Immediate Loading of the Grafted Maxillary Sinus Using Platelet Rich Plasma and Autogenous Bone: A Preliminary Study With Histologic and Histomorphometric Analysis

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Objective: *The goal of this clinical study was to evaluate dental implant survival rates using the concept of a nonfunctional, immediate loading protocol with nonsplinted dental implants in the grafted maxillary sinus during a 52-week period. Random histomorphological and histomorphometric analysis was completed to evaluate the early healing effect of platelet rich plasma (PRP) and 50% autogenous bone combined with 3 different substitute graft materials.*

Materials: *Four to 8 months after grafting the sinus with PRP sprayed autogenous bone combined with 3 different substitute graft materials in a 50:50 composite ratio, 27 hydroxyapatite-coated dental implants were surgically placed in 41 patients and immediately loaded between 48 hours and 5 days later with custom titanium abutments and acrylic provisional restorations placed out of functional occlusion. Six months later, definitive ceramometal restorations were cemented on to the custom abutments.*

Results: *During a 52-week observation period, no implants were lost. Between 4 and 8 months of graft healing time, histologic and histomorphometric analysis revealed formation of new vital bone in different graft specimens ranging from 77% to 100%.*

Conclusion: *The preliminary results of this clinical study indicate that immediate nonfunctional loading using PRP and 50% autogenous bone combined with different substitute graft materials is a predictable protocol in the grafted maxillary sinus as early as 4 months of postgrafting. The high implant survival rate is due to the early formation of large percentages of new vital bone as confirmed by using histologic and histomorphometric analysis. (Implant Dent 2008;17:59–73)*

Key Words: immediate nonfunctional loading, grafted maxillary sinus, platelet rich plasma, vital bone formation, implant survival rates

In the maxilla, dental implant treatment has required a healing phase of 6 months to allow for the formation of vital, mineralized tissue at the interface of dental implants before functional restoration.[1,2] If this strict protocol were not adhered to, it was theorized that early or immediate loading would promote fibrous tissue formation around the implants rather than bone that would result in failure of the implant to osseointegrate.[3] Because of improved surgical instrumentation, bioengineering techniques, and implant surface topography, this concept has now been challenged. Human clinical[4–7] and animal[8–11] experimental studies have demonstrated that implants immediately loaded develop bone at the implant interface and are able to tolerate occlusal forces up to 150 μm. Implants placed in the totally edentulous anterior mandible that are cross-arch stabilized with a rigid bar or fixed restoration, and are immediately loaded, have demonstrated successful osseointegration comparable with success rates of conventionally loaded implants using the Branemark protocol.[5,6,12–14]

There is a paucity of articles in the implant literature describing graft maturation and attempts to decrease graft healing time to permit early implant placement. There are even fewer reports in the literature describing immediate or delayed loading with and without functional occlusion in the nongrafted posterior maxilla. In a study by Luongo *et al*,[15] they reported a 1-year 98.8% implant survival rate in the nongrafted posterior maxilla.

In this study, multiple implants were always splinted together. Tarnow *et al*[6] reported their experience with immediate loading of the edentulous maxilla in 4 patients, 10 implants were placed in each patient. Thirty-three implants were immediately loaded with a provisional restoration. Six months after implant placement, the definitive restorations were fabricated and delivered to the patients. Follow-up ranged from 1 to 4 years with no implants lost for a 100% survival rate. Horiuchi *et al*[16] reported

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their experience with immediate loading of the edentulous maxilla in 5 patients. Each patient received a minimum of 8 implants that were immediately loaded. After a healing period of 4 to 6 months, the definitive prostheses were delivered to the patients. Two of 44 implants failed for an implant survival rate of 96.5%. Misch and Degidi[17] presented a 2-center study consisting of 31 edentulous patients. In 2 patients, 18 implants were surgically placed and immediately loaded on the day of surgery with provisional acrylic resin restorations. Four to 7 months later, the definitive restorations were fabricated and delivered to the patients. Follow-up ranged from 1 to 5 years and no implants failed for a 100% survival rate. This study also evaluated an early loading protocol of the maxilla. Twelve patients were enrolled in this study. After implant placement, provisional acrylic resin restorations were placed within 2 weeks. Four to 7 months later, the definitive restorations were fabricated.

Follow-up ranged from 1 to 5 years, with no implants lost for a 100% survival and success rate.

In the grafted maxillary sinus, there is only one article[18] in the English dental implant literature describing immediate loading of implants placed in the grafted maxillary sinus. Thirty-three sinuses were grafted with platelet rich plasma (PRP) sprayed autogenous bone and a xenograft substitute material. A total of 77 implants were immediately placed and provisional acrylic restorations delivered to the patients, but placed out of functional occlusion. In 2 cases presented by the authors, teeth were extracted and implants were immediately placed simultaneously with sinus grafting. Of 77 implants, only 1 implant failed to osseointegrate. The authors reported an overall 2-year implant survival rate of 98.7%. However, the authors did not include information regarding initial vertical bone height using any recognized bone classification system, such as that described by Cawood and Howell.[19] The study also did not include histologic data or histomorphometry.

The purpose of the present study was to evaluate implant survival rates using a nonfunctional immediate loading protocol in the grafted maxillary sinus. We hypothesized that the early enhanced healing effects of PRP with 50% autogenous bone would accelerate the amount of new, vital bone formation in the grafted maxillary sinus.

The decreased healing time would allow us to surgically place and immediately load the implants. Histomorphologic and histomorphometric analysis was used to randomly evaluate the formation of a new bone during different healing time intervals from 4 to 9 months.

Terminology

Until recently, there was no clear consensus as to the precise definition of immediate loading and early loading. As a result, considerable confusion existed as to when these terms should be applied. In 2004, The Immediate Function Consensus Conference[20] was conducted to resolve this issue, and terminology regarding immediate loading and its guidelines were developed. Using the terminology adopted from this conference, all 41 cases included in this study were defined as a nonfunctional immediate restoration. In each case, the implant prosthesis in a patient who is partially edentulous was delivered within 2 weeks of implant insertion with no direct occlusal loading. The 41 cases also satisfied the criteria to be included in early occlusal loading, which is defined as occlusal loading to an implant prosthesis between 2 weeks and 3 months after implant placement.

The concept of immediate loading continues to gain acceptance in the dental implant community. This is mainly due to the overall decreased treatment time, improved function, and aesthetics and patient satisfaction.[21,22] However, since the 2004 Consensus Conference,[20] confusion still does exist regarding the practice and precise definition of immediate loading. This same topic was revisited in 2006 by the International Congress of Oral Implantologists meeting in Naples, Italy to provide parameters and guidelines for clinicians who decide to introduce this clinical concept into their implant practice when managing the single tooth restoration or partially edentulous areas. One of the most important conclusions of the 2006 International Congress of Oral Implantologists Consensus Conference[21] was that clinical judgment in patient selection was the single most important parameter in achieving a favorable outcome when implementing the immediate loading protocol.

Review of the Literature

No quantitative correlation exists between formation of vital bone and implant success. In any grafting procedure related to successful implant osseointegration, the objective is the formation of 100% vital bone.[23] The majority of grafting procedures involves the use of autogenous bone harvested from the patient, or the use of xenografts and, recently, allogeneic grafts. In dental implant treatment, many different grafting materials have been used to augment the posterior maxilla to facilitate dental implant placement. The ideal graft material has yet to be discovered and the current debate is which is the best bone graft material to use with the sinus lift elevation procedure that offers the best chance for implant survival.[24–28] The ideal characteristics of a bone graft substitute include the following: it should be cost effective; biocompatible with the host bone;[29] minimize surgical time and exposure; osteogenic; osteoinductive; and osteoconductive, where the graft material can serve as a scaffold for bone apposition.[30–33]

The normal posterior maxilla usually consists of 20% to 25% type III or IV bone.[34] Glauser *et al*[35] reported a higher implant failure rate in the posterior maxilla, especially in type III and IV bone. They reported a 34% failure rate for implants placed in the posterior maxilla, compared with a 9% failure in other parts of the maxilla and mandible.

