

1 Implants 101: History, Implant Design, Parts, and Pieces

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Understand as hygienists a tidal wave of ailing or failing implants may be imminent. It is imperative that hygienists are trained in identifying and treating peri-implant mucosal inflammation that could affect overall body health. (1)

—G. Nogueira-Filho, DDS, MDent, PhD

Dental hygienists must be ready and be prepared to take on this next, very important challenge in our profession! The 21st century is an important and critical time to be a hygienist. During this exciting time in dentistry, we as hygienists have a critical role in implant therapy. As a hygienist, your role will be to assess patients for healthy periodontium prior to placement of implants, to monitor the tissue surrounding the implants, and to maintain the implants through safe, effective implant maintenance. Current studies reveal that infections in the periodontium occur in more than 50% of implants placed (2). Therefore we as dental

professionals will be faced with different dynamics, challenges, and complications.

As a hygienist the history of implant dentistry makes you aware that implants are not new, but have been evolving for decades. Patients may have concerns that implants are so new that not enough research or development has been done for them to feel comfortable with the procedure. With your knowledge of the history, design, and research done on implants you will be better able to talk with your patients and answer these concerns. A fundamental understanding of key terms and statistics associated with implant dentistry will also be a valuable tool to add to your verbal skills when talking with patients about tooth replacement.

History

Believe it or not, the history of dental implants dates back to 600 AD with the ancient Mayans. Dr. and Mrs. Wilson Popenoe found the lower mandible of a young Mayan woman in Honduras in 1931 (Figure 1.1). She was missing some of her lower teeth and they had been replaced with the earliest example of the first dental implants, made from pieces of shell shaped to resemble teeth. Scientists believe

Peri-Implant Therapy for the Dental Hygienist: Clinical Guide to Maintenance and Disease Complications, First Edition. Susan S. Wingrove.

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Figure 1.1 Discovery by Dr. and Mrs. Wilson Popenoe, Honduras, 1931. Reprinted with permission from Malvin E. Ring, *Dentistry: An Illustrated History*, 1st ed., Mosby.

that these shells may have actually worked. Slots were made into the bone and the shells were pounded in like little wedges, without anesthesia!

Similar discoveries were made in Egypt, artifacts that date back to the 1700s. Ivory and the bones of animals were also sometimes used to replace missing teeth. It would be decades after these archaeological discoveries before the modern world caught up with the Mayans' and Egyptians' dental technology.

In the late 18th and 19th centuries, the level of dental care went through many changes. Through the letters, journals, and accounts left by our first president, George Washington, we have a well-documented case history of his lifelong dental problems and the level of dental care available at that time. George Washington started losing his teeth at age 24 and by 1789, the year that Washington took his oath of office, he had only one of his original teeth left (Figure 1.2).

Dr. John Greenwood made a set of dentures for Washington made of hippopotamus ivory and eight real human teeth attached by brass screws. The denture, which was anchored on the one remaining tooth in Washington's mouth, has a hole that fit snugly around the one tooth. Dr. Greenwood was noted to be quite ahead of his time in his dental practice,



Figure 1.2 George Washington's lower denture. Courtesy of Rick Blanchette.

extracting teeth and utilizing them in the manufacture of dentures, but he also experimented with implantation.

Unfortunately for Dr. Greenwood, the 18th century's lack of antibiotics and any understanding of germ theory or antisepsis doomed any such experiments to failure. He did make President George Washington several sets of dentures, none made out of wood as often referred to. They were made from gold, ivory, lead, and human and animal teeth (horse and donkey teeth were common components), with springs to help them open and bolts to hold them together.

In the 18th century, researchers experimented with gold and other metal alloys including lead as implants. Dr. Maggiolo fabricated gold implants that were placed in sockets where teeth had recently been extracted and after a healing period attached a "donor" tooth. Dr. Harris, a physician, attempted the same procedure with a platinum post, both had poor results.

Dr. Edmunds in 1886 was the first in the United States to implant a porcelain crown mounted on a platinum disc and presented at the First District Dental Society of New York. Other metal alloys with porcelain crowns were experimented with, but these implants did not have a long-term success rate.

Dr. E.J. Greenfield, pioneer of the endosseous implant, provided many of basic concepts of nascent field of implantology. He was known for his patented hollow-cylinder implants made of wire soldered with 24 karat gold. This hollow-basket design was a similar design that Straumann Implant Company from Switzerland adopted many years later. He presented his research and surgical technique in 1913, and although histological proof of bone-to-implant contact was not available at that time, he understood the clinical importance to what he called “primary stability” or osseointegration. His surgical techniques, stepwise use of drill diameters starting with round bur, were presented in 1913 and are still practiced today (3).

