Implant Reconstruction of the Jaws and Craniofacial Skeleton

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Abstract

Full oral rehabilitation with a high degree of success is now possible with osseointegrated implants. Osseointegration is a direct connection between living bone and the titanium implant at the level of the light microscope. Osseointegrated implants are currently used to replace single teeth, support fixed bridges and stabilize full dentures. These implants can also be placed extraorally for attachment of facial prosthesis.

The surgical technique used to place implants intraorally into jaws or facial skeleton is performed in two stages using a local anesthetic and/or conscious sedation. During stage I surgery, holes are placed into the jaw using a series of gradually larger diameter burs until the desired diameter and depth of the bony preparation is achieved. The implant is then placed. The implant must remain undisturbed for 4 months for osseointegration to take place. Stage II surgery is then required to remove the mucosa over the implant and place the transmucosal abutment. After 1–2 weeks of healing, the restorative dentist can take an impression and fabricate the prosthesis.

On occasion, it is necessary to augment the height and width of the atrophic jaw with autogenous or allogeneic bone grafts prior to implant placement. Bone grafts are sometimes placed on the floor of the nose or the floor of the maxillary sinus.

Guided tissue regeneration is a technique used to generate bone within bony defects adjacent to implants.

With long-term rates of success (5 years) of 99% for implants placed in the mandible and 95% for those placed in the maxilla, reconstruction of the jaws and cranial facial skeleton with osseointegrated implants has become the treatment of choice.

Key Words: Dental implant, osseointegration, implant reconstruction.

Introduction

For almost 200 years, implants have been placed in human jaws. Early types of dental implants came into common clinical use during the 1960s. At that time, there was little sound scientific research to characterize their success rates. In 1978, the National Institutes of Health (NIH) sponsored a conference which defined the criteria for implant success. The NIH implant success criteria are the following: (1) mobility of less than 1 mm in any direction; (2) bone loss no greater than one third of vertical height; (3) gingival inflammation amenable to treatment; and (4) implant to provide function for 5 years in 75% of the cases. At that time, none of the available implant systems met these criteria; thus, they were not accepted by the dental profession. In 1982, osseointegrated implants were first presented at an implant consensus development conference of the North American dental profession. “Osseointegration” is defined as a direct connection and attachment, as seen under light microscopy, between living bone and the load-bearing implant. This implant was reported to have a 91% success rate in the mandible for more than 15 years (1). Professor Per-Ingvar Branemark, an orthopedic surgeon, while studying bone healing and regeneration of the rabbit femur, using a titanium chamber, found serendipitously that bone adhered to the metal. Branemark performed extensive animal and clinical trials implanting various shapes and sizes of titanium implants into bone. In some cases, the bone attached and adhered to the titanium so tightly that the bone fractured before it could be removed. He called this process of attachment and adherence “osseointegration” (Fig. 1).

Fig. 1. Osseointegration: the direct connection between bone and titanium.

The first clinical trials of these implants began in 1965 and continued thereafter for 17 years before marketing. Branemark found that what was needed to achieve osseointegration included a biocompatible material, atraumatic surgery with drilling temperatures below 47°C, precise adaptation of the implant to bone, and an undisturbed, immobile healing phase. Titanium was determined to be the most biocompatible material because a surface coating of titanium oxide created a stable ceramic interface onto which bone could be deposited (2). This oxide surface is a dynamic system and has been shown to release a measurable amount of titanium ion into the tissues. The reactivity of this oxide surface is one reason why titanium is so biocompatible. The implant surface and design can also influence osseointegration; a rough surface will increase the amount of contact surface. The design of the implant affects the transfer of functional load. It is imperative that the implant remain stable during the initial healing phase to prevent formation of connective tissue instead of bone. The quality and quantity of bone present also affect implant stability. Areas of the jaws with large amounts of cortical bone versus cancellous bone are advantageous for successful initial stabilization of the implant. A healing phase of 4–6 months in the jaws is necessary to achieve successful osseointegration.

Diagnosis and Treatment Plan

Proper treatment planning, along with implementation of appropriate surgical and prosthetic care, are the keys to implant success (3). A comprehensive medical evaluation is necessary to obtain information on systemic problems that may affect bone physiology and healing. Medical contraindications to implant placement include pregnancy, liver disease, endocrine disorders, and collagen/bone disease. Tobacco usage, poor oral hygiene and poor patient compliance are relative contraindications, especially if bone grafting is involved. A comprehensive intraoral physical exam is performed to assess the size of the ridge and the amount of attached gingiva. Impressions are taken of the maxilla and mandible, so surgical stents and radiographic stents can be fabricated. A 3-dimensional computed tomogram (CT) may be required to determine the available bone and obtain accurate measurements of bone height and width. Computer software is available to accurately plan the surgical treatment.

After the patient's attitude and expectations are evaluated, a treatment plan is developed noting the type of prosthesis, the number of implants, and the need for augmentation techniques. The surgical stent fabricated dictates the placement and angulation of the implants. This is critical to the final prosthetic result.

