Dental Implants: A Comprehensive Review

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Continuing Education Units: 3 hours

Disclaimer: Participants must always be aware of the hazards of using limited knowledge in integrating new techniques or procedures into their practice. Only sound evidence-based dentistry should be used in patient therapy.

According to the National Institutes of Health, there are over 100 million people missing teeth, and the need for implant dentistry is stronger than ever. Patients often ask dental team members questions regarding dental treatment options. Knowledge of the current procedures for implants is a must for anyone in the dental field. By becoming knowledgeable about different implant options, dental professionals will be able to help patients make educated decisions regarding their dental treatment.

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Overview
According to the National Institutes of Health, there are over 100 million people missing teeth, and the need for implant dentistry is stronger than ever. The number of implants placed in the United States increased ten-fold between 1983 and 2002 and continues to increase every year.¹ Dental implants are considered “the standard of care” today to replace a missing tooth due to osseointegration and improved oral function. It is critical for the dental team to be familiar with the implant procedures available. Patients often ask dental team members questions regarding dental treatment options. Knowledge of the current procedures for implants is a must for anyone in the dental field.

Any patient with one or more missing teeth is a candidate for dental implants. Both volume and quality of bone in the recipient site are determining factors for treatment. The ability to provide patients with a third set of teeth has changed how dentistry views missing teeth – and how patients with missing teeth perceive dentistry. By becoming knowledgeable about different implant options, dental professionals will be able to help patients make educated decisions regarding their dental treatment.

Learning Objectives
Upon completion of this course, the dental professional should be able to:
• Understand the history of dental implants and Dr. Brånemark’s breakthrough discovery of osseointegration.
• Understand the difference between subperiosteal and endosteal designs.
• Distinguish between different dental implant treatment options.
• Relate the value of CT scans prior to implant placement, the “standard of care” today.
• Answer questions on informed consent.
• Recite surgical protocol.
• Complete surgical set ups.
• Deliver pre- and post-surgical instructions to the patient.
• Obtain basic information about bone grafting materials and implant advances.
• Understand that implant maintenance is an important part of the treatment.
• Properly sterilize and handle the implant equipment.

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Glossary
abutment – A tooth, root, or implant used for support and retention for a fixed or removable prosthesis.

Arnica montana – A raw herb used in the homeopathic treatment of bruises and inflammation; also known as mountain tobacco and wolf’s bane.
atrophy – A wasting or loss of tissue.

blade form dental implant – Type of endosseous implant; shaped like a flat plate.

endosseous implant – Positioned within the jaw bone, which gains support by osseointegration into the bone.

homeopathy – Nontraditional system for treating patients; minute amounts of a substance that in large amounts causes disease symptoms are given to healthy individuals.

hydroxyapatite (HA) – Calcium phosphate complex that is a primary mineral component of bone; sprayed-on coating used on early dental implants.

intrude – Forceful change to tooth position, driving further into the tooth sulcus resulting in less crown visibility.

ligature – Piece of floss attached to small components that acts as a safety feature for ease of retrieval.

muscles of mastication – Four pairs of muscles that aid in chewing; masseter, temporalis, and the internal and external pterygoid.

open bite – Lack of vertical overlap of the maxillary centrals resulting in an opening of the anterior teeth.

osseointegration – Biological concept where a direct connection exists between the living bone and metal.

osteotomy – A hole in the alveolar bone made by a dental surgeon using an implant drill for the placement of a dental implant.

peri-implantitis – The equivalent to periodontitis manifesting around dental implants; bone loss around implants due to bacterial pathogens.

pneumatize – Formation of air cells or cavities in tissue; in this case, when the sinus spaces are increased due to bone resorption.

pontic – Artificial tooth that replaces a missing tooth.

roundhouse bridge – Fixed partial denture for an entire arch.

subperiosteal implant – Cast-metal frame which rests on bone, under the gingiva, to support an overdenture; may be fixed with screws to the bone; used for fully edentulous patients in the mandibular arch.

tachycardia – Fast heart beat.

titanium – Metal (chemical symbol Ti) having low density, good strength, and corrosive resistant properties.

transosseous implant – Machined implant consisting of a lower plate fixated under the mandible with pins projecting through the mandible which penetrate into the oral cavity.

trephine – A surgical instrument used for cutting out circular sections.

Vitalium® – Trademark name for a dental alloy comprised of cobalt, chromium and molybdenum.