It wasn’t until 1937 before the first relatively long-term implant success was noted. Dr. A.E. Strock used the metal alloy Vitallium®, placing a series of implants at Harvard University in animals and humans. He published a paper on the physiological effects of Vitallium in bone, with no post-operative complications or reactions noted, total toleration. These were the first relatively successful dental implants and certain types of implants are still cast in Vitallium today.

The turning point of implant dental history happened in the 1950s, when Professor Per-Ingvar Brånemark, an orthopedic surgeon, discovered that titanium components can bond irreversibly with living bone tissue. His team designed many studies on the healing effects of bone with one specific study on rabbits in which a titanium metal cylinder was screwed in a rabbit’s thigh-bone. A several-month healing period and other experiments of the blood circulation in animals using a hollow titanium cylinder demonstrated that the titanium cylinder fused to the bone. Brånemark named this discovery osseointegration (the firm, direct, and lasting biological attachment of a metallic implant to vital bone with no intervening connective tissue) (Figure 1.3).



Figure 1.3 Professor Per-Ingvar Brånemark, an orthopedic surgeon. Courtesy of Nobel Biocare.

Brånemark’s research and other colleagues from other disciplines evolved this theory of osseointegration along with the design of the “Brånemark titanium screw” device with a number of specific surface treatments to enhance bioacceptance with bone. One of the key reasons that titanium was chosen by Brånemark is his relationship to Hans Emneus, an orthopedic surgeon, who studied different metals used for hip joint prostheses. His research indicated that a new metal, titanium, from Russia and used in nuclear industry, might be optimal. Brånemark used a sample from Russia and from there on the best metal for implants has been pure titanium.

In 1964, commercial-grade pure titanium was accepted as the material of choice for dental implants. Other bodies of medicine (e.g., joint replacements) had recognized the fact that the body does not recognize titanium as a foreign material, which results in higher success rate and fewer rejections. Eventually the use of commercial pure titanium evolved into the use of titanium alloys (TiAl₆V₄ being

the most commonly used) due to experimentation and improved durability.

In 1981, Dr. Per-Ingvar Brånemark published his findings covering all the data on the animal and human clinical trials: success rate, concept, and the design of endosteal root-form titanium implants most commonly placed today. In an effort to gain international support and collaboration, based on patient care with sound biological and clinical principles Brånemark founded the Association of Brånemark Osseointegration Centers (ABOC).

Brånemark identified the edentulous patient as an amputee, an oral invalid, to whom we should pay total respect and rehabilitation ambitions. He was also instrumental in identifying the mouth as a much more important part of the human body than medicine and controlling agencies had previously recognized. He coined the term *osseoperception*, “the dentate mouth communicates with the brain, possibly improving not only daily function, but also being an important factor in restitution after intra-cranial vascular events” (P-I Brånemark, September 2005).

In the 21st century, technology and clinical awareness will take on more importance. The science and clinical advancements have made it possible for oral and maxillofacial surgeons, periodontists, and general dentists in the United States to double the number of implants performed per dentist between 1995 and 2002.

Dental implant history timeline

Ancient history: Mayans back in AD 600 had dental implants made from pieces of shell and ancient Egyptians used shells and ivory.

1700s: Lost teeth were often replaced with teeth from human donors. The process was mostly unsuccessful due to immune system reactions to the foreign material.

1800s: Researchers fabricated gold, platinum, and other metal alloys, including lead, into posts that were placed into the sockets of

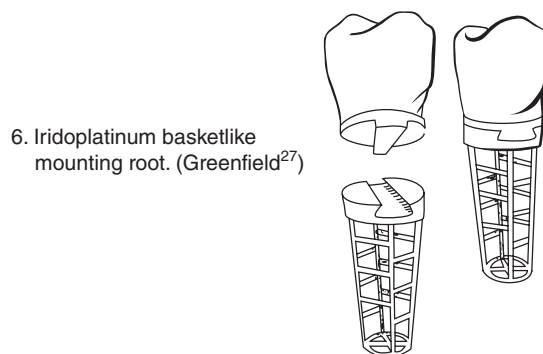


Figure 1.4 Dr. Greenfield's basket design. Source: EJ Greenfield, “Implantation of artificial crown and bridge abutments,” *The Dental Cosmos*, 1913; 55(4):364–369.

extracted teeth and donor teeth were attached after a healing period.

