

Progressive Loading

Abstract

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INTRODUCTION

The density of available bone in an edentulous site has a primary influence on treatment planning, implant design, surgical approach, healing time, and initial progressive bone loading during prosthetic reconstruction. Endosteal implants achieve predictable success with osteointegration. A direct bone-implant interface has been demonstrated with a variety of endosteal implant designs and materials. Three requirements are necessary for initial osteointegration: atraumatic bone preparation, rigid fixation of the implant, and absence of movement at the interface during healing. Bone density is a most important parameter of the implant site for initial fixation, and is a variable which can be controlled by the use of proper grouting stimulants and scientific load application by the surgeon from the very onset of the fixture placement to the seating of the final restoration. Branemark et al. recognized "a great variety of combinations between jaw shapes and bone qualities exist, but concluded "in general, all jaws irrespective of shape and bone quality can be treated if approached intelligently based on a solid application of physiologic principals.

I propose an Implant design and a prosthetic and surgical protocol which addresses both the surgical and physiologic variables associated with today's common failures. These failures result from being forced to deal with the many different qualities of bone and an industry that has not yet addressed the issue of back engineering implant or the prosthetic protocols to accommodate the physiologic needs of the many different patient presentations

In the literature many have defined four main bone density groups, which vary in both macroscopic cortical and trabecular bone types. The regions of the jaws with different densities are often consistent. The bone density may be estimated by tomogram radiographic evaluation, or evaluated by conventional dental radiographs such as periapical, panoramic, or lateral cephalometric films. However, the easiest and most accurate method is to evaluate the bone clinically at the time of surgery. The presence and thickness of a crestal-cortical plate and the density of trabecular bone are easily distinguished during the implant osteotomy. The density of the bone is determined by the initial bone drill, and continues until final implant placement.

HISTORY

The term "available bone" is particularly important in implant dentistry, and describes the edentulous area considered for implants in width, height, length, and angulation. Sufficient quality and quantity has and is the primary determining condition for the use of endosteal implants. Bone is also described in quality, which reflects the density of the bone. Most recently Dr. Gary R. O'Brien D.D.S. has demonstrated, in his Mayo Clinic Dog studies, that regardless of the site, or initial quality and quantity of bone, he has been able to predictably reproduce bone of known modulus of elasticity around every one of his patented implants. Each of the O'Brien implants is designed to hydraulically force the ideal grafting material into the adjacent marrow chambers and provide calculated voids in areas of high stress concentration, with the intention of accommodating and maximizing our knowledge of bone physiology and stress distribution dynamics. When a tooth is lost, the alveolar bone starts to lose dimension and density. The spacing of trabeculae in relation to variable forces of mastication was discussed by MacMillan in 1926. Levels of bone density are directly related to stress. The greater the physiological stress the denser the bone. When the tooth is lost and hence does not transmit any stress, the local alveolar process begins to remodel and more bone is resorbed than formed, since the requirements of the bone to respond to stress are reduced. The longer alveolar bone is edentulous, the less trabeculae are present. In general, bone loss occurs with immobilization or decreased stress in the body. This bone decrease begins within a few months, continues long term and affects the cortical and trabecular bone. Simultaneously, the bone width usually decreases, followed by a decrease in height. Bone is a fascinating connective tissue. When you don't stress bone it dies or atrophies. When you stress it properly it is stimulated and not only grows but flourishes and remodels to ideally accommodate the associated stress. When the bone is over stressed it can not accommodate the load (which is relative to each different modulus of substrate) and it dies. The O'Brien technology capitalizes on this physiologic constant both with surgical design and prosthetic protocol.

Adell et al, listed four bone qualities found in the jawbone, Quality 1 is comprised of homogeneous compact bone has a thick layer of compact bone surrounding a core of dense trabecular bone. This particular type of bone is deceptively favorable. Although this bone has the highest % mineralized tissue this also leads to a very poor vascular supply which in turn increases repair time and predisposes the tissue to higher Iatrogenic bone loss and failure. Quality 2 bone has a thick layer of compact bone surrounding a thick layer of trabecular bone. This particular type of bone is usually most favorable for implant therapy. The typical response is one to two mm of bone loss correlating with the very dense bone the first one to three mm at the onset of the ostiotomy. Quality 3 has a thin layer of cortical bone surrounding dense trabecular bone of favorable strength. Quality 4 has a thin layer of cortical bone surrounding a core of low density trabecular bone. Irrespective of the different bone qualities, all bone was treated according to the same standard protocol. With the O'Brien Implant and prosthetic loading kit, standardization of quality and quantity of bone combined with uniform and calculated introduction of stress, the problems associated today's Implant dentistry will be standardized and eliminated.