History of Dental Implants

Pre-osseointegration

Human skulls dating from 600 A.D. show that man attempted to implant carved shells into the anterior mandible. However, the first documented dental implant did not appear until 1809, with a poor success rate.2,3 Teeth are anchored into the alveolar bone by the periodontal ligament. This ligament is a muscle attachment that acts as a shock-absorbing mechanism. Researchers are spending numerous hours and resources to artificially developing a periodontal ligament that would anchor dental implants into the alveolar bone, but to date have not been successful (Figure1).4

Prior to the era of osseointegration, there were various designs of dental implants and frameworks used to support dentures and partial dentures. Some of these functioned well for several years, but most designs had an unpredictable success rate. The first of this type, the subperiosteal implant framework, was described in 1949 by Drs. Goldberg and
This framework could be used on the maxilla or mandible. It was placed underneath a gingival flap and in direct contact with the bone. It was not implanted directly into the bone. An impression was made of the edentulous jaw from which the framework was cast in Vitallium®, with posts projecting through the mucosa into the oral cavity. A denture or partial denture was then fabricated to fit the posts. There were a few complications associated with this method. Exfoliation of the bone connecting the screws, and the exposure of the frame through mucosal perforation were problems. Twenty-year studies showed a failure rate of 34% in the mandible. A 10-year study reported a 60% survival rate, and an even lower survival rate of 50% after 15 years. Because of these low success rates, this implant framework is no longer used today.

Almost 25 years later in 1968, a new dental implant concept called the transosseous implant was introduced by Dr. Small. The name was derived from the fact that it transversed the mandible from the bottom to the top. This implant was inserted underneath the chin. A flat bone plate was fixed under the skin against the inferior border of the mandible. Several threaded posts projected into the anterior mandible from the plate. Two to four of the posts went completely through the mucosa and into the oral cavity to help fixate the denture prosthesis. Transosseous implants were machined from titanium, or a gold alloy. There were several disadvantages to this implant system. This procedure was performed under general anesthesia in a hospital setting and was quite invasive. Another downside was frequent bone loss around the posts with bleeding on probing. Studies showed that this design had a success rate of 91% after 10 to 16 years of function, but it was not a healthy environment. This implant design is no longer used today and was replaced by the endosseous implant.

In 1966, Dr. Linkow presented the “blade implant” around the same time as the transosseous implant. This is now known as an endosseous implant (Figure 2A, 2B). This implant is inserted intraorally in the bone by making a groove in the alveolar bone. One or more posts were attached to the fin-shaped plate, which anchored the restoration. The success rate for this implant was under 50%, and is no longer used today. The problem with this type of implant was that it became loose, infected, and had to be removed.
Discovery of osseointegration
The concept of osseointegration was an accidental discovery in the early 1960’s by physician and professor Per-Ingvar Brånemark. Brånemark was working on his thesis, studying bone regeneration in rabbits. He developed a titanium chamber to study wound healing. This device was implanted in the bone of a rabbit. At the end of the study, when he wanted to remove the chamber from the bone, it could not be removed because the bone had fused (osseointegrated) to the titanium surface. The bond was so strong that it could not be broken (Figure 3A). He conducted several other experiments to confirm that titanium could indeed integrate and become part of the bone. After this discovery, dental applications were the first that came to mind.

Brånemark’s first patient, Gösta Larson (Figure 3B), was born in 1931 with severe chin and jaw deformities. Larson had several congenitally missing teeth and the teeth he had were misaligned. He was not able to chew properly. Larson was treated in 1965, with the first implant supported bridge, in Gothenburg, Sweden. Four implants were inserted in the mandible, which integrated within six months, and the prosthesis was then attached. Forty years later, that prosthesis was still in place.

Following this first implant, Brånemark did extensive clinical research and placed more implants with regular recheck appointments. In the beginning, he only worked with fully edentulous patients. In 1977, Brånemark presented his data to the Swedish government for its aid. He received the support needed to collect a large amount of data. The American Dental Association gave “full acceptance” to his dental implants for a variety of uses including: single tooth replacement, partial and fully edentulous bridges, and implant-supported overdentures.

Post-osseointegration
The Brånemark system was introduced into the United States in 1982. These implants were machine surfaced to be a cylindrical screw (Figure 4). Since then, other endosseous implant designs have been introduced. Cylindrical implants are tapped into the osteotomy. Vented cylinders, expansive screws, and hollow posts are also available.

In order to improve the attachment of the bone cells to the implant surface, some manufacturers placed coatings on the implant surface. These coatings consisted of hydroxyapatite (HA) with
a titanium plasma spray. HA was shown to attract bone cells, especially in areas where bone density was compromised. A main problem with this type of implant was that the coating could separate from the implant once inserted in the alveolar bone. That separation caused the implant to become loose, resulted in failure, and required removal. HA-coated implants are no longer manufactured.

It was discovered that one way to increase the rate and success of osseointegration was to increase the surface area of the implant. This was accomplished by spraying the machined implant surface with liquid titanium or by dipping the implant in an acid that created microporosities (Figure 5). Due to this discovery, the majority of the implants available today have a porous surface allowing the bone cells to better attach to the implant surface (Figure 6).