Jensen *et al*[25] reported an overall 3-year implant success rate of 90% when implants were placed in the grafted maxillary sinus for all graft materials combined. Using meta-analysis, Tong *et al*[36] compared success rates of implants placed in sinuses grafted with different materials, including autogenous bone. They concluded that autogenous bone should still be considered the "gold standard" for bone grafting.

In the sinus grafted with 100% autogenous bone, histomorphometric anal-

ysis revealed an average of 26% to 69% vital, mineralized bone formation.[37–39]

When graft substitute materials were used, the range of vital, mineralized bone formed was between 5% and 45%.[24,37,40,41] In the nongrafted posterior maxilla, the average percentage of mineralized bone has been reported between 17.1% and 26.7%.[40]

In bone grafting procedures, autogenous bone is still considered the gold standard, because it is osteogenic, osteoconductive, osteoinductive, and contains large quantities of fibrin and platelets.[42–47] Autogenous bone was the first graft material used with this procedure to reconstruct the posterior maxilla. Many of the earlier studies involved the harvesting of bone from the iliac crest of the hip. Reports of implant survival rates ranged from 100% to 54.5%.[33,48,49] Other clinicians reported using autogenous bone harvested from the mandible to graft the sinus. Jensen and Sindet-Pedersen[43] used block grafts harvested from the mandible and placed into the floor of the maxillary sinus. They reported a 95% implant survival rate after 58 months in function.

However, autogenous bone as the sole graft material has several disadvantages. One disadvantage reported is early and severe graft resorption.[25] Del Fabbro *et al*[27] reported an 87.7% survival rate of implants placed in the grafted sinus using 100% autogenous bone. In their systematic review, they reported that of 3398 implants placed, 418 implants failed because of graft resorption. Nystrom *et al*[50] reported an implant survival rate of 77% after bone grafting using 100% autogenous bone harvested from the iliac crest. The low survival rate was attributed to resorption of graft volume.

A study by Uchida *et al*[51] using computerized diagnostic software calculated that 5.47 mL of graft material would be required to graft the sinus to surgically place 3 or more implants. To graft both sinuses, more than 11 mL of autogenous bone would be required and the mandible is unable to provide this amount of bone. For this reason, bone graft substitutes have been developed to be used in combination with autogenous bone.

Bone graft substitute materials are nonvital foreign bodies that provide a scaffold for the formation of new bone.[52] They do not provide the cellular elements needed for osteogenesis as they only possess osteoconductive properties.[38,53] Therefore, the need to add autogenous bone as an osteogenic and osteoinductive factor is necessary in composite grafts. Xenografts are osteoconductive materials and have been used extensively in sinus grafting.[24,26,41] This substitute graft material has been used alone as the sole graft material, or as a composite mixture with autogenous bone. Several clinicians[24,26,41] reported implant survival rates as high as 98% when using a composite mixture of bovine and autogenous bone in the grafted sinus. In 2000, Krauser *et al*[54] demonstrated that the addition of the P-15 molecule to a xenograft enhances bone formation in the grafted maxillary sinus permitting earlier implant placement compared with other graft materials. Valentini and Abensur[55] retrospectively evaluated the survival rate of implants placed in the maxillary sinuses grafted with Bio-Oss (Osteohealth, Shirley, NY), which is an inorganic bovine bone with a microscopic structure similar to human bone. Data showed that sufficient bone formation occurred to support dental implants with or without the addition of autogenous bone. After 6.5 years of patient recall and a 94.5% survival rate, they concluded that inorganic bovine bone alone was a suitable material for sinus graft augmentation. Studies by other clinicians showed that implant survival rates were higher when using either a composite graft mixture of autogenous bone and a xenograft, or 100% xenograft.[56,57]

Simunek *et al*[58] reported a 97.8% implant survival rate using a fluorohydroxyapatite (FHA), which is a phycogenic bone graft substitute made from a calcium encrusted sea algae. During a 15-year period, Ewers[59] reported a 95.6% survival rate of implants placed in the maxillary sinus grafted with FHA, which is marketed in the United States as C Graft (ScionX LLC, Denver, CO).

In the conventional sinus grafting protocol, a healing period of 6 to 9 months is generally accepted before implant placement.[2,60–62] Many of the studies that used histologic or histomorphometry to evaluate bone formation obtained core bone biopsies of the grafted sinus at 6 months or later. A study by Tadjoedin *et al*[63] compared the formation of mineralized bone using a composite mixture of bovine bone substitute and autogenous bone and 100% autogenous bone at 4- and 6-month intervals. In the composite graft group at 6 months, they observed 38% vital bone formation. However, in the 100% autogenous graft group, they observed a 41% to 44% formation of mineralized vital bone only after 4 months. Thorwarth *et al*[64] performed a comparative study of bone harvested from the posterior mandible and iliac crest and compared the percentage of mineralized bone in the grafted maxillary sinus. After 6 months, they observed a mean mineralization rate of 53.9% in the grafted sinus using bone harvested from the posterior mandible. In contrast, bone harvested from the anterior and posterior iliac crest showed a mean mineralization rate of 36.1% and 34.5%, respectively.

From these studies, it seems that a graft-healing period of 6-months or longer may be too prolonged and unnecessary. This is especially true when an additional 6 or more months of implant healing is to follow when using the conventional sinus grafting protocol. The conventional sinus protocol with its delayed approach to implant placement in the grafted sinus could result in excessive bone resorption and loss of bone volume.[32,43,44,65]

In contrast, a modified decreased healing time of 4 months should be considered. Bone graft maturation, volume, and density may be optimal for implant placement based on histomorphometric studies evaluating the mineralization rate of the graft. A shortened healing time may be ideal, especially if autogenous bone and PRP are added to the graft.

Platelet Rich Plasma

Contemporary research in the art and science of bone grafting and regeneration attempts to provide a superior graft to ensure successful implant osseointegration. In the past years, the focus has been on applying native growth factors to the graft material to enhance osteogenesis, increase vascu-

larity, and shorten the healing time for bone maturation. A biotechnology method that involves tissue engineering and cellular therapy contains a high-concentrated source of platelets, but the use of autologous PRP remains controversial.

PRP applied to autogenous bone grafts was first reported by Whitman *et al*.[66] Bone formation is accelerated by the liberation of specific growth factors contained in the alpha granules of the platelets.[67] In their clinical studies with mandibular reconstruction, Marx *et al*[67] demonstrated that the addition of PRP resulted in early graft consolidation and mineralization in half the time compared with grafts without the addition PRP. Bone healing was accelerated approximately 2 times that of autogenous bone grafts without PRP. Bone grafts in general produce a trabecular dense bone area that is equal to or greater than that of the nongrafted posterior mandible. But, with the use of PRP, it was observed that trabecular bone density improved by 15% to 30%. Histomorphometric analysis showed a greater amount of mineralized bone density (75% ± 11%) compared with bone grafts without PRP (55% ± 8%). Their results showed that the addition of PRP accelerated the rate of bone formation during the first 6 months after grafting. Subsequent studies[68,69] demonstrated that using PRP during implant surgery promotes implant osseointegration and bone regeneration.