1886: Dr. Edmunds was the first in the United States to implant a porcelain crown mounted on a platinum disc and presented at the First District Dental Society of New York.

1913: Dr. E.J. Greenfield, pioneer of endosseous implant, provided many of basic concepts of the nascent field of implantology. He was most known for his patented hollow-cylinder implants made of wire soldered with 24 karat gold and outlined surgical implant placement technique (Figure 1.4).

1939: Dr. A.E. Strock introduced the first biocompatible material, the metal alloy Vitallium, to place a series of implants at Harvard University in animals and humans. He is credited with the first relatively long-term successful dental implants.

1941: Dr. Gustav Dahl of Sweden is credited with the development of the **subperiosteal implant**, a metal framework that is surgically placed on top of the jawbone for completely edentulous patients (Figure 1.5).

1952: Professor Per-Ingvar Brånemark discovered that titanium components can bond irreversibly with living bone tissue and coined the term osseointegration.

1964: Commercial grade pure titanium, or commercial pure titanium, was accepted as material of choice for dental implants.

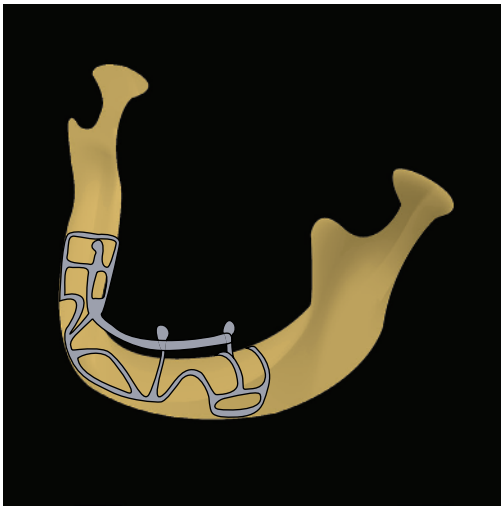


Figure 1.5 Dr. Dahl subperiosteal design.

1967: Dr. Leonard Linkow of New York developed the blade implants and Doctors Ralph and Harold Roberts are also credited to the development of **endosteal implants** (Figure 1.6).

1968: Dr. Irwin Small developed the **transosteal dental implant** (Figure 1.7).

1969: Dr. Per-Ingvar Brånemark provided the proof of long-term success of titanium implants.

1981: Dr. Per-Ingvar Brånemark published his finding covering all the data on the animal and human clinical trials: success rate, concept, and the current design of **endosteal root-form titanium implants**.

1982: The Toronto Conference on Osseointegration in Clinical Dentistry created the first guidelines for what would be considered the standardization of successful implant dentistry.

1986: Implants received the endorsement of the American Dental Association.

1989: The Brånemark Osseointegration Center (BOC) in Gothenburg, Sweden, was founded. BOC's primary mission was to provide treatment for patients with severe oral, maxillofacial, and orthopedic impediments.

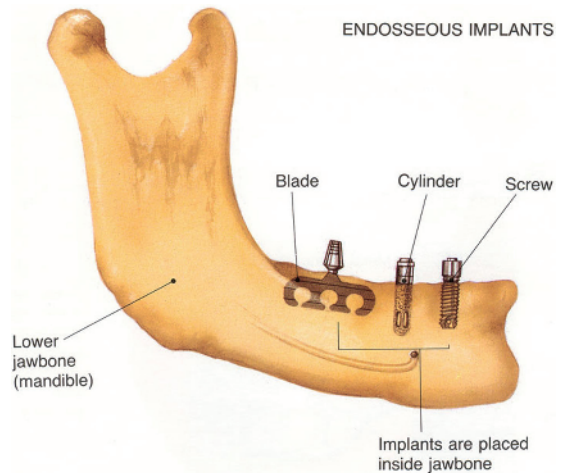


Figure 1.6 Endosteal design. Source: G Juodzbalys, HL Wang, "Guidelines for the identification of the mandibular vital structures: practical clinical applications of anatomy and radiological examination methods," J Oral Maxillofac Res 2010; 1(2):e1.