Many implant studies were conducted in the 1980’s. Since then, over 100 implant companies have been established. In order to sell implants in the United States, a manufacturer must submit research and documentation, known as a 510(k), to the Food and Drug Administration (FDA) for approval. Clinical testing is currently not required by the FDA for endosseous implants.

The American Dental Association (ADA) has a seal of acceptance given to products used in dentistry, including dental implants. The ADA seal is not a requirement to sell implants, but companies voluntarily submit to receive the seal. The ADA has stricter guidelines than the FDA, requiring clinical testing for at least 5 years. Among the implant companies with ADA Seal of Acceptance include Astra, Nobel Biocare, and Straumann.

**Rationale for Dental Implants**

As the baby boomer generation ages, the need for dental implants increases. Implants offer several advantages over bridges and dentures. People who are missing teeth have compromised chewing ability and speech, facial appearance, and self-confidence. When a tooth is lost, the surrounding bone starts to atrophy due to lack of use (Figure 7). Dental implants help maintain the bone profile and volume when chewing, by applying direct forces on the bone during mastication. These forces are essential in maintaining strong muscles and bone. Dentures or partial dentures have the opposite effect on the maxilla and mandible. Poorly fitted removable prosthetics allow the bone to resorb because they only regain approximately 10% of chewing capability. This is not enough to maintain the bone and results in a gradual loss of bone.

Since chewing ability is reduced with dentures, atrophy is also noted in the muscles of mastication, giving the patient’s cheeks a sunken appearance. Implants also maintain facial muscles, aiding in improved mastication and muscle tone. After receiving dental implants, many patients who had been missing teeth for a long time notice a natural “face-lift” effect when the muscles of mastication are once again used properly.

Patients who are rehabilitating their oral cavity with dental implants gain a priceless, new, self-confidence. Replacing missing teeth with implants is the best and closest thing to natural teeth (Figure 8). Many patients forget that they
shape was its “wedging effect” into the bone. This allowed for better initial stability, especially in less dense bone. However, if too much pressure was exerted on the bone, then necrosis or death of the cells occurred, causing severe pain and implant loss within a month following surgery.24

Vent holes were also introduced toward the apex of the implant which improved osseointegration into the bone.4 This mechanical retention occurred as new alveolar bone grew into the open areas essentially locking the implant in place.

The thread design of implants also varies between systems. One design is self-tapping, meaning that the threads are sharp and able to cut their way through the bone (i.e. Nobel Biocare). Another design has non-cutting threads (i.e. Straumann). A self-tapping thread has an advantage: the osteotomy can be perfected as the implant is being placed resulting in a close fit between the implant and the bone.

The implant platform can also have different shapes. It can have an internal or external platform with the abutment. The original Brånemark system had an external connection. The internal connection platform is the most preferred method utilized now in dental practices (Figure 9A, 9B, 9C).

have implants since they feel so natural due to the osseointegration. Recipients are able to smile with confidence, without worry of denture displacement or showing gaps when smiling.

Dental implants can last a lifetime. The crown work cemented to the exposed tip of the implant may need to be replaced for esthetic reasons, but the osseointegrated implant becomes a part of the patient’s body.

**Endosseous Implants**

There are several designs of root-form implants. The original Brånemark implant was designed as a cylindrical implant. In the 1980’s, a tapered implant became available. The advantage of this

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**Figure 7.** Bone loss is the end result of tooth loss.

**Figure 8.** Implant restoration on tooth #11. Courtesy of Dr. Del Goodrick
Mini-implants

Mini-implants were introduced in dentistry as a temporary implant. These were placed to support a denture or temporary prosthesis during the healing time following implant surgery (Figure 10). 25,26 Several manufacturers now produce mini-implants for permanent restoration of missing teeth. The cost of a mini-implant is approximately ¼ the cost of a regular implant making it more affordable for the patient. However, the post-operative studies to date only show a success rate of 60-70% after five years.

In 1983, Creekmore and Eklund started working with small-sized bone screws used as anchors for elastics in orthodontics. 27 These are mini-implants, known in orthodontics as temporary anchorage devices (TAD’s), and are gaining more attention in this field. They are usually inserted and remain in place for six to nine months, after which they are easily removed. 28 TAD’s have a diameter of 1.2-2 mm and are especially useful to intrude and distalize molars and to close open bites. 29

Zygomatic Implants

Certain patients no longer have an adequate amount of bone remaining in the maxilla. This happens if the patient has worn dentures for an extended time, or has severely atrophied bone or bone reductions due to cancer. When posterior teeth are missing for an extended period of time, the sinus can pneumatize or drop down, and only a shell of bone remains between the sinus and oral cavity. Brånemark wanted to find a treatment solution for these patients. If the patient proved to
have sufficient, quality bone in the zygomatic arch behind the maxillary sinus, a zygoma implant was placed. The zygomatic bones are situated lateral to the nose and also form part of the orbital bone and prominence of the cheek. The initial 10-year implant study conducted by Brånemark and colleagues found a success rate of 94%.30

The length of a zygoma implant is 30 to 52.5 mm, which is 2 to 5 times the length of a regular implant. By using zygomatic implants, the cost and need for bone grafting can be decreased. A multicenter study completed in 1997, showed a success rate of 96.3%.30

Prosthetic Options

**Single Tooth**
Most adults (70%) are missing at least one tooth.31 Developing a diagnosis and final treatment plan for tooth replacement is the dentist's responsibility. However, all dental team members should be familiar with the different options, risks and benefits of replacing a single missing tooth.