A study by Barry and Murphy[70] showed that cancellous marrow grafts contain mesenchymal stem cells that contain the receptors for PDGF and TGF-β. Together with tissue growth factors, mesenchymal stem cells have the ability to differentiate osteogenic cells that will stimulate bone formation. In a dog model, Gerard *et al*[71] showed that PRP enhanced early healing by decreasing the amount of nonviable grafted bone that was resorbed, and increasing the amount of new vital bone that was formed during the first 2 months of postgrafting. This benefit was no longer observed between 3 and 6 months of postgrafting.

PRP has also been shown to be potentially useful with various xenogenic, allogenic, and alloplastic graft materials.[69,72,73] It has been observed that PRP has enhanced the osteoconductive and possibly the osteoinductive properties of these graft materials.[69,72] Kim *et al*[74] speculated that the addition of PRP to osteoconductive graft materials may potentiate osteoinduction. Another study using bovine xenograft material and PRP suggests that adding PRP to osteoconductive graft materials possess osteoinductive properties.[73] It is known that endothelial cells, adipocytes, fibroblasts, and macrophages constitute the marrow stromal cell population. It is theorized that these cell populations may be transformed into osteoblasts via critical biochemical signals from cytokines in the PRP. The cytokines include bone morphogenic protein, transforming growth factor beta (TGF-β), and platelet-derived growth factor (PGDF).[73]

Although PRP has been shown to enhance wound healing, other studies have questioned the healing benefits of PRP.[75–77] In a canine model, Choi *et al*[75] suggested that PRP did not seem to enhance bone formation in autologous grafts of the mandible. They observed no accelerated bone formation, but suggested that the addition of PRP could actually interfere with bone healing. A study by Butterfield *et al*[78] failed to provide a statistically significant direct stimulatory effect on healing of autogenous bone grafts in maxillary sinus augmentation procedures in the rabbit model. In a similar study using a sheep model, Jakse *et al*[79] found no statistically significant advantage in using PRP with autogenous bone grafts in the grafted maxillary sinus.

Materials and Methods

Patient Selection and Evaluation

Fifty-two maxillary sinuses were bone grafted in a total of 41 (27 women and 14 men) patients from 2002 to 2005. The mean age of all patients was 59 years (range, 33–83 years). Their general health was classified according to standards set by the American Society of Anesthesiologists (ASA) on a 5-grade scale.[80] The patients in this study were classified as ASA health status grade 1 (no systemic disease), or grade 2 (mild systemic disease). Smokers were not excluded from the study. Preoperative prophylactic antibiotics were not given to any of the patients. However, postoperative antibiotics were prescribed to all patients.

Treatment options were discussed with every patient and all of the participants selected the treatment plan requiring maxillary sinus elevation. Patients included in the study were selected after a careful review of their medical history and an examination that included panoramic radiographs or in-office cone beam computed tomography (CT) scans (Imaging Sciences International, Hatfield, PA). All patients were selected according to specific inclusion criteria: Cawood and Howell classification V and VI,[19] where the posterior vertical bone height is 5.0 mm or less. All participants required the sinus lift elevation procedure with bone graft augmentation for the placement of dental implants in the posterior maxilla.

Patients with relative contraindications such as controlled diabetes mellitus, use of anticoagulants, and hypertension were included in the study. Patients with the following were excluded from the study: ASA Class III and IV, immunosuppressive disorders, current alcohol or substance abuse, excessive parafunctional habits, untreated periodontal disease, pregnant or nursing females, patients exposed to radiation of the jaws due to malignancies, uncontrolled insulin dependent diabetes mellitus, coagulopathies, and chronic steroid use. All patients were informed of the requirements for treatment and participation, such as multiple office visits for observation, radiographs, CT scans, photographs, and core biopsies of the grafted maxilla for histologic analysis.

Data were collected from the time of sinus grafting and implant placement until the last office evaluation based on the 12-month observation protocol. The last office appointment marked the termination of the study for each individual patient. However, patient follow-up continues, which has ranged from 12 to 50 months. As the study continues to be in progress for future research, decisions regarding which graft material to use for each patient were made on a random basis as each case was presented to the surgeon. Randomization schedules were designed to provide a balanced distribution of graft material in each patient. Implant position was also randomized to ensure that a balance of implants

could be surgically placed in the graft materials.

All surgical procedures (bone grafting, implant placement, and core biopsies) were completed in a single private practice. Clinical information recorded in the patient database included the following: patient age, sex, and medical history. Research information included graft material, number of implants placed in the maxilla, height of existing alveolar crest in the posterior maxilla before and after surgery, postoperative complications, and failure of any implants to osseointegrate.

Graft Materials

Three bone graft substitute materials were used in this study and combined with approximately 50% autogenous bone. For unilateral sinus grafts, autogenous bone was harvested from the buccal cortical plate of the posterior mandible using the MX-Grafter (Maxillon Laboratories, Hollis, NH) as described by Peleg *et al*.[81] In all bilateral cases, bone was harvested from the left tibia as described by Lee.[82] The 50:50 composite graft ratios consisted of one of the following: allogeneic, mineralized bone (Puros, Zimmer Dental, Carlsbad, CA); a natural, coral FHA (C Graft); and a bovine derived xenograft (Bio-Oss).

Dental Implants

Multi threaded, internal hexed straight, and tapered screw-type implants with hydroxyapatite surfaces (Zimmer Dental) were surgically placed into the grafted maxillary sinuses. Data from panoramic radiographs and CT scans were used to select implant location, implant length and diameter, and amount of bone graft material.

Sinus Graft Surgical Technique

The sinus lift elevation technique used in the present study is similar to that described by Tatum.[83,84] All of the cases were performed in the office under local anesthesia or intravenous sedation. In every instance, the oral cavity was rinsed for 60 seconds with 0.12% chlorhexidine gluconate mouthwash (Peridex, Proctor & Gamble, Cincinnati, OH) preoperatively and the patient was draped in sterile fashion to ensure strict asepsis.

In some cases, the Schneiderian membrane would tear during the procedure to elevate it off of the walls of the sinus cavity. Membrane perforations were repaired by placing a resorbable collagen membrane saturated with PRP solution and activated with thrombin and calcium chloride (Biomend Extend; Zimmer Dental, Encino, CA) over the perforation. Once the membrane was elevated out of the surgical field, the graft material was mixed with PRP and then carefully packed into the sinus floor. After the graft material was packed into the maxillary sinus, the soft tissue flap was reapproximated and passively sutured using 4-0 black silk sutures without tension. Sutures were removed 2 weeks after surgery. The graft material was allowed to mature, allowing the formation of new, vital bone around the graft particles for a period of 4 to 9 months before implant placement. At the time of implant surgery, the immediate nonfunctional loading protocol was initiated.

PRP Preparation Technique

Approximately 55 mL of whole blood from every patient was obtained from the antecubital fossa of the arm via venipuncture using a 23-gauge needle. The blood is collected and anticoagulated with an anticoagulant citrate dextrose-A solution. The venous blood is then injected into a disposable dual chamber that is placed into a cell separator. During a 13-minute period, the blood is processed using a microprocessor controlled, automated cell separator (Harvest Technologies, Plymouth, MA). At a speed of 5600*g*, the cell separator divides the venous blood into 3 components: PRP, platelet poor plasma, and red blood cells.

Centrifugation of 55 mL of whole blood results in 10 mL of PRP. Five thousand units of bovine thrombin (King, St Louis, MO) is mixed with 10% calcium chloride (American Regent, Shirley, NY). The mixture is applied to the bone graft material and activation of PRP results in degranulation of the platelets and immediate release of its growth factors.