Types of Implants

There are 3 major subgroups of dental implants: subperiosteal, transosteal, and endosseous implants (Figs. 2a–c).

a b c

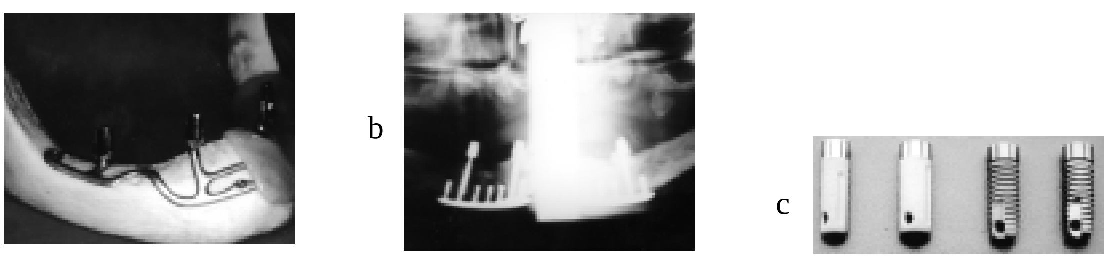

Fig. 2. a. Subperiosteal implant, b. transosteal implant, c. endosseous implant.

A subperiosteal implant is a framework fabricated to fit intimately on top of the mandible or maxilla under the mucoperiosteum. The technique involves surgical exposure of the bone of the jaws, taking an impression of the bone, and making a model. The implant is then fabricated by the laboratory from this model. A second surgery is then required for placement of this subperiosteal implant. A model may first be fabricated from computer-aided design/computer-aided manufacturing(CAD/CAM) CT technology thereby eliminating the initial surgery to make the model. This implant has a 93% success rate over 5 years, but only a 50–60% success rate over 10 years.

The transosteal implant is an implant with a bone plate fitted against the inferior border of the symphysis. The bone plate is attached to the mandible by a series of penetrating posts. Two of these posts enter the oral cavity to support a lower denture. The technique requires an extraoral incision placed in the submental fold. An advantage is the ability to reattach the musculature and improve the cervicomental aesthetics. These implants have a 94% success rate over 5 years and an 87% success rate over 10 years (4).

Endosseous implants are most frequently utilized. They are placed in the bone of the maxilla or mandible via intraoral incisions. There are several different designs available commercially, including screw, cylindrical, and blade types. They may be categorized as one- or two-stage implants. The one-stage implant is surgically placed in bone and projects through the mucosa into the oral cavity. The two-stage endosseous implants are placed in bone, and the mucosa is sutured over the implants to facilitate the healing phase. However, the healing phase is primarily dependent on the quality and quantity of bone. Usually, after 4–6 months, the implant is uncovered. An abutment which projects through the mucosa into the oral cavity is attached. The dentist can then complete the prosthetic restoration.

Surgical Technique to Achieve Osseointegration

The techniques for placing implants intraorally into the jaws or extraorally into the skull or facial bones are technically identical. This procedure is usually performed under intravenous sedation, but may be performed with local anesthetic nerve blocks. A surgical stent is placed in the mouth, identifying the position and angulation of implant placement. Using low speed (less than 1000 rpm) internally irrigated drill bits, holes are placed into the jaw. The depth and width of each hole are determined radiographically and are limited anatomically in relation to the position of the maxillary sinus and inferior alveolar nerve. These sites are then widened using a series of gradually larger burs. After the desired diameter and depth of the bony preparation is achieved, the implant is placed. Non-threaded cylinder implants are gently tapped into position, whereas threaded implants may require tapping the bony preparation prior to placing the implant (Fig. 3). After all the implants are placed, the mucoperiosteal flap is closed without tension, using a monofilament suture in an interrupted fashion. Postoperatively, a radiograph is taken to assess the position of the implants. The patient is then placed on analgesics and on a 0.12% chlorhexidine gluconate rinse for 2 weeks. At that time, the patient is allowed to begin a soft diet and given an interim prosthesis. After completion of stage I surgery, the patient is followed on a monthly basis for the entire healing period. Once the healing period is completed, stage II surgery is required to uncover the implant and place the transmucosal abutment. It takes approximately one to two weeks for the mucosa to heal around the abutment before the dentist can take an impression and fabricate a prosthesis. There are multiple restorative options, including single crowns, fixed bridges, and implant retained removable dentures.

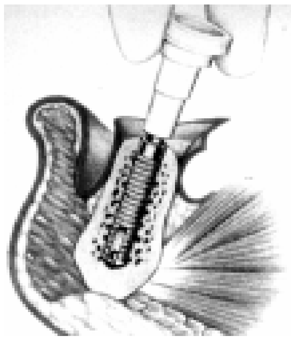

Fig. 3. Implant placement.