The dense compacta bone type also presents several disadvantages, which should be considered. The implant height is often limited to less than 12 *mm.* in the atrophic mandible, and the crown-implant ratio is greater than one. As a result, force factors applied to the implant-prosthetic system should be evaluated to determine if stress reducing factors should be designed in the prosthesis. Dense compacta bone is more difficult to prepare for endosteal implants than any other bone density. The bone is easily overheated during implant ostiotomy procedures, since rotary drills are less performant and progress with more difficulty. External and internal irrigation with cool sterile saline is suggested in order to reduce heat, help rinse bone particles away from the cutting surface and act as a lubricant. Internal coolant is only effective in this bone type when the drill portal exit remains open, and intermittent pressure is applied. Intermittent force is applied to the hand piece during bone preparation to reduce the amount of heat generation, which also depends upon the speed of drill rotation, drill sharpness, design, amount of force, and time. The O'Brien system of drills introduce a new concept in ostiotomy preparation which is user friendly and less traumatic to the adjacent bone regardless of the density type. This bone density may require greater burr revolutions up to 2000 rpm, to obtain adequate depth penetration. If too light a force is applied against the bone, the drill rotates without depth progression, and only generates heat.

Since this bone has fewer blood vessels than the other three types, it is more dependent on the periosteum for nutrition. The cortical bone receives the outer third of its arterial supply, and 100 percent of its venous supply from the periosteum. D1 bone quality is almost all cortical. Therefore, delicate and limited periosteal reflection is indicated. The O'Brien system of drills are so efficient that it eliminates the need for sequential cutting. After the initial pilot hole is outlined the one step final sizing drill easily completes the ostiotomies. Intermittent pressure and light pressure at 500 RPM with constant debriment of chips is always recommended. Many of the cutting cones which develop from monocytes responsible for bone remodeling at the implant interface come from the blood vessels found in trabecular bone. Therefore, dense compact bone requires more healing time. In addition, this bone density may establish lamellar bone after the initial trauma. Lamellar bone forms at the rate of 0.6 micrometers per day. Most other types of bone first from woven bone at the rate of 30 to 50 micrometers per day. Roberts reports that 17 weeks are necessary for bone to remodel and become 70 percent mineralized after an endosteal implant is inserted in a combined cortical and trabecular bone density. Therefore, for complete regeneration of vital bone and Osseointegration to be maintained in this dense oak-like structure, five months healing may be required before final prosthodontic loading. Once the implant interface has been established in this bone density, lamellar bone is present. The O'Brien Implant design provides for voids or areas of neo-vascularization where new clots may form in a predictable environment, both in the cones at the coronal segment area of the implant but also along the entire body where the antirotational cut out and hydraulic grout dispersing area. By allowing for new bone to form in these areas of predictable quality, a prosthetic loading protocol may be standardized. The concept of converting each location to a consistent bed of ideal bone and then properly loading that bone over a period of six months based on the location, length, and surface area, will be made possible by using the O'Brien system.

PROGRESSIVE BONE LOADING

Progressive or gradual bone loading is important at the beginning of prosthodontic procedures, especially in the less dense bone types. The histology of the implant-bone interface at the time of abutment attachment shows a preponderance of woven bone. The microscopic, woven bone is the fastest and first type of bone to form after trauma, but it is not as organized or as strong as lamellar bone. Implants initially osteointegrated, yet become mobile within the first year and may fail because the load transmitted to the implant interface is too great for the immature woven bone. Lamellar bone is a load bearing bone and the ideal choice for an implant interface. However, this bone does not initially form in trabecular bone around an unloaded implant. The presence of this bone type is improved with a gradual loading of the implant interface. Progressive loading of the implant permits the bone to remodel and organize in accordance to Wolff's law, which states that trabecular bone places and displaces itself in relationship to the forces around it. DeAngelis showed deformation of the alveolar bone by mechanical forces was even related to Dalin reported the thickness of the bony plate, similar findings of the cortical plate, along with an increase in mineral content on the skeletal system in general, with the addition of stressful stimuli. An increase in bone density has been repeatedly observed by the author upon re-entry of implants placed in D3 or D4 bone. Each step of the progressive loading process is allowed sufficient time for the bone to respond to the increased stimulation. Ideally, woven bone transforms into load bearing lamellar bone, along with an increase in the percentage of bone at the implant interface. The first perimucosal abutment post of the implant is added to the body of the implant after the corresponding time frame the type of bone density observed during surgery. These time frames permit formation of a stable woven bone interface and increased surrounding trabecular bone pattern. These conditions vary with age, healing factors, systemic conditions, and surgical trauma. The suggested healing times error on the long side. The first pergingival post permits soft tissue healing around the implant site, but is not connected or loaded by any prosthesis. The healing cap should seal and be of the same diameter as the outerpart of the implant, to prevent soft tissue ingrowth underneath the low profile cap. Approximately two weeks elapse before the next appointment.