Implant Surgery and Bone Core Biopsies

After a healing period of 4 to 9 months, implants were surgically placed into the grafted maxilla. Custom surgical templates were prefabricated before surgery that allows the implant team to determine the correct number of implants, their position, size, and custom abutments before surgery. The surgical guide was based on the preoperative treatment plan formulated by the restoring general dentist and surgeon.

Under local anesthesia, a total of 10 randomly selected core biopsies from the grafted posterior maxilla were taken using a trephine bur with an inner diameter of 2 mm and an outer diameter of 3 mm from the alveolar crest of the implant site. Immediately after the biopsy specimen was removed from the posterior maxilla, the implant was surgically placed into the osteotomy site according to the implant manufacture's protocol.

Prosthetic Protocol

After each implant was surgically placed in the maxilla, implant position was immediately indexed by the surgeon with the closed tray technique using the impression coping provided by the implant manufacturer and a polyvinylsiloxane impression material to facilitate the fabrication of the provisional acrylic resin restoration. The Screwvent dental implant (Zimmer Dental) is supplied with a premounted titanium abutment that serves as the fixture mount, temporary abutment, and impression coping for indexing to transfer the position of the surgically placed implant to the master cast. The decision to place the provisional restoration 48 hours to 5 days was later determined by the limited time available for this procedure after surgery between the surgeon, patient, and dental laboratory. The custom abutment and provisional restoration was fabricated by the dental laboratory and returned to the surgeon. When the custom abutment was placed onto the implant, it was only hand tightened. The provisional restoration was then adjusted chairside and cemented with temporary cement out of occlusion. Six months later, final impressions were obtained by the restorative dentist and the definitive ceramometal restorations were fabricated and delivered to the patient. During placement of the final ceramometal restorations, all

custom abutments were tightened to 30 Ncm. In 1 patient who was experiencing travel restrictions to Hawaii, she was not able to resume treatment until 9 months after the sinus grafting procedure.

In this patient, no provisional restorations were incorporated into the treatment plan. The restoring dentist immediately placed the definitive ceramometal restorations onto the implants under occlusal loading.

Specimen Processing

Each core bone biopsy contained both the grafted area and the native, alveolar crest of the maxillary sinus floor. Biopsy samples were fixed in 10% buffered formalin and submitted for histologic examination. Upon receipt in the Hard Tissue Research Laboratory, the specimens were immediately dehydrated with a graded series of alcohols for 9 days. After dehydration, the specimens were infiltrated with a light-curing embedding resin (Technovit 7200 VLC, Kulzer, Wehrheim, Germany). After 20 days of infiltration with constant shaking at normal atmospheric pressure, the specimens were embedded and polymerized by 450 nm light with the temperature of the specimens never exceeding 40°C. The specimens were then prepared by the cutting/grinding method of Rohrer and Schubert.[85] The specimens were cut to a thickness of 150 μm on an EXAKT cutting/grinding system (EXAKT Technologies, OK). After this, the slides were polished to a thickness of 45 μm with a series of polishing sandpaper discs from 800 to 2400 grit using the EXAKT microgrinding system followed by 3 μm alumina polishing paste. The slides were stained with Stevenel's blue and Van Gieson's picro fuchsin and subjected to histologic analysis.

Microphotographs were obtained, scanned, digitized, and analyzed using a Zeiss Axiolab photomicroscope (Carl Zeiss, Jena, Germany) and an Nikon Coolpix 4500 digital camera (Nikon Corp., Tokyo, Japan). All core specimens were photographed at a fixed focal point and 25× magnification for histomorphometric evaluation. Histomorphometric measurements were completed with a Macintosh G4 computer (Apple, Cupertino, CA) and a public domain image program (NIH Images, US National Institutes of Health) along with Adobe Photoshop (Adobe, San Jose, CA).

The following parameters were measured in terms of the percentage of the primary area of interest: total primary area, new bone formation, residual graft material (xenograft, mineralized allograft, and alloplast), and marrow space. In cores with mineralized allograft, the vital bone and mineralized allograft were combined as total bone area.

Results

Patients were organized into 3 groups based on the graft material selected, and if the patient had one or both sinuses grafted. Thirty patients had only 1 sinus grafted, whereas the remaining 11 patients had both sinuses grafted for a total of 52 sinus grafts.

Of the 41 patients, 27 (61.8%) were female, and 14 (38.2%) were male. Females ranged from 33 to 81 years of age. The average age of this group was 58.3 years. Of the 14 males participating in the study, age ranged from 45 to 83 years. The average age for this study group was 64.2 years. The average age for both groups combined was 61.2 years.

A total of 52 sinuses were grafted. Group I consisted of the 30 unilateral sinus grafts. Fourteen patients were grafted with the 50:50 composite graft ratio of the mineralized allogeneic bone and autogenous bone. Sixteen patients received a 50:50 composite ratio of the natural FHA and autogenous bone. The remaining 11 patients were grafted with 50% Bio-Oss and 50% autogenous bone. This group of patients had both sinuses grafted for a total of 22 sinus grafts.

A total of 97 implants were surgically placed in the 41 patients enrolled in the study. Thirty-seven implants were placed in the sinuses grafted with the composite mixture of allogeneic bone and autogenous bone. Forty-one implants were placed in the sinuses grafted with FHA and autogenous bone. The remaining 19 implants were placed in the sinuses grafted with Bio-Oss and autogenous bone.

Criteria for Implant Success

All implants with the provisional and definitive restoration were determined to be successful if the following criteria were observed up to 1 year after implant placement: (1) no implant mobility; (2) no complaint of pain around the implant; (3) no evidence of infection associated with the implant; and (4) no neurosensory deficits reported by the patient.

During implant surgery, 3 implants were removed from the maxilla as they were determined to be mobile. All 3 implants were in the second molar (2 and 15) areas of the maxilla. No attempt was made to allow for further healing of the grafted maxilla to attempt implant placement. These implants were not considered implant failures and, therefore, were not included in the total amount of implants placed in the grafted maxillary sinuses.

Histologic and Histormorphometric Results

Ten randomly selected bone core samples were examined. Histomorphometric results are shown in Table 1. Microscopically, all histological specimens showed *de novo* synthesis of bone formation. Histologic examination of all graft specimens showed areas of vital cancellous bone formation, marrow spaces, fibrous tissue, and osteoid formation. In some specimens, mature bone was also observed. Particles of residual substitute graft material were seen in the xenograft and alloplast specimens. No residual autogenous bone was seen in any specimen.

FHA and autogenous bone. The sinus grafted with 50% autogenous bone and 50% natural FHA material showed a good cancellous bone pattern comprising woven bone and osteoid. Newly formed bone was observed growing into the pores of the resorbing FHA graft material (Fig. 1). In other areas, appositional bone growth was observed growing on to the resorbing substitute graft material. Histomorphometric analysis revealed that 41% of the core sample was bone, 100% of which was vital. Residual FHA graft made up 9% of the core (Table 1).

Allogeneic and autogenous bone. Histologic evaluation of several graft specimens that consisted of 50% au-

Table 1. Patient Data Showing Histomorphometry of Newly Formed Vital Bone and Nonvital Bone

Graft Type	Time of Core Biopsy (mos)	Percentage of Bone in Core	Vital Bone Percentage	Nonvital Bone Percentage	Percentage of Total Core Residual Graft
FHA	5	41	100	0	9
Xenograft	6	30	100	0	6
Allograft	5.5	59	98	2	0
Allograft	7	45	94	6	0
Allograft	4	41	92	8	0
Allograft	7	45	87	13	0
Allograft	9.5*	38	87	13	0
Allograft	7	28	82	18	0
Allograft	5	44	80	20	0
Allograft	8	47	77	23	0

Note high percentages of vital bone formation in a 4- to 9.5-month healing period and very little residual graft material.