Advanced Surgical Techniques

In the severely atrophic mandible, it may be necessary to augment the height and width with autogenous grafts prior to implant placement (5). Occasionally, implants can be placed concomitantly with the graft and used to assist in the stabilization of the graft. The donor sites used for autogenous grafts include the iliac crest, tibia, mandibular symphysis and mandibular lateral ramus. The site selected is determined by the amount of graft needed for the augmentation. Allogeneic bone grafts can be used alone or in conjunction with autogenous bone. An augmentation technique can be utilized to fashion a one-piece autogenous graft, harvested from the inner table of iliac crest, to conform to the mandible. The graft is then rigidly fixed to the mandible with 4–6 screw-type endosseous implants (Fig. 4). This technique obviates the need for placement of the implants after consolidation of the graft, thereby reducing treatment time by 3–6 months. If inadequate bone height is present in the posterior mandible, a procedure may be used to reposition the mandibular nerve so that implants can be placed medial to the lateralized nerve. This procedure carries the risk of permanent paresthesia, so it is not widely used. Immediate implant placements with an onlay graft in the mandible have a 97% success rate.

Fig. 4. Mandibular graft with endosseous implants.

In the severely atrophic maxilla, the problems of implant reconstruction and types of grafts are different. The maxilla has a limited amount of bone mass due to the maxillary sinus and nasal cavity. The bone quality is less dense due to the large amount of cancellous bone and thin cortical plates. Thus, the onlay graft rigidly fixed to the maxilla with endosseous implants has an 87%

success rate. Bone grafts can also be placed on the floor of the nose or the floor of the maxillary sinus. A common procedure used to increase the amount of bone in the posterior maxilla is the sinus lift procedure (6) (Fig. 5). A window is cut into the lateral wall of the sinus without tearing the schneiderian membrane of the maxillary antrum. The lateral window is elevated superiorly along with the membrane off the bony walls using various sized curettes. The lateral wall now becomes the new floor of the sinus. A particulate bone graft material, allogeneic, autogenous, or a combination thereof, can then be placed. This procedure has a success rate of about 90% (7), especially when autogenous bone is used. Implants may be placed at the same time as the graft procedure, provided there is more than 5 mm of residual alveolar ridge to stabilize the implants. The floor of the nose graft is constructed via a vestibular incision with elevation of the anterior nasal floor. A corticocancellous graft is placed and can be stabilized using the endosseous implants or small 1.5 mm titanium screws.

Fig. 5. Sinus lift procedure with implant placement.

"Guided tissue regeneration" is a procedure used to regenerate bone within bony defects and adjacent to implants. When a barrier is placed between a bony defect and the overlying epithelium, bone growth will preferentially take place and fill the defect. This barrier or membrane selectively prevents the ingrowth of connective tissue and epithelium. Various materials can be used as barriers, but expanded polytetrafluoroethylene has been the most extensively tested and utilized. The procedure is particularly useful in grafting bony defects around implants and increasing the width of the bony ridge in preparation for implants.

Clinical Applications

Osseointegrated implants are used to replace single teeth, to support fixed bridges, and to stabilize removable full dentures. These implants, which offer full oral rehabilitation with a high degree of success, may also be placed extraorally for the attachment of facial prosthetic devices (8, 9). Historically, these structures have been restored using a silicone prosthesis attached to the face with tissue adhesives, but these adhesives are not stable when heat or moisture is present. Using osseointegrated implants to anchor the prosthesis more securely allows these patients better function.

Implants also can be used to anchor bone conduction hearing aids (10). The implant is placed directly into the mastoid process. The conduction of sound to the auditory nerves directly through bone improves the level of hearing by 15 decibels. When combined with an auricular prosthetic device, function can be further enhanced along with improved cosmetic appearance. Osseointegrated implants have been used to rigidly fixate proximal and distal stems of the joint (11) and to reconstruct metacarpophalangeal and proximal interphalangeal joints in the hand.

Success and Failure

The criteria of success for endosseous implants are as follows: the implant should not demonstrate any clinical mobility, associated symptoms of pain or discomfort, damage to adjacent structures and crestal bone loss. If an implant becomes mobile, it should be removed. Long-term success rates with intraoral and extraoral implants have been established. A 5-year success rate of 99% has been achieved for implants placed in the mandible; for those placed in the maxilla, the rate is 95%. The 5-year success rate of 93% has been achieved with extraoral implants in patients with no previous radiation therapy (12).

The common causes of implant failure are biomechanical overload and infection. Bacterial toxins and compressive forces will cause tissue changes leading to epithelial downgrowth, bone resorption, mobility and implant failure. Biologic, iatrogenic, or mechanical factors can also lead to complications and failure. Poor bone quantity and/or quality, smoking, and previous radiation are the biologic factor; inappropriate planning, patient selection, and surgical and prosthetic treatment are the iatrogenic factors; and patient parafunctional habits and forceful manipulation are the mechanical factors that may contribute to failure and complications. Fortunately, most of these complications are treatable with early detection through careful follow-up during the healing period.

Conclusion

Osseointegrated implants have made possible the reconstruction of the jaws and cranial skeleton, and is the treatment of choice. Long-term success rates exceed 93%, and even this degree of success may be subject to improvement, if and when new materials become available.

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