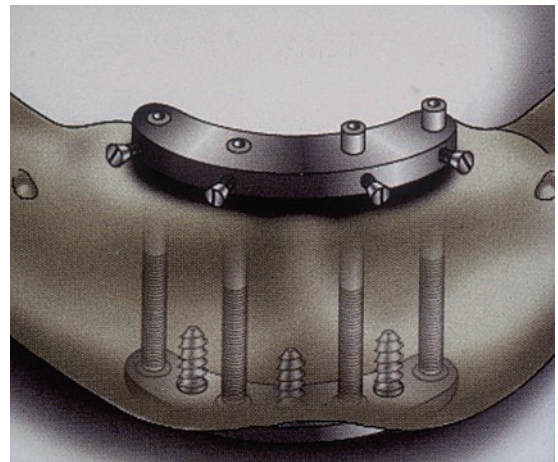


Figure 1.7 Transosteal design. Reprinted with permission from Mosby's Dental Dictionary, 2nd ed., © 2008 Elsevier, Inc. All rights reserved.

2002: An ADA survey showed that oral and maxillofacial surgeons, periodontists, and general dentists doubled the number of implants performed per dentist between 1995 and 2002.



Figure 1.8 Implants. Courtesy of BioHorizons.

Today: The FDA regulates the oral and dental implants being placed, requiring implant companies to furnish data and controlled studies under medical devices to gain full approval.

Implants

Over the past 30 years, research has validated the success of osseointegrated implants as a viable alternative to fixed or removable prosthetic restorations (Figure 1.8) (4). Implant placement in the premolar and molar are 95% successful and are considered the first choice in tooth-replacement options (5, 6). This is supported by the dental literature for many implant systems in every area of the mouth (7). According to Michael Tischler, et al. (8, 9), because of “the amount of edentulism currently documented, it is essential for clinicians to incorporate dental implants into everyday practice.” The American Association of Oral and Maxillofacial Surgeons report that 69% of adults between ages 35 and 44 years have lost at least one permanent tooth and 43% of adults over the age of 65 years old are missing six or

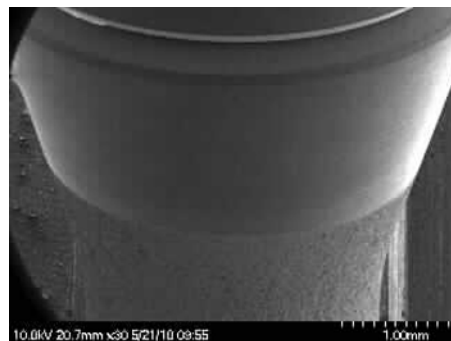


Figure 1.9 SEM titanium alloy implant macro/micro roughened surface. Courtesy of PDT.

more teeth due to tooth decay, periodontal disease, a failed root canal, or trauma (8, 9).

As hygienists, these changes have evolved into a new phase of maintenance care for our patients. Before we can understand the new protocols for our maintenance appointments, an understanding of the basics of implants and why most implants are made from titanium alloy is necessary. The choice of which type of implant to use will be in the hands of the surgeon, but hygienist should have an understanding of the component parts. The main component parts of an implant are the fixture (design, length, shape, diameter, and surface), transmucosal abutment, and the prosthesis (Figure 1.9).

Why is titanium metal used for dental implants? The reasons make quite a remarkable list: it is strong, lightweight, corrosion resistant, nontoxic, nonferromagnetic, biocompatible (not rejected by the human body), long lasting, and osseointegrative (joins to human bone), and its flexibility and elasticity are similar to that of human bone. Titanium alloy which is what dental implants are made from are mainly $TiAl_6V_4$ otherwise known as medical grade 5 and grade 23 for the greatest fracture resistance. Implants have a rough, smooth, and/or coated surface to speed up the osseointegration process. Types of treated surfaces are always evolving with the goal being

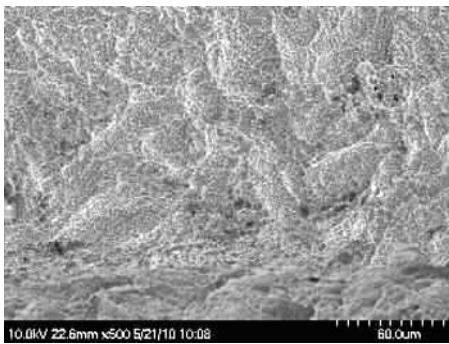


Figure 1.10 Titanium-coated implant. Courtesy of PDT.

to provide a biologically compatible surface to attract the bone to integrate to the implant. Some current examples are hydroxyapatite (HA), the crystalline phase of calcium phosphate found naturally in bone mineral that is sprayed onto the implants, and titanium plasma sprayed (TPS), which simply means a heat/spray technique used in the industry to apply metal (rough titanium) or ceramic (zirconia) coatings to implants (Figure 1.10). These coatings are sprayed on the implant body at the factory, placed in sterile container, and sealed. According to Vallecillio et al. (10), “long term success rates were outstanding for HA-coated implants and acceptable for TPS-coated implants after 5 years” (10).