There are 3 options to replace a single missing tooth:
1. a removable partial denture,
2. a 2 – 3 unit fixed bridge, or
3. an implant finished with a permanent crown.

Dentists must agree to the American Dental Association's Code of Ethics as a condition of membership. This code upholds the principles to "do good" and "do no harm" to dental patients. The standard of care that advocates these principles is to recommend the placement of a dental implant. It is the most conservative option and preserves the integrity of the adjacent teeth and surrounding bone structure.

A removable partial denture (RPD) is the least expensive alternative, is reversible, and can be altered. Many patients, however, do not like a removable prosthetic and have trouble getting used to it. The RPD needs to be removed at night to let the tissues and teeth it sits on rest, it is not as stable during chewing (10% of original chewing capability 23) or speaking, and must be replaced when the jaw changes shape due to bone and tissue resorption.

A bridge involves replacing the tooth with a pontic which is suspended by one or more abutments. This technique involves the removal of healthy, adjacent tooth structure to create the abutment support. It is difficult to clean underneath a bridge which makes them more prone to caries and periodontal disease. Also, the adjacent teeth take on a heavier load, which increases the risk of fracture. If a problem develops with an abutment tooth, the entire bridge fails and must be removed. Studies show up to 50% failure rates from 10 to 15 years in function.32

A dental implant most closely replicates natural tooth structure. Once it is osseointegrated, many patients cannot differentiate an implant from a natural tooth. Furthermore, dental implants do not decay or need root canal therapy. Even though the cost is slightly more than a bridge, it is an investment for the future, as implants usually last longer than a bridge. A 10-year report on posterior single implants shows a success rate of 97%.33 Once an implant is placed, the osseointegration and tissue healing time of approximately four months is necessary before a final crown is placed. A temporary crown can be placed the same day the implant is placed, but this is only for esthetics, not for function (Figure 11 A-E).

Young patients, those under 16-17 years of age and still in their growing years, cannot receive dental implants. A hand-wrist radiograph is prescribed to determine if growth is complete (Figure 12). If the patient is still growing, a resin-bonded fixed bridge can be used as an option until they are a viable implant recipient. Another temporary option is a denture, also known as a "flipper" or "stayplate." This option is intended for esthetics only until a permanent solution is chosen.

**Partially Edentulous**
When patients are missing multiple consecutive teeth, the best replacement options are dental implants. A bridge is not a preferred choice due to the long span of edentulism, causing excessive stress on the abutment teeth. A removable partial denture is the least expensive, non-surgical option. However, the anchor teeth supporting this prosthesis are also subject to excessive forces. Studies report that up to 44% of anchor teeth for RPD's are lost early.34
Figure 11A. Extraction of anterior tooth (#8) without detaching the gingiva.

Figure 11B. Extracted tooth with the root canal material (gutta percha) extending from the apex.

Figure 11C. A zircon (white) abutment was attached immediately following the extraction and implant placement.

Figure 11D. Immediate placement of temporary crown over the abutment; laser crown lengthening was performed on the adjacent teeth to improve gingival symmetry.

Figure 11E. Four months post surgery with temporary implant at #8.

Figure 12. Hand-wrist radiograph verifies complete growth.
There are two options when planning implant treatment for partially edentulous patients. One is to replace every missing tooth with an individual implant and crown. The second option is to attach a fixed bridge onto several implants.

Replacing every missing tooth with an implant and crown may not be possible in every case. However, some patients want to recreate individual teeth. The hard task of replacing individual teeth in the esthetic zone (anterior) is maintaining or creating the soft tissue architecture (interdental papillae). The best results occur when inserting implants immediately following extraction, thus preserving the gingival tissue. In the posterior zone, where the forces of mastication are highest, individual implants are recommended.

Implant-supported bridges are a predictable and efficient way of replacing several missing teeth. As with a tooth-supported bridge, oral hygiene requires patient instruction in flossing underneath the bridge and around implants. If the patient fails to maintain healthy tissues under bridges and around implants, bone loss, known as peri-implantitis, can occur.

**Completely Edentulous**

Many fearful dental patients avoid dental treatment, resulting in the loss of teeth due to periodontal disease or extensive decay. With the advancements in dental implant technology, the dentist can insert implants immediately following extraction and fix a temporary, full-arch prosthesis to the implants. Many patients are unaware of the option of not going even one day with a removable denture. It is the responsibility of the dental team to remain current on dental technology and to educate patients about their implant options.