FHA: flourohydroxyapatite (C Graft. ScionX, LLC, Denver, CO).

Xenograft: Bio-Oss (Osteohealth, Shirley, NY).

Allograft: Puros (Zimmer Dental, Carlsbad, CA).

* Patient did not receive provisional restorations.

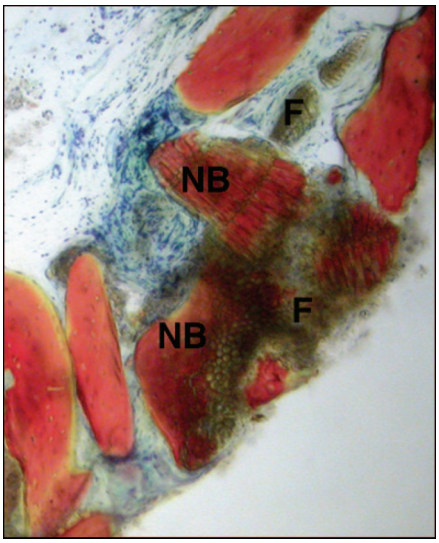

Fig. 1. High power image shows new bone formation (NB) and residual particles of FHA (F). Stevenel's blue and Van Gieson's picro fuchsin (200×).

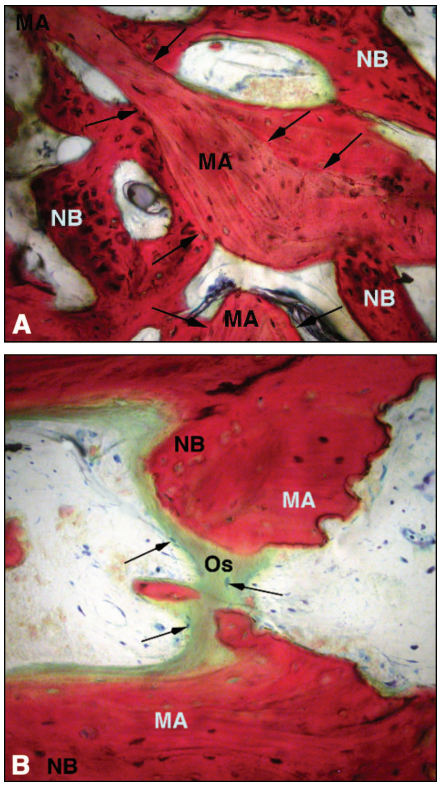

Fig. 2. A, High power image shows mineralized allograft (MA) outlined by arrows. New, immature bone formation (NB) is well integrated and bridging among graft particles. Stevenel's blue and Van Gieson's picro fuchsin (200×). B, High power image shows 2 particles of mineralized allograft (MA) connected with thick osteoid (Os) and new bone formation (NB). Arrows identify osteoblasts and osteocytes. Stevenel's blue and Van Gieson's picro fuchsin (200×).

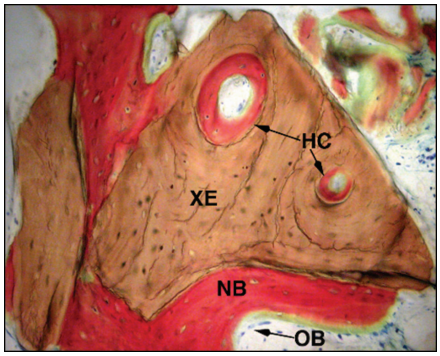

Fig. 3. High power image shows particles of xenograft (XE) with new bone formation within the haversian canal (HC). Stevenel's blue and Van Gieson's picro fuchsin. Arrows identify osteoblasts and osteocytes (200×).

togenous bone and 50% mineralized allogeneic graft material showed anastomosing segments of osseous tissue in close apposition to the graft substitute particles. Additional observation demonstrated that most of the osseous tissue was immature, calcified bone with a woven bone pattern. The mineralized allogeneic particles were well integrated in the core specimens. High power histological views showed very delicate newly formed bone that had formed on the surface of the graft particles (Fig. 2, *A*). In addition, thick osteoid was frequently observed connecting graft particles (Fig. 2, *B*). In a core specimen obtained at 16-week postgrafting, histomorphometry demonstrated that the core was 41% of bone, 92% of which was vital new bone formation. In another specimen obtained at 22-week postgrafting, 59% of the graft was bone and 98% was vital new bone formation. The 2% that was mineralized allograft was extremely well integrated and somewhat difficult to differentiate from the new bone formation.

Xenograft and autogenous bone. Histologic evaluation of a core sample at 24-week revealed formation of vital mature lamellar bone and some areas of immature, woven bone. This bone bridged among particles of xenograft, which showed no evidence of resorption (Fig. 3). Medullary spaces were almost always filled with well-vascularized connective tissue. Haversian systems in the graft material showed evidence of new bone formation. In the 24-week core sample, histomorphometry showed 30% new

bone formation, 100% determined to be vital, with 6% residual xenograft material.

Discussion

Based on our knowledge of bone biology, surgical observations and what has been reported in the contemporary implant literature, we hypothesized that the addition of 50% autogenous bone and PRP to the substitute bone graft materials would accelerate bone formation, increase revascularization, and trabecular bone density of the graft material. We further hypothesized that the increased bone density would permit earlier implant placement without compromising implant survival in the grafted maxillary sinus. Comparing our implant survival rates with conventional treatment protocols and analysis of 10 randomly selected bone core specimens, our hypotheses were realized. The modified surgical protocol of the grafted maxillary sinus challenges the total conventional healing time of 12 to 18 months (surgical and prosthetic healing times combined) before any type of restorations are placed onto the implants.

Like PRP, autogenous bone contains large quantities of growth factors, such as PDGF, TGF, and bone morphogenetic proteins, which are all involved in osteogenesis.[67] Because of its cellular nature and osteoinductive properties, the addition of 50% autogenous bone to the graft mixture will accelerate the formation of new vital bone. All these growth factors lead to improved angiogenesis and revascularization of the graft, which results in enhanced wound healing allowing for an overall shorter healing time.[71,73,86] The alpha secretory granules in platelets contain high concentrations of various growth factors, including PDGF, TGF-β1, TGF-2, vascular endothelial growth factor (VEGF), and insulin-like growth factor (IGF).[67,68] Release of these growth factors allows for the stimulation of stem cells and osteoblast progenitor cells to initiate early osteogenesis and angiogenesis.[67,68]

In Marx *et al* study,[67] histology at 6 months showed greater formation of trabecular bone with PRP grafts due to release of increased levels of PDGF and TGF. This was also observed in Gerard *et al*[71] animal study as early as 1 to 2 months of postgrafting. The PRP graft sites had less grafted nonviable bone and significantly more amounts of new vital bone. Also significant was the finding that the PRP-grafted bone was radiographically denser during the early stages of bone healing. All these observations could be explained by the possibility that the release of growth factors caused by PRP results in early release of large amounts of osteoclasts and osteoblasts. Although it is difficult to extrapolate clinical results using an animal model to human studies, our histologic and histomorphometric results could be attributed to the biological effects of PRP on early bone formation while decreasing the amounts of nonviable bone.

