. Diagnostic wax-ups, mounted articulated study casts, and the use of scanning templates help to improve the diagnostic accuracy of the CBCT data as it relates to the desired implant placement or ancillary grafting procedure. The use of scanning and surgical templates helps to improve surgical accuracy, reduce postoperative morbidity, and aid in the restorative phase of treatment.

- Pre- and postadvanced bone grafting evaluation (e.g., sinus lift, ridge splitting, and block grafting).
- History or suspected trauma to the jaws, foreign bodies, maxillofacial lesions, and/or developmental defects.
- Evaluation of postimplant complications (e.g., postoperative neurosensory impairment, osteomyelitis, and acute rhinosinusitis).

It is important to keep in mind that the smallest possible FOV should be used and the entire image volume should be interpreted.

Part C: Surgical Stents[5–7]

1 Surgical Stent Types

A Type 1: Teeth Occlusal Access Hole

Figure 1.1 Surgical stent with teeth and occlusal access hole.

In Figure 1.1, teeth are set in an ideal diagnostic arrangement, and a hole is drilled through the tooth giving the most ideal placement and angulation for the implant. It allows the surgeon to place the pilot drill through this hole to the tissue and drill a small pilot hole into the bone at this exact location. When the tissue flap is made, the pilot holes are visible and the implant can be placed in this area. A few of the drawbacks are: once the flap is made the stent is no longer useful, and the long axis of the implant is not visually apparent. The buccal flange can be removed, which would aid the surgeon visually if bone grafting or the use of particle bone in areas is needed. It also can be worn by the patient during healing as long as relief is made to the underside so there is no pressure to the ridge during the healing process. The position of the hole in the template determines whether the implant crown will be screw retained or cemented.

B Type 2: Clear Occlusal Access, No Teeth

Figure 1.2 Surgical stent with clear occlusal access and no teeth.

In Figure 1.2, this type of stent defines the outer perimeter of the teeth that have been set in an ideal diagnostic arrangement. It allows the surgeon to flap the tissue and place the stent over the visible bone. The gingival tissue position is also apparent from the facial, giving the surgeon information regarding whether grafted or particle bone is needed in any particular area for proper tissue support or the regeneration of the inner dental papilla. The stent also can be utilized as an impression tray during first-stage surgery in preparation of a temporary prosthesis for placement at second-stage surgery.

C Type 3: Teeth Barium Coated

Figure 1.3 Surgical stent with teeth and barium coated.

The type of stent in Figure 1.3 is prepared as the “Confined,” with the addition of barium placed within the inner. This stent is specifically designed for diagnostics with CBCT.

D Type 4: Clear with Sleeves

Figure 1.4 Surgical stent clear with sleeves.

The type of stent in Figure 1.4 is prepared as the "Confined" design with metal pins placed into the pilot holes. The facial side of the stent is removed, leaving a lingual wall. This allows the surgeon to flap the tissue and place the stent over the visible bone. The surgeon has open access to the labial side with the aid of these guide pins to maintain a visual parallel path during first-stage surgery. The stent can be used for single-tooth to full-arch implant placement. The stent also can be used as an aid when taking a full panorex. The guide pins will be a visible reference in the early planning stages. The gingival tissue position is apparent from the facial, giving the surgeon information regarding whether grafted or particle bone is needed in any particular area for proper tissue support or the regeneration of the inner dental papilla. The stent also could be utilized as an impression tray during first-stage surgery in preparation of a temporary prosthesis for placement at second-stage surgery.

E Type 5: Clear, No Lingual

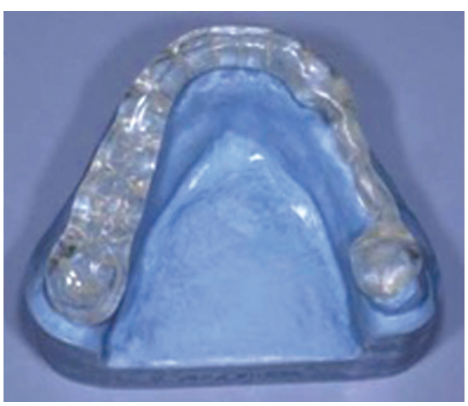

Figure 1.5 Surgical stent clear with no lingual flange.

In Figure 1.5, this type of stent is prepared as the "Parallel Pin" without the addition of the pins, and the lingual is hollowed out.

F Type 6: Clear, Fully Edentulous

Figure 1.6 Surgical stent clear fully edentulous.

The type of stent in Figure 1.6 is used when a bar or individual abutments will be used for an implant-supported overdenture.

G Type 7: Opposite-Arch Pins

Figure 1.7 Surgical stent on the opposite arch with pins.

In Figure 1.7, this type of stent is used when no interferences from the stent are desired in the affected surgical site. The stent that is fabricated on the opposite arch has pins that correspond to the implant's location on the opposite (surgical) site.

2 Comparison of Surgical Stents

Stent	Access hole diameter	Visibility	Ability to change alignment during drilling	Ability to determine need for bone grafting	Can be used for diagnosis with radiographs and scans	Can be used for impression taking	Can be used as temporary appliance during healing
Type 1: Teeth occlusal access hole	Pilot drill only	Limited	No	Yes	Yes	No	Yes
Type 2: Clear occlusal access, no teeth	Any drill diameter	Unlimited	Yes	Yes	No	Yes	No
Type 3: Teeth barium coated	Any drill diameter	Limited	No	Yes	Yes	No	Yes
Type 4: Clear with sleeves	Pilot drill	Limited	No	Yes	Yes	No	No
Type 5: Clear, no lingual	Any drill diameter	Unlimited	Yes	No	No	No	No
Type 6: Clear, fully edentulous	Pilot drill	Limited	No	No	No	No	No
Type 7: Opposite-arch wires	Any drill diameter	Unlimited	Yes	Yes	No	No	No

3 Recommendations

1. Surgical stents with access holes should be wide enough to accommodate the drills.
2. Patients wearing stents during a CT scan or cone beam tomography taken outside the dental office should be trained first on how to wear the stents. Identify the upper and lower stents to patients.

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