The second step is to replace the healing cap with the abutment of final size, design and height. A preliminary impression may be made to elaborate the design of the prosthesis and fabricate custom impression trays. Minimum trauma from external forces on the final abutment post should occur until the next appointment. For example, in the completely edentulous arch, the mandibular denture is relieved to eliminate any contact with the low profile fixed/detachable abutment post, even in function. A soft tissue conditioner is then placed into the prosthesis. The patient is asked to leave the prosthesis out of the mouth as much as possible. For a posterior partially edentulous patient, the abutment post height of the implant is left out of occlusion, free standing, and no removable prosthesis is worn. If the removable partial denture also replaces anterior teeth, a hole is made completely through the prosthesis over the position of the abutment post. All patients are instructed to follow a masticatory soft diet until the final prosthesis is completed. The time before the next prosthetic appointment depends on the density of bone at the surgical appointment. At this time, D1 bone often has developed lamellar bone at the implant interface and one week between appointments is all that is necessary. D2 bone has a good percentage of lamellar bone and two weeks is all that is

required until the next appointment. D3 bone requires three weeks between each appointment, and four weeks are requested in D4 bone between each of the following prosthodontic phases .

The prosthetic reconstruction of the patient is the third step. Final impressions may be made of the implants and abutment teeth. A temporary prosthesis is fabricated and attached to the implants designed for fixed prosthetic support. This acrylic transitional prosthesis should have reduced occlusal tables and be slightly out of contact when the patient swallows. The patient is instructed to follow a soft diet. The interval of time before the next appointment follow the previous schedule. The temporary may be placed into occlusion by adding acrylic to the appropriate contact areas. The occlusal tables are still reduced at this time. An additional 1 to 4 weeks elapse before the following appointment, depending on the bone density observed at the surgery. On the fifth appointment, the patient receives the final implant supported prosthesis. **If** the restoration is fixated with cement, a "soft access" or temporary cement is used. The patient remains on a masticatory soft diet until the following appointment.

On the final prosthetic appointment, the restoration is carefully evaluated regarding occlusion, hygiene design, and patient acceptance. The prosthesis is removed and implants and abutments evaluated. Cemented prostheses often use temporary cement as the final luting agent when natural teeth have copings or are not connected to the implants. The patient is now ready for a normal diet and maintenance program, However, since complete compact bone maturation may require 52 weeks from the time of initial implant placement, the patient is instructed not to eat any hard food for one year after implant insertion. A gradual loadinaprocess of the implant interface insures greater implant long term survival. Bone is allowed time to remodel, organize, and develop in relation to the external forces. This results in an interface at the surface of the Implant which is more lamellar than at the initial abutment post placement and increases the percentage of implant-bone contact. The time interval between each gradual bone loading step varies from one to four weeks. The final prosthesis and normal mastication begins 6 to 18 weeks after the implant Is uncovered and the initial healing cap is placed. Bone densities D1 and D2 are more apt to follow the 6 to 10 week loading protocol. The fine trabecular bone, (D4), should be loaded more cautiously, hence the 18 week process during prosthodontic reconstruction is suggested.

The Maximum amount of force on the implant should continue to be restricted. since the surrounding bone will not be completely mineralized in D2 or D3 bone for approximately 52 weeks from implant placement. This time period is not as important for the long term completely edentulous patient, since the muscles of mastication are often atrophied. As a result, the maximum occlusal force is less when the final prosthesis is first delivered. The increased force developed with an implant prosthesis is about 85 percent the first year, and 300 percent after two to three years. The Partially edentulous patient should be aware that the implant interface continues to improve in the first year of function, and it is of benefit if maximum occlusal force is not used during this time.

SUMMARY

Bone remodels in relationship to the forces upon it. Depending on the location of the edentulous ridge, and the amount of time the area has been edentulous, the density of bone is variable. Clinically, the surgeon can correlate the hardness of the bone and the presence of a cortical plate to four different qualities of bone. The typical locations of these different densities, the alteration in surgical technique, the advantages, disadvantages, and progressive bone loading have been related to each density classification. Different bone densities have unique treatment plans, healing requirements, and initial implant bone interfaces.

Using the O'Brien Implant with grouted ostiotomy provides the standardization of the density of bone around every Implant eliminating the confusing variables associated with the forgoing information. Then the application of a prosthetic loading kit, where the doctor predictably replaces the meso-structure of varying modulus of elasticity, allows the stress introduced to the surrounding bone in a scientific and mathematically perfect fashion. This will then produce the most favorable bone and clinical situation for long term Implant success and eliminate bone loss.