After approximately four months of healing, the final denture can be fabricated. This can be made of acrylic or porcelain. Both achieve great esthetic results, but porcelain is three to four times more expensive. Recent studies show that it is beneficial to splint implants together with a fixed temporary denture versus a removable transitional denture because it decreases the risk of failure.

As stated earlier, dentures replace approximately 10% of chewing function. This causes digestive problems due to an inability to chew the food properly, also leading to malnutrition, due to eating only softer, more processed foods. Atrophy of the alveolar arches occurs due to lack of adequate pressure on the bone. This atrophy results in resorption of the tissues leading to mouth sores and tissue irritation. When the denture is allowed to irritate the mental foramen, the patient can experience pain and numbness of the lower lip. A positive solution for a denture patient is to have two to four implants inserted into the alveolar bone. The denture is then connected to the implants via snap-on attachments or a bar resulting in stabilization (Figure 13 A-C). According to the 2002 McGill Consensus Statement on overdentures, mandibular two-implant overdentures are superior to conventional dentures in all clinical trials, even up to nine years following insertion.

Since the maxillary arch is wider than the mandibular arch, and the cancellous bone is more porous, four to six implants are utilized for a maxillary overdenture. An advantage of having an implant-supported overdenture in the maxilla is that the palatal area remains uncovered to the soft palate. Having the palate open to the taste buds allows for an enhanced sense of taste. Another advantage is relief from triggering the gag reflex. A properly inserted overdenture can be inserted without adhesives and easily removed allowing for consistent and thorough cleaning. Finally, it produces better lip support for patients who have experienced bone loss in the anterior area.

Correctly completing a treatment plan for the edentulous patient is very important. Some edentulous patients may not be candidates for fixed overdentures due to the lack of existing alveolar bone. To restore the lip support, a flange is often necessary or an extensive amount of bone grafting must be completed. A flange cannot be attached onto a fixed bridge because the patient will not be able to clean under it (Figure 14).

**Diagnostics**

A few records are necessary to determine the treatment options for the patient and placement of the implant(s). When considering potential implant treatment, the standard of care today is for the patient to receive a Computed
mounted impressions need to be obtained to determine the correct bite and location of the teeth to be replaced with implants. The guide is prescribed and made in a dental laboratory.

**CT Imaging**

CT scans have been used in medicine since 1973 and in dentistry since 1987. The CT scan allows the dentist to visualize the bone anatomy and nerve locations in 3-dimension (Figure 16). The latest technology in CT scans is called a cone beam CBCT scan. These scans are digital and require less radiation than a full mouth series of dental radiographs. Medical CT scans use 40 to 60 times more radiation than CBCT scans in dentistry. Most dental offices do not currently own a CBCT scanner so patients are referred to a local imaging center that has the dental software. However, as the CBCT scanners become more affordable, it is expected that more dental offices will be purchasing them (Figure 17).
procedure in layman’s terms in order for the dentist to obtain an informed consent and keep their trust.

Pre-packaged, sterile implant kits can be purchased from implant manufacturers. The kits can be customized for dental operatories. It is very important to maintain a sterile field during implant surgery. This minimizes the number of infections post-surgically and the risk of implant failure (Figure 18). While setting up for implant surgery, it is recommended to have a roving, second dental assistant who can retrieve the supplies while an assistant wearing sterile gloves prepares the treatment area. A proper surgical set up requires approximately 30 minutes. This stringent technique to maintain sterile field may be a challenge to implement but is absolutely necessary. Several training DVD’s on proper treatment room preparation are available and highly recommended, especially as the team is just beginning to add implant placement to their treatment list and for training new dental team members.

The responsibilities of a surgical assistant are: setting up the treatment room, monitoring the patient, instrument exchange, retraction, and effective oral evacuation of the oral cavity and surgical site. Ideally, a second, roving assistant stays available to obtain any necessary supplies outside of the sterile area.

A challenge with the implant surgical kit is maintaining the organization of many small parts that are used intraorally (Figure 19). It is important to ensure that small drills and/or screwdrivers

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**Figure 16.** CT scan – cross-section of the patient’s posterior maxilla and mandible; note the gutta percha shows up as a white vertical cylinder between the arches.

**Figure 17.** Cone beam CT scan.

**Figure 18.** Proper sterile treatment room set-up for implant surgery.

**Treatment Planning Software**

Several companies are providing dental software as a solution for accurate treatment planning of implant cases. Surgeons can simulate implant placement prior to surgery and obtain bone density values. Once the simulation of implant placement is set, a precisely replicated surgical guide can be fabricated leaving little or no chance for error.