Another point to call the patient’s attention to about titanium implants is the nonferromagnetic quality of titanium. *The benefit of being nonferromagnetic allows for patients with titanium implants to safely be examined with MRIs and NMRI.* One of the biggest benefits is the osseointegration of titanium and the human body, allowing for the patient’s own natural bone to integrate and attach to an artificial device.

What this means for hygienists is that dental implants are biocompatible with the patient’s body, not likely to be rejected. One disadvantage of titanium implants that is often listed in the literature is that they scratch easily. This will be addressed in Chapter 9; the hygienist

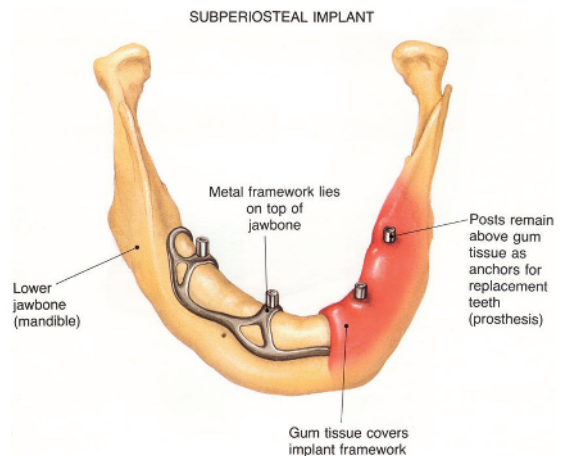


Figure 1.11 Subperiosteal Implant. Reprinted from TD Taylor and WR Laney, *Dental Implants: Are They for Me?* 2nd ed., Quintessence, 1993, with permission from the author.

needs to be aware of this and adjust his or her maintenance protocol to ensure safe, effective implant maintenance.

Implant design

There are multiple kinds of dental implant systems, but three main implant design types are transosteal, subperiosteal, and endosteal (endosseous) implants. They are classified according to their shape and how they interface with the bone.

Subperiosteal implants (Figure 1.11) are custom-casted framework of surgical grade metal or alloy that lies on top of the jawbone. They are surgically placed onto the ridge of an edentulous patient, similar to how a saddle is placed on a horse, and underneath the gum membrane.

This was a treatment option for patients when there was not enough bone to place an endosteal implant. Most of the implant structure, as illustrated in Figure 1.11, is covered with the original ridge tissue, so only the posts and bar are exposed above the gingiva. Sub-

periosteal implants came in different designs: unilateral, bilateral, and circumferential posterior only. A custom-designed superstructure denture or partial attaches to the posts for retention of this prosthesis. These implants were somewhat successful, but infection was common and it caused damage when they needed to be removed. Hygienists must be aware of this form of implants because they may encounter a patient with this form of implant design. Radiographs are going to be necessary to monitor this type of implant and it may be necessary to refer to a specialist if infection or pathology is observed.

A **transosteal** or **staple implant** (Figure 1.12) is an orthopedic device that is inserted through the inferior border of the mandible and designed to function for an edentulous atrophic mandible. A titanium plate with five to seven parallel posts or dowels, two of which protrude through the mandible, function as abutments to attach a custom designed overdenture. The discovery by Brånemark of osseointegration made rigidly designed fixed implant restorations possible to provide firm anchorage. The original design allowed for stress-directing attachments connected to transosteal pins to provide the stability for a

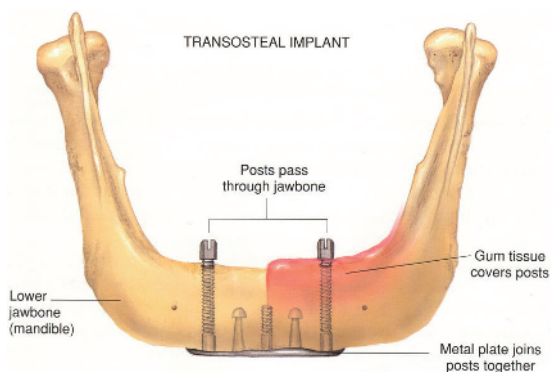


Figure 1.12 Transosteal implant. Reprinted from TD Taylor and WR Laney, *Dental Implants: Are They for Me?* 2nd ed., Quintessence, 1993, with permission from the author.

removable overdenture. The implants for this procedure are costly and difficult to produce, so this procedure is not usually recommended. However, hygienists need to be aware of this design and monitor with radiographs. A referral to a specialist may be necessary if infection or pathology is observed.