The literature has shown a wide range of percent vital new bone formation using various bone graft substitutes, ranging from 14% to 44%.[41,63] In a study by Hallman *et al*,[56] they showed that the combination of the bovine xenograft, Bio-Oss, and autogenous bone and platelet fibrin glue in an 80%:20% ratio grafted in the maxillary sinus yielded a 90% implant success rate at 1-year after loading. Histomorphometric analysis at 6 months demonstrated 21.2% vital lamellar bone formation. After 3 years of postgrafting, further analysis showed 50.7% vital lamellar bone formation. In our xenograft core sample at 6 months of postgrafting, histomorphometric analysis showed 100% formation of new vital bone. In contrast, a study by Froum *et al*[87] demonstrated no significant benefit with the addition of PRP to inorganic bovine bone (Bio-Oss). Histomorphometric analysis revealed 23.3% bone formation with PRP. Without PRP added to the graft material, bone formation was 21.3%.

Mineralized allogeneic bone from human cadavers has only recently been used in implant reconstruction of the jaws, including the sinus grafting procedure. In a study using a combination of freeze-dried bone allograft and platelet-rich fibrin, the authors[88] demonstrated 65% formation of new vital bone after 4 months of healing. Histologic analyses demonstrated formation of mineralized trabecular bone rich in osteocytes. The authors concluded that the addition of platelet-rich fibrin to a bone graft material accelerates bone formation in the grafted sinus after 4 months of healing, which will shorten the healing time between grafting and implant placement.

In the present study, the mineralized bone particles at 4 months became partially resorbed and surrounded by new woven, immature bone. Histologic inspection showed that the mineralized allogeneic bone particles were incorporated and interconnected by a scaffold of new bone as early as 16 weeks. This is due to its high osteoinductive properties. In a single case report using human mineralized allogeneic bone mixed with 10% autogenous bone and no PRP added to the graft mixture, Froum *et al*[89] reported 25.2% of new bone formation. The authors theorized that despite the low percentage of new vital bone formation, this low amount of bone is sufficient to withstand the biomechanical loads of the posterior maxilla during function. After a healing time of 9 months, the implant was placed into the grafted sinus. In one of our composite allogeneic core samples at 16-week postgrafting, histomorphometric analysis demonstrated 41% bone, 92% of which was new vital bone formation. Because of the formation of large amounts of new vital bone only after 4 months of postgrafting, this allowed us to implement the immediate loading protocol, much to the patient's satisfaction. In our opinion, the formation of high percentages of vital new bone in such a short healing time-period could be attributed to the early healing effects of PRP and the use of 50% autogenous bone.

A number of animal and human histomorphometric studies have shown that the marine algae derived hydroxyapatite FHA is osteoconductive, porous, and demonstrates a high resorption and remodeling rate.[54,59,90] All these properties result in early revascularization of the FHA particles and new bone formation. This entire process of graft turnover is stimulated by the osteoconductive properties of the material.[54,59,90]

After a mean healing time of 7 months, several authors[54,58,59] demonstrated 23% and 34.5% vital new bone formation around the FHA particles. Compared with what has been reported from the authors, histomorphometry in

our core sample at 20-week postgrafting demonstrated 41% formation of new bone, 100%vital. This impressive amount of vital bone formation in such a short period of time could be attributed to the early healing effects of PRP and use of 50% autogenous bone.

To the authors' knowledge, a large-scale study evaluating implant survival in a nonfunctional immediate loading protocol of the grafted maxillary sinus using different graft materials combined with PRP and 50% autogenous bone during a 52-week period analyzing the formation of new vital bone using histologic and histomorphometric analysis has not been reported. When histologic specimens were evaluated with histomorphometry, the increased percentage of new vital mineralized bone was statistically significant compared with what has been presented in the contemporary dental implant literature. The present study also demonstrated that the immediate loading protocol did not compromise the high implant success rates that have been previously reported in the dental literature for the nongrafted posterior maxilla. This modified surgical protocol using 50% autogenous bone and PRP results in a shorter, total (bone graft and implant) healing time and results in predictable vital new bone formation.

Conclusion

The preliminary results of this study suggest that a nonfunctional immediate loading protocol for the grafted maxillary sinus with high implant success rates can be achieved. We attribute the high implant success rates to the early formation of statistically significant amounts of new vital mineralized bone. Our results demonstrate that cellular therapy using 50% autogenous bone and PRP has a significant positive effect on the early formation of new vital bone. Although we have routinely implemented this immediate loading protocol into our implant practice, further long-term studies are needed to confirm the encouraging results of this study.

Disclosure

The authors claim to have no financial interest, directly or indirectly, in any entity that is commercially related to the products mentioned in this article.

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ID Abstract Translations

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Unmittelbare Belastung des mittels Transplantat angereicherten Oberkiefersinus durch Verwendung von thrombozytreichem Plasma und autogenem Knochengewebe. Eine vorläufige Studie inklusive histologischer und histomorphometrischer Analysen

ZUSAMMENFASSUNG: Zielsetzung: Die vorliegende klinische Studie zielte darauf ab, Überlebensraten bei Zahnimplantaten zu ermitteln. Dazu wurde das Konzept eines nicht funktionalen Protokolls mit unmittelbarer Belastung bei nicht geschienten Zahnimplantaten im transplantierten Oberkiefersinus über einen Zeitraum von 52 Wochen angewendet. Die randomisierte histomorphologische und histomorphometrische Analyse wurde zur Beurteilung der frühzeitigen Heilungstendenzen unter Verwendung von thrombozytreichem Plasma (PRP) sowie 50% an autogenem Knochengewebsmaterial in Kombination mit drei unterschiedlichen Substitutionstransplantierungsmaterialien durchgeführt und abgeschlossen. ***Materialien und Methoden:*** Vier bis acht Monate nach einer Transplantierung des Sinus mit PRP-besprühtem autogenem Knochengewebe in Verbindung mit drei unterschiedlichen Substitutionstransplantierungsmaterialien in einem Verhältnis von 50 zu 50 wurden bei 41 Patienten insgesamt 97 Zahnimplantate mit Hydroxylapatitbeschichtung eingepflanzt und unmittelbar 48 Stunden bis zu 5 Tagen nach Implantierung mit normalen Titanstützapparaturen sowie provisorischen Prothesen außerhalb des funktionalen Bissschlusses belastet. Nach

sechs Monaten wurden endgültige Wiederherstellungslösungen aus Keramik-Metall auf die normalen Stützzähne aufzementiert. ***Ergebnisse:*** Über einen Beobachtungszeitraum von 52 Wochen war kein Implantatverlust zu verzeichnen. Bei einer Heilungszeit des Transplantats von 4 bis 8 Monaten zeigten die histologischen und histomorphometrischen Analysen eine Neubildung von vitalem Knochengewebe bei verschiedenen Transplantaten im Bereich zwischen 77% und 100%. ***Schlussfolgerung:*** Die vorläufigen Ergebnisse dieser klinischen Studie weisen aus, dass eine sofortige, nicht funktionale Belastung unter Verwendung von thrombozytreichem Plasma und 50% an autogenem Knochengewebe in Kombination mit verschiedenen Substitutionstransplantationsmaterialien ein vorhersagbar zuverlässiges Protokoll für den transplantierten Oberkiefer im zeitlichen Rahmen von 4 Monaten nach erfolgter Transplantierung darstellt. Die hohe Überlebensrate der Implantate ist auf die frühe Bildung eines großen Prozentsatzes an neuem vitalem Knochengewebe zurückzuführen. Dies wurde auch durch die histologischen und histomorphometrischen Analysen nachgewiesen.