**Surgical Protocol**

Any licensed, properly trained dentist can place dental implants. It is important to understand the implant placement protocol of the system used. A team approach will result in a smoother procedure and a happier patient.

Patients count on the dental assistant to answer questions regarding the procedure, often when the doctor is out of the treatment room. The dental assistant can ease a nervous or confused patient. It is advisable to give complete information to the patient about the surgery so they are confident of the procedure before surgery. Patients must understand the whole...
are not aspirated by the patient. Screwdrivers can be ligated at the handle with a long piece of floss for easy retrieval if they slip and become an aspiration risk.

Every dental implant system has a unique drilling sequence. Some designs are tapered and some are cylindrical. The cylindrical system kit has fewer drills. It is important to know the correct terminology for each piece of the kit prior to surgery. It is recommended to contact the company representative and arrange an education session with the entire clinical team to learn about each particular implant system.

All implant handpieces are electric and need to be set up prior to the start of surgery. The electric unit can be used with any implant drill system. Dental unit water lines utilizing city water should be suspended for implant procedures. Sterile saline bags are connected to the unit, allowing saline to be pumped to the handpiece at all times during drilling of the osteotomy. Sterile saline is used to prevent the possibility of any infection caused by bacterial bioburden in regular water. As a regular handpiece uses water for cooling, the use of irrigation fluid helps to prevent overheating of the bone, which can lead to implant failure (Figure 20).37

**Restorative Protocol**

A restorative temporization procedure immediately follows implant placement surgery. Often times, especially in the esthetic zone, immediate abutments are placed over the implant to support an immediate, temporary restoration.

After four to six months of tissue healing and osseointegration, the final restoration is fabricated. An impression is obtained, either at implant level or at the abutment level, to fabricate the final crown. The implant-level impression records the implant position and requires precision. An impression coping is screwed onto the implant to be transferred into the impression. The copings are utilized for a closed- or open-tray technique. The closed-tray technique is used mostly with one implant, and the open-tray technique is used more frequently for multiple implants, when different implant angles exist (Figure 21A, 21B). With either technique, the
of abutment is made according to the esthetics desired, thickness of tissue around the implant, and the angle of the implant. It is important to note that every abutment is connected to the implant using a screw.

The crown can be cemented into place or retained by screw over the implant. For a multiple implant bridge or bar overdenture restoration, the framework try-in appointment is important prior to porcelain build-up or overdenture fabrication to ensure a passive fit. The fit must be confirmed by a radiograph. Framework trial appointments require a minimal set-up. No anesthetic is required, however a screwdriver for the chosen implant system is required.

The implant prosthesis delivery appointment is similar to that of a crown or bridge delivery (Figure 22B-C). If the prosthesis is screw retained, then no cement is necessary and an occlusal filling material, such as composite, is necessary. After the occlusal bite registration
Sterilization and Handling
The instruments used in the dental implant placement and restoration require special care. It is important to contact a representative from the manufacturer of the implant system for specific recommendations of that particular system.

All instruments and reusable drills used in the dental implant procedure should be cleaned using an ultrasonic cleaner with an enzymatic wash. Prior to placing them in the ultrasonic bath, each drill, screwdriver, and torque wrench must be cleaned manually with a small brush to remove any blood or bone particles. The torque wrench must be disassembled if it was used in a surgical field, to remove any remaining blood and debris preventing it from proper sterilization and future use (Figure 23). Some drills have an internal channel used for irrigation during surgery that acts as a cooling system. This inside drill channel is kept free of blockages by cleaning it after every surgery with an irrigation syringe and water. To prevent rusting, it is important to dry the instruments before sterilization. Dry heat, autoclave, gas, and chemiclave techniques are all acceptable methods of sterilization. It is very important to replace the drills in their proper position in the surgical kit.

The contra-angle must be cleaned first under running water. The head should be separated from the shank and both parts carefully lubricated and sterilized according to the manufacturer’s recommendations.

Patient Management
Informed Consent
The informed consent information should be presented to the patient prior to the start of treatment. Proper informed consent paperwork will list the dentist performing the treatment, the patient’s name, the expected procedures being completed, alternatives to treatment, the risks involved in performing treatment and refusing treatment, the average times for healing and possible healing complications, and the expected costs to be incurred. By signing the consent form, the patient is confirming an understanding of the treatment, the risks of treatment, and any alternative options.

A pre-operative discussion with time for questions and answers is completed prior to the date of surgery. Patients may telephone with additional concerns before the surgery date. These questions should be asked and addressed in person at a follow up consultation appointment. Additional informed consent information can
Patients must follow all medication protocols as prescribed, especially in taking the antibiotic as directed until gone. They are advised to rest, eat soft foods, and rinse with salt water for the remainder of the day. The patient is given an ice pack to minimize swelling and a pack of sterile gauze to be used in case of minor bleeding. They should start chlorhexidine mouth rinses the second day post surgery. Chlorhexidine, the active ingredient in Peridex® or Periogard®, has been shown to inhibit the initial stages of blood clot formation, therefore emphasis must be placed on delaying these rinses until the second day post surgery. Additional home care instructions include not smoking, using drinking straws, exercising, or directly brushing the surgical site for one week.