Endosteal, or “within the bone,” implants are generally made of titanium alloy, and are designed to replace the root of one or more teeth. They are classified as **blade-** or **root-form**, cylindrical/press-fit or screw-threaded, and come in many different sizes, lengths, and shapes. The **blade-form endosteal implant** (Figure 1.13) is wide, flat metal plate or blade in cross section available in different heights and lengths, some with tapered sides. They may replace one to multiple teeth with a single blade and were used for narrow bones in maxillary or mandible, which had sufficient height to accommodate the implant placed. The blade-shaped implants (see Figure 1.13) were surgically placed into the bone, then posts were attached to the blade, and an individual crown or bridgework affixed on the posts after a healing period.

The **root-form implants** (Figure 1.14) mimic the shape of natural root, threaded, smooth, or rough surface, with or without coating. They are stepped, parallel, or tapered, with or without grooves or vents and designed to join with multiple components to retain prosthesis. They can replace one to multiple teeth, are placed directly into the bone, and can be used in maxillary or mandibular arches. The bone must be of sufficient height, width, and length to accommodate the implant(s) placed. These implants are referred to as cylinder or press-fit implants; screw retained implants also referred to as threaded implants or a combination of the two.

They are available in different widths, varying from 3.2mm to 7mm, and are available in different lengths, varying from 10mm to 18mm. The width and length is decided on by the dentist, depending upon the width and the

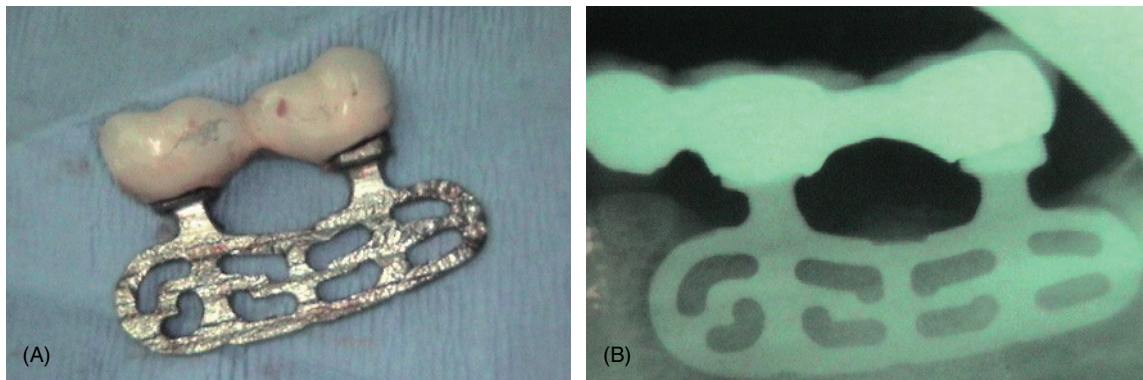


Figure 1.13 Blade form implants. Courtesy of Dr. Frank Wingrove.

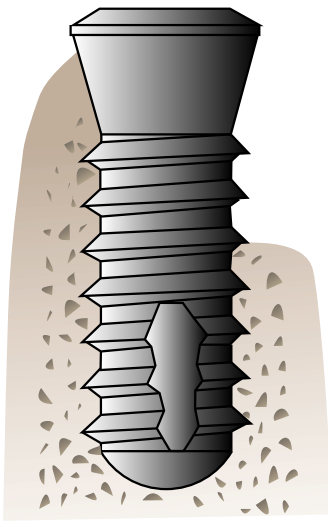


Figure 1.14 Endosteal blade and root form implants. Reprinted from TD Taylor and WR Laney, *Dental Implants: Are They for Me?* 2nd ed., Quintessence, 1993, with permission from the author.

height of the bone, the type of bone, and the number of teeth to be replaced. An implant-supported abutment, often called a post, attaches to the surgically placed implant. Alternatively, one-piece root-form implants are also available that do not require placement of separate abutments. The two-stage root-form implants are placed in the bone, an

abutment is attached to the implant, and the prosthesis is then placed. The final restoration or prosthesis is fabricated into a crown, bridge, or overdenture.