SCHLÜSSELWÖRTER: Unmittelbare, nicht funktionale Belastung, transplantierter Oberkiefersinus, thrombozytreiches Plasma, Bildung vitalen Knochengewebes, Überlebensquoten der Implantate

SPANISH / ESPAÑOL

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Carga inmediata del seno maxilar injertado usando plasma rico en plaquetas y hueso autógeno. Un estudio preliminar con análisis histológico e histomorfométrico

ABSTRACTO: Objetivo: La meta de este estudio clínico fue evaluar las tasas de supervivencia de los implantes dentales usando el concepto de un protocolo de carga inmediata, no funcional, con implantes dentales sin unión en el seno maxilar injertado durante un período de 52 semanas. Se completaron análisis histomorfológicos e histomorfométricos al azar para evaluar el efecto curativo inicial del plasma rico en plaquetas (PRP) y un 50% de hueso autógeno combinado con tres materiales diferentes como sustitutos de injerto. ***Materiales y Métodos:*** Cuatro a ocho meses después de injertar el seno con hueso autógeno rociado con PRP con tres materiales diferentes como sustitutos de injerto en una aleación de 50:50, se colocaron noventa y siete implantes dentales recubiertos con hidroxiapatita en 41 pacientes e inmediatamente cargados entre las 48 horas y los cinco días después con pilares especiales de titanio y restauraciones temporarias de acrílico colocadas fuera de la oclusión funcional. Seis meses después, se cementaron las restauraciones definitivas de cerámica-metal a los pilares especiales. ***Resultados:*** Durante el período de observación de 52 semanas, no se perdió ningún implante. Entre los 4 y 8 meses del período de curación del injerto, los análisis histológicos e histomorfométricos revelaron la formación de nuevo hueso vital en diferentes muestras del injerto que iban desde el 77% al 100%. ***Conclusión:*** Los resultados preliminares de este estudio clínico indican que la carga inmediata, no funcional, usando plasma rico en plaquetas y un 50% de hueso autógeno combinado con diferentes materiales sustitutos de injerto es un protocolo pronosticable en el seno maxilar injertado tan rápido como a los 4 meses luego del injerto. La alta tasa de supervivencia del implante se debe a la rápida formación de un alto porcentaje de nuevo hueso vital según lo confirman los análisis histológicos e histomorfométricos.

PALABRAS CLAVES: carga inmediata, no funcional, seno maxilar injertado, plasma rica en plaquetas, formación de hueso vital, tasa de supervivencia del implante.

PORTUGUESE / PORTUGUÊS

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Carga Imediata da Cavidade Maxilar Enxertada Usando Plasma Rico em Plaquetas e Osso Autógeno. Estudo Preliminar com Análise Histológica e Histomorfométrica

RESUMO: Objetivo: A meta deste estudo clínico era avaliar taxas de sobrevivência de implantes dentários usando o conceito de protocolo de carga não-funcional e imediato com implantes dentários não-esplintados na cavidade maxilar enxertada por um período de 52 semanas. Análise aleatória histomorfomológica e histomorfométrica foi completada para avaliar o efeito de cura precoce do plasma rico em plaquetas (PRP) e osso 50% autógeno combinado com três diferentes materiais de enxerto substitutos. ***Materiais e Métodos:*** Quatro a oito meses após enxertar a cavidade com osso autógeno borrifado com PRP combinado com três diferentes materiais de enxerto substitutos numa proporção de composto 50:50, noventa e sete implantes dentários cobertos com hidroxiapatita foram cirurgicamente colocados em 41 pacientes e imediatamente carregados entre 48 horas a cinco dias mais tarde com suportes de titânio feitos sob medida e restaurações provisórias de acrílico colocadas fora da oclusão funcional. Seis meses mais tarde, restaurações definitivas de ceramometal foram cimentadas nos suportes feitos sob medida. ***Resultados:*** Durante um período de observação de 52 semanas, nenhum implante se perdeu. Entre 4 e 8 meses de tempo de cura do enxerto, a análise histológica e histomorfométrica revelou formação de novo osso vital em diferentes espécimes de enxerto num intervalo de 77% a 100%. ***Conclusão:*** Os resultados preliminares deste estudo clínico indicam que a

carga não-funcional imediata usando plasma rico em plaquetas e osso 50% autógeno combinado com diferentes materiais de enxerto substitutos é um protocolo previsível na cavidade maxilar enxertada por volta de 4 meses após o enxerto. A alta taxa de sobrevivência dos implantes se deve à formação precoce de grandes porcentagens de novo osso vital conforme confirmado usando-se a análise histológica e histomorfométrica.

PALAVRAS-CHAVE: carga não-funcional imediata, cavidade maxilar enxertada, plasma rico em plaquetas, formação de osso vital, taxas de sobrevivência de implantes

RUSSIAN / РУССКИЙ

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Установка имплантата непосредственно в заполненную трансплантатом верхнечелюстную пазуху при использовании богатой тромбоцитами плазмы и аутогенной кости. Предварительное исследование с гистологическим и гистоморфометрическим анализом.

РЕЗЮМЕ: **Цель.** Цель данного клинического исследования – оценить показатель приживаемости зубных имплантатов по прошествии 52 недель при использовании концепции протокола нефункциональной установки нераздельных зубных имплантатов непосредственно в заполненную трансплантатом верхнечелюстную пазуху. Выборочный гистоморфологический и гистоморфометрический анализ проводился для оценки раннего заживляющего эффекта богатой тромбоцитами плазмы (PRP) и 50% аутогенной кости в сочетании с тремя различными взаимозаменяемыми материалами трансплантата. **Материалы и методы.** Через 4–8 месяцев после заполнения верхнечелюстной пазухи аутогенной костью, обработанной богатой тромбоцитами плазмой, в сочетании с тремя различными взаимозаменяемыми материалами трансплантата в соотношении 50:50, сорока одному пациенту были установлены 97 зубных имплантатов с гидроксиапатитным покрытием с немедленной (в срок от 48 часов до 5 часов) установкой выведенных из окклюзии обычных титановых абатментов и акриловых временных протезов. Через 6 месяцев постоянные металлокерамические протезы были установлены на обычные абатменты. **Результаты.** По прошествии 52 недель наблюдения все имплантаты были сохранены. Период приживления трансплантата составил от 4 до 8 месяцев, при этом гистологический и гистоморфометрический анализы показали 77% - 100% формирование новой жизнеспособной кости в трансплантатах из различных материалов. **Вывод.** Предварительные результаты данного клинического исследования показали, что непосредственная нефункциональная установка имплантатов при использовании богатой тромбоцитами плазмы и 50% аутогенной кости в сочетании с различными взаимозаменяемыми материалами трансплантата является прогнозируемым протоколом установки имплантатов в заполненную трансплантатом верхнечелюстную пазуху как минимум через 4 месяца после трансплантации. Высокий показатель приживаемости объясняется высоким процентным соотношением раннего формирования новой жизнеспособной кости, что подтверждается гистологическим и гистоморфометрическим анализами.

КЛЮЧЕВЫЕ СЛОВА: непосредственная нефункциональная нагрузка, заполненная трансплантатом верхнечелюстная пазуха, богатая тромбоцитами плазма, формирование жизнеспособной кости, показатель приживаемости имплантата.