Written, post-operative instructions may also include recommended homeopathic treatments. The most common of these is the plant extract, Arnica montana, which aids in decreasing bruising, swelling, and pain. This product is commonly used after plastic surgery or any other trauma. It comes in gel, cream or sublingual pellets. The sublingual pellets are preferred for implant surgery. Only short term use is recommended as there are potential, undesirable side effects including tachycardia, shortness of breath, and contact dermatitis.

Implant Maintenance
Implants attach differently to bone than teeth. The periodontal ligament (PDL) is a fibrous attachment that anchors teeth into the alveolus. When the PDL is lost or diseased, the tooth becomes loose and tender. Since implants do not rely on PDL's for attachment, even if the majority of bone is lost around an implant, no mobility is observed. Often times, the patient does not have any symptoms when peri-implantitis occurs. Therefore, it is imperative that regular dental prophylaxis appointments are scheduled. If bone loss is detected early, treatment can be administered quickly to restore health around the implants.

Home care for dental implants is the same as for natural teeth. Daily brushing and flossing are mandatory to remove plaque build-up, which can cause peri-implantitis. However, patients rely on the dental team to give them instructions on how to clean the implants. If regular floss is too small for the interproximal spaces, then proxy-
Implant brushes should be recommended (Figure 24). It is necessary to offer home care instructions for every oral hygiene aid offered to a dental implant patient.

For an older patient with poor dexterity, due to arthritis for example, it may be difficult or impossible to clean using dental floss. Irrigating devices may be recommended for daily use for patients receiving an implant. Antiseptic rinses can be used as the irrigation in the reservoir helping to reduce the inflammation in the tissues surrounding the implant.40

Implant Complication

Dental implants are the best option we have today to replace missing teeth. However, complications during treatment may arise, such as failure to osseointegrate or bone loss while in function (Figure 25).

Implant integration happens in 95%-99% of the cases. Occasionally, gingival tissue infections occur shortly after surgery due to any one of the billions of bacteria in the oral cavity. To minimize infections, it is important for the patient to take an oral antibiotic, as well as use an antiseptic rinse from post surgery days two through seven.

As mentioned earlier, dental implants require daily brushing and flossing or peri-implantitis can occur. This condition is the equivalent to periodontitis due to poor oral hygiene and lack of recare/recall visits (Figure 26). Signs of this condition include redness, bleeding upon probing and gingival pocketing.

Geriatric patients, patients with osteoporosis, and those receiving treatment for certain cancers, have a higher incidence of implant failure due to decreased bone density. With these groups of patients, their physician often prescribes bisphosphonate drugs, such as Boniva® and Zometa®. These drugs can interfere with normal bone healing and prevent necessary osseointegration. This condition is called osteonecrosis of the jaw (ONJ). Patients taking these types of drugs for other health conditions should not be recommended for dental implants.41

Mechanical complications include loosening of screws, fractured screws, and even fractured implants due to force overload. However, the incidence of fixture fracture has been reported to be less of an issue than that of tooth fracture (Figure 27A-B).13
Many patients struggle with ill fitting removable full and partial dentures. The resulting conditions of periodontal bone loss, malnutrition, and overall low self esteem can occur. Fortunately, better options exist with today’s implant technology. As patients are counseled on dental implant procedures, they can be assured that with basic home care protocols, their dental implant investment can have a high rate of success. Furthermore, implants will not decay once osseointegrated so crowns do not need to be replaced due to recurrent caries (Figure 28).

Every patient must understand the importance of having any dental treatment. Dental professionals must comprehend all implications involved in implant kit choices and the pre- and post-operative procedures. This knowledge enhances the advocacy for single tooth implants and implants that allow for a well-fitting overdenture. Patients count on dental team members to educate them on all choices to replace missing teeth and dental implants are recommended as the standard of care for patients.

**Conclusion**

Dentistry has advanced significantly in the area of dental implant technology. Dental implants offer same day tooth replacement options. After a few months of tissue healing, osseointegration, and final crown delivery, patients will have a fixed restoration that enhances their oral health function and esthetic appearance.
Course Test Preview
To receive Continuing Education credit for this course, you must complete the online test. Please go to www.dentalcare.com and find this course in the Continuing Education section.

1. ___________ discovered osseointegration and brought dental implants to North America in 1982.
   a. Dr. Linkow
   b. Dr. Brånemark
   c. Dr. Albrektsson
   d. Dr. Maggiolo

2. Current implant research indicates success rates for individual implants in the ________ range.
   a. 70 - 75%
   b. 75 - 80%
   c. 80 - 85%
   d. 95 - 99%

3. Self-tapping implants can cut into the bone and thus have a closer fit. The blade implant is no longer used in dentistry.
   a. Both statements are true.
   b. The first statement is true. The second statement is false.
   c. The first statement is false. The second statement is true.
   d. Both statements are false.