Looking to the future we may see more endosteal implants made from zirconia or a combination of titanium and zirconia. Studies are being conducted due to its biocompatibility, tooth-like color, mechanical properties, and low plaque affinity. It has the potential to become the alternative to titanium as the alloy of choice. More long-term studies are being conducted on different rough surfaces with one-piece zirconia dental implants, which to date have an average of 95% success rate after 5 years (11). More specialized types of endosteal implants to be aware of are mini dental implants and zygoma implants.

Mini dental implants (Figure 1.15) were introduced in the 1980s and accepted by the FDA as long-term implant devices by 1999. They are very narrow (1.8–2.9 mm), some as thin as toothpicks, and can be temporary anchoring devices (TAD) or permanent implants (MDI) used to stabilize a lower overdenture. They are solid, not hollow like traditional implants, and are made in one piece that includes the abutment. In most cases, mini implants are used in the lower jaw to stabilize a lower denture. They can also be



Figure 1.15 Mini dental implants. Courtesy of Glidewell.

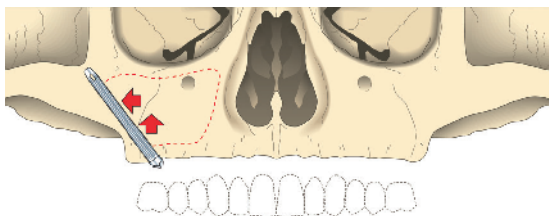


Figure 1.16 Zygoma implants. Courtesy of Nobel Biocare.

used for temporary implants, replacement of smaller diameter teeth such as lower incisors, or in cases where a traditional implant is too large in diameter. They are generally placed as a single-stage surgical process and are often loaded immediately.

Zygoma implants (Figure 1.16), also referred to as zygomatic implants, are longer than regular implants, initially developed Bråne-mark in the 1980s. They are usually recommended to replace missing teeth in the upper jaw, in cases where severe bone resorption is present in the maxilla. They are longer than regular dental implants; they extend up to 55 mm, compared with 10–15 mm. Zygomatic

implants penetrate through the maxillary sinus and anchor in the very dense zygomatic bone. The head of the fixture normally emerges in a slightly palatal position in the second premolar/first molar area of the maxilla. The advantage to this choice of treatment is for patients with insufficient bone quality who may not be good candidates for traditional implant treatment or traditional dentures because of the high level of bone resorption. This can allow these patients durable, fixed, long-lasting teeth without additional bone grafting procedures.

There are many styles and types of dental implants that have been placed and are currently being placed on the market today. Their use is determined by type of bone available and prosthesis needed to accomplish the treatment. Implant systems have been developed by different manufactures with a variety of component parts, but there are primary components that generally are used.

Parts and pieces for implants

Today, the FDA regulates and requires data on all oral and dental implants being placed with controlled studies under medical devices to gain full approval. It is not necessary for hygienists to know all the ins and outs of implant metals and designs, since the choice of implant to use will be in the hands of the surgeon. However, the biomechanics of implants or component parts of an implant are important to know and understand. The three main component parts of an implant are the implant body, with different designs, lengths, shapes, diameters, and surfaces; secondly, the abutment, which comes in many different types and materials, and even custom abutments are available, all screw directly into the implant to connect with the restoration/prosthesis. The final stage is the prosthesis; crown, bridge, fixed prosthesis, or removable overdenture (see Figure 1.17).

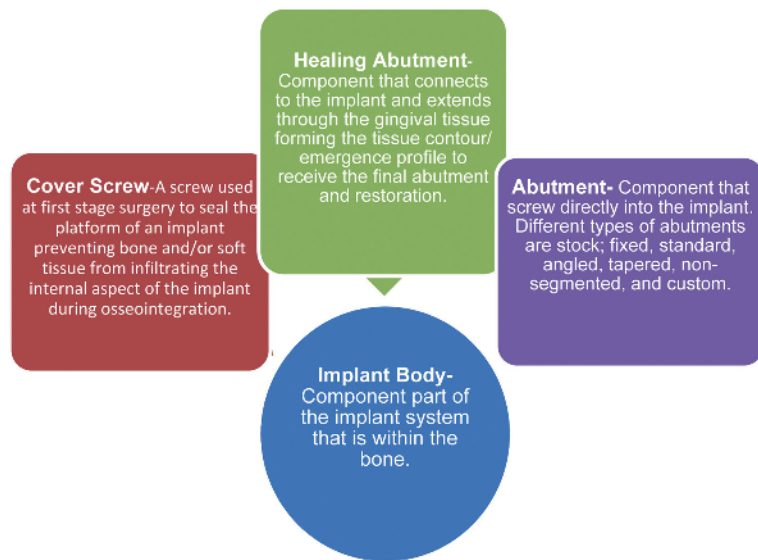


Figure 1.17 Parts and pieces.