4. Pre-surgical implant protocols for the patient include _______________.
   a. a 30-second chlorhexidine rinse to reduce oral bacteria
   b. a prophylaxis within 30 days of surgery
   c. taking antibiotics to reduce possibility of infection
   d. All of the above.

5. The term osseointegration refers to _______________.
   a. bone fusing to another bone
   b. a metal implant fusing with the bone
   c. two bones fusing together at a joint
   d. a healed bone fracture

6. ___________ is used in water lines during implant surgery.
   a. Regular water
   b. Soft water
   c. Sterile saline
   d. A water and chlorhexidine mix

7. The advantage(s) of dental implants is/are they _______________.
   a. preserve the bone around it
   b. do not require cutting into adjacent teeth
   c. do not develop cavities
   d. have high, long-term success rate(s)
   e. All of the above.
8. **The advantage(s) of a removable partial denture is/are that _____________.**
   a. no surgical treatment is involved
   b. it is easy to get used to
   c. it does not affect the teeth it rests on
   d. it is cost-effective
   e. Both A and D.

9. **The disadvantage(s) of dentures is/are _______________.**
   a. they replace only 10% of the chewing function
   b. nutrition is impaired because food is not chewed properly
   c. bone resorption progresses
   d. soft tissue irritation is common
   e. All of the above.

10. **An abutment is _______________.**
    a. connected to the implant with a screw
    b. connected directly to the bone
    c. part of the implant crown
    d. completely submerged under the gingiva

11. **__________ can surgically place dental implants.**
    a. Only oral surgeons
    b. Only periodontists and oral surgeons
    c. Any licensed, trained dentist
    d. Only endodontists

12. **The roughed, porous surface of the dental implant has been recommended to generate a stronger bond to bone because of increased surface area. Hydroxyapatite-coated implants are preferred in dentistry today.**
    a. Both statements are true.
    b. The first statement is true. The second statement is false.
    c. The first statement is false. The second statement is true.
    d. Both statements are false.

13. **In dentistry, TAD stands for _______________.**
    a. transfer abutment device
    b. temporary anchorage device
    c. titanium alloy dip
    d. Both A and C.

14. **A falsehood regarding zygomatic implants is that they _______________.**
    a. are placed in the zygomatic bone
    b. have a 94% success rate, in a 10-year study
    c. are used for patients with severely atrophied maxillae
    d. are used for patients with severely atrophied mandibles

15. **Approximately ________ month(s) time is required for an implant to integrate before a final crown restoration can be placed.**
    a. four
    b. three
    c. two
    d. one
16. ______________ is/are the responsibility(ies) of a sterile surgical assistant during implant surgery.
   a. Monitoring the patient
   b. Effective oral evacuation and retraction
   c. Instrument transfer
   d. All of the above.

17. The ______________ should NOT be included on the informed consent.
   a. patient’s name
   b. procedure being performed
   c. patient’s address and emergency contact information
   d. alternative treatments
   e. possible risk factors

18. ______________ is/are a contraindication(s) for dental implants.
   a. An edentulous patient
   b. A patient who has had cancer treatment with I.V. bisphosphonates
   c. An 80-year-old woman
   d. Both B and C.

19. CBCT scans are less desirable in treatment planning as they require more radiation to the patient than a full mouth series of radiographs. A patient may have a dental implant placed after bone development ends.
   a. Both statements are true.
   b. The first statement is true. The second statement is false.
   c. The first statement is false. The second statement is true.
   d. Both statements are false.

20. Specialized implant instruments require special care including ______________.
   a. drill channel irrigation
   b. manual scrub and/or ultrasonic cleaning in an enzyme wash
   c. sterilization by autoclave, gas, chemiclave, or dry heat
   d. All of the above.
References

About the Author

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Sanda Moldovan, DDS, M.S., CNS, specializes in dental implants, periodontics and integrative nutrition. She graduated from the School of Dentistry of Ohio State University in Columbus, Ohio in 2001. She continued her studies in the Department of Postgraduate Periodontics at UCLA, concurrent with a Master of Science in Oral Biology. After she completed her postgraduate program in 2004, Dr. Moldovan accepted a lecturer position at UCLA School of Dentistry. Today, she is in private practice and provides dental implant lectures in the Continuing Education Department of the UCLA School of Dentistry. She is a regular on the Doctors TV show on CBS and has appeared on several other TV networks.

Dr. Moldovan is a Diplomate of the American Academy of Periodontology. She continues to stay involved and up-to-date with the latest research and technology available in her field, including laser techniques and stem cell bone grafting techniques.