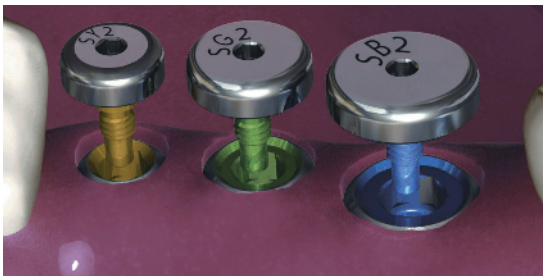


Figure 1.18 Examples of cover screws. Courtesy of BioHorizons.



Figure 1.19 Parts and pieces. Courtesy of BioHorizons.

After the implant is placed into the bone, a cover screw or healing abutment (Figure 1.18) is placed directly into the implant to prevent bone and/or soft tissue from infiltrating the internal aspect of the implant during osseointegration. The healing abutment extends through the gingival tissue, forming the tissue contour/emergence profile to receive the final abutment and restoration (Figure 1.19).

At this time, well over half a million dental implants are being surgically placed annually. Implants are being properly planned and

executed with success rates well over 90%. And yet, as rapidly as this field of dentistry is growing, the majority of potential dental implant patients are unaware that this treatment exists. To address this, dental hygienist can take the lead and talk with his or her patients about tooth replacement and implant dentistry. As hygienists we need to “plant the seeds” with our patients that the technology exists today to better their quality of life. The knowledge of key implantology terms will allow hygienists the opportunity to talk with their patients about implants and these quality of life issues. See the Appendix for more implant dentistry terminology.

Implant dentistry terminology

Connecting bar: System between two or more implants to be utilized for stability for implant prosthesis.

Dental implant: A biocompatible device placed in the bone to replace the root lost, preserve the bone level, and support the prosthesis.

Dental implant abutment: The component part that screws directly into the implant to retain the crown, bridge, and/or overdenture prosthesis in place.

Implant coatings: Applied to the outer surface of the implant to accelerate integration of bone to the implant.

Implant thread: The screw-like component part of the body of the endosteal, root-form implant.

Osseointegration: The firm, direct, and lasting biological attachment of a metallic implant to vital bone with no intervening connective tissue.

Peri-implant diseases: Collective term for inflammatory lesions that may affect the peri-implant area, mucositis, and peri-implantitis.

Peri-implant mucositis: Similar to gingivitis, reversible, caused by bacteria, and manifested by redness and inflammation in the mucous membrane around the implant with no bone loss.

Peri-implantitis: Similar to periodontitis with significant inflammation, exudate, and a sulcular crevice that deepens around the implant to allow bacteria to migrate down, causing bone loss; can be irreversible.

Periosteum: Fibrous vascular membrane that fits tightly on the outer surface of the bone.

Permucosal seal: The tissue seal that separates the connective tissues from the outside environment around a dental implant.

Prosthesis: The removable or nonremovable restoration that attaches to the implant to replace the teeth.

Summary

The 21st century is an important and critical time to be a hygienist! History has shown us that implants are not new and are definitely here to stay. An understanding of the evolution of implants, implant design, and the key terminology will allow you to talk to patients about the background of implantology. The relationship between periodontal health and diseases involving other organs and physiological systems (e.g., cardiovascular disease, preterm birth, diabetes, and respiratory disease) has been clearly documented (12–16). Hygienists need to be trained in the treatment of peri-implant diseases.

According to Dr. Nogueira-Filho, et al., writing in 2010 (1), *“There is no reason to believe that mucosal inflammation affecting endosseous implant (i.e., peri-implant mucosal inflammation) would have fewer effects on general health than similar levels of inflammation affecting teeth (e.g., periodontitis, gingivitis).”* Therefore, it is imperative that hygienists are trained in identifying and treating peri-implant mucosal inflammation that could affect overall body health. The explosion of dental implants over the next decade will change the way we practice dental hygiene.

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