TURKISH / TÜRKÇE

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Greftlenmiþ Maksiler Sinüsde Trombositten Zengin Plazma ve Otojen Kemik Kullanarak Hemen Yükleme. Histolojik ve Histomorfometrik Analiz Ýçeren Bir Ön Çalýþma

ÖZET: **Amaç:** Bu klinik çalışmanın amacı, greftlenmiş maksiler sinüsde splintlenmemiş dental implantlarla, fonksiyonel olmayan hemen yükleme protokolü kavramını kullanarak 52 haftalık bir süre boyunca dental implant başarı oranlarını araştırmaktı. Trombositten zengin plazma (TZP) ve %50 otojen kemiğin üç değişik yedek greft materyali ile birlikte erken iyileşme etkisini değerlendirmek amacıyla rasgele histomorfolojik ve histomorfometrik analiz de yapıldı. **Gereç ve Yöntem:** TZP'nin spreylendiği otojen kemikle birleştirilmiş 50:50 komposit orantıda üç değişik yedek greft materyali ile sinüs grefti yapılmasından dört ila sekiz ay sonra, 41 hastada doksan-yedi adet hidroksiapatit ile kaplanmış dental implant yerleştirilmiş ve 48 saat ile 5 gün sonrasına kadar özel titanyum abutman dayanak ve akrilik geçici restorasyon, fonksiyonel oklüzyon olmadan hemen yüklenmiştir. Altı ay sonra nihai seramik-metal restorasyonlar özel abutman dayanakların üzerine simante edilmiştir. **Bulgular:** 52 haftalık gözlem süresi boyunca hiçbir implant kaybı olmadı. 4 ila 8

aylık greft iyileşme dönemindeki histolojik ve histomorfometrik analiz, değişik greft örneklerinde %77 ile %100 arasında değişen yeni canlı kemik formasyonu olduğunu gösterdi. **Sonuç:** Bu klinik çalışmanın ilk sonuçları, trombositten zengin plazma ve %50 otojen kemik ile birleştirilen üç değişik yedek greft materyal kullanılarak işlevsel olmayan hemen yüklemenin, greft sonrasında 4 aya kadarki erken dönemde greftlenen maksiler sinüs için önceden tahmin edilebilir bir protokol sağladığını göstermiştir. Yüksek implant başarı oranı, histolojik ve histomorfometrik analiz ile kanıtlandığı üzere, büyük ölçüde yeni canlı kemiğin erken formasyonuna bağlıdır.

ANAHTAR KELÝMELER: işlevsel olmayan hemen (immediat) yükleme, greftlenmiş maksiler sinüs, trombositten zengin plazma, canlı kemik formasyonu, implant başarı oranı

JAPANESE / 日本語

多血少板血漿と自家骨を使用した上顎骨サイナスグラフト即時負荷。組織学ならびに組織形態測定学分析を伴う予備研究

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研究概要：

目的： 当研究目的は上顎骨サイナスグラフトを行った部位に、non-splinted デンタルインプラントをnon functional 即時負荷条件のコンセプトで埋入したデンタルインプラントの存続率を52週間期間評価したものである。多血小板血漿(PRP) と三種類の異なるグラフト置換素材を混合した50%自家骨の早期治癒効果を評価するため、組織形態学上と組織形態測定学上両面の無作為分析を完了した。

研究素材と方法： 50：50の配合で三種類の異なるグラフト置換素材を混合し、PRPをスプレーした自家骨を用いサイナスグラフトを行った後、4ヶ月から8ヶ月目にヒドロシキアパタイトでコーティングした97本のデンタルインプラントを41名の患者に埋入した。術後48時間から5日目に咬合機能外部位にカスタムチタンアバットメントを埋入しアクリルテンポラリー補綴物を装着した。その6ヶ月後、最終的にセラモメタル補綴物をカスタムアバットメントにセメント固定した。

結果： 52週にわたる観察期間中、インプラント喪失は1本も見られなかった。4週間から8週間のグラフト治癒期間に組織学および組織形態測定学上の分析を行った結果、77%から100%の範囲で異なるグラフトスペシメンに新生体骨組織形成を確認した。

結論： 当臨床検査予備結果では多血小板血漿と異なったグラフト置換素材混合５０％自家骨を使用したnon-functional即時負荷条件は、上顎骨サイナスグラフト術後早くも4ヶ月で予知性が確認された。インプラント高存続率は組織学ならびに組織形態測定学上分析で、高比率の新生体骨組織早期形成が確認されたことに起因する。

キーワード： non-functional 即時負荷, 上顎骨サイナスグラフト, 多血小板血漿, 生体骨組織形成, インプラント存続率.

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CHINESE / 中国語

利用血小板豐厚血漿與自體骨進行移植上頷竇立即載入。組織學與組織形態學分析之初步研究

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摘要：

目的：52 週內的存活率。進行隨機組織形態學分析以評估血小板豐厚血漿 (PRP) 以及 50% 自體骨結合三種不同替代移植材料的早期癒合作用。

資料與方法：使用噴灑以 50:50 組成比例結合三種替代材料之自體骨 PRP 進行竇移植，四至八個月後，以外科手術爲 41 名患者植入97 顆氫氧基磷灰石塗層的牙科植體，並於 48 小時至五天內以訂做鈦金屬支柱牙及壓克力臨時義齒進行立即載入。六個月之後，將定形的瓷金屬義齒與訂做的支柱牙黏合。

結果：52 週的觀察期間沒有損失任何植體。在 4 和 8 個月的移植癒合時間當中，組織學與組織形態學分析發現不同移植樣本中有新的活骨形成，範圍從 77% 至 100% 不等。

結論：本臨床研究初步結果指出，在移植後 4 個月就運用血小板豐厚血漿以及 50% 自體骨結合不同替代移植材料進行立即、非機能性載入，是一種在移植的上頷竇上可預測的治療方式。根據使用組織學和組織形態學分析確認，植體存活率高是因爲新活骨早期形成的百分比高。

關鍵字：非機能性立即載入、移植的上頷竇、血小板豐厚血漿、重要骨形成、植體存活率

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KOREAN / 한국어

혈소판 농축 혈장(PRP) 및 자가골을 사용하여 이식된 상악동의 즉시 매식. 조직학적 및 조직계측학적 분석 예비 연구

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초록

목적: 본 임상시험은 52주에 걸쳐 이식된 상악동의 부목을 대지 않은 치아 임플란트로 비기능적, 즉시 매식의 임상시험계획서의 개념을 이용하여 치아 임플란트 생존율을 평가하는데 목적이 있었다. 혈소판 농축 혈장(PRP)과 세 가지의 대체 이식 재료와 결합된 50% 자가골의 초기 치료 효과를 평가하기 위해 무작위 조직적응 및 조직계측학적 분석이 실시되었다.

재료 및 방법: 50:50 혼합 비율의 세 가지 대체 이식 재료가 결합된 PRP를 분무한 자가골로 상악동을 이식한 지 4 - 8개월 후, 97수산화인회석(hydroxyapatite) 코팅 치아 임플란트가, 41명의 환자들에게 외과적으로 안착되었고, 맞춤형 티타늄과 아크릴 임시 수복이 기능적 교합에서 안착된 지 48시간에서 5일 사이에 즉시 매식되었다. 6개월 후 항구성 세라믹 수복이 맞춤형 인공치아에 접합되었다.

결과: 52주에 걸친 관찰 기간 동안, 소실된 임플란트는 없었다. 4 - 8개월간의 이식 치료 시간 사이에 77% - 100% 범위의 여러 이식종에 살아있는 조직의 골(vital bone) 형성이 조직학 및 조직계측학적 분석을 통해 나타났다.

결론: 본 임상 연구의 예비 결과에 따르면, 혈소판 농축 혈장(PRP) 및 기타 대체 이식 재료로 결합된 50% 자가골을 이용한 즉각적이고 비기능적 매식은, 이식 후 빠르면 4개월 내에 이식된 상악동에서 예상되는 계획안이다. 높은 임플란트 생존율은 조직학적 및 조직계측학 분석을 이용하여 확인되었듯이 살아있는 조직의 골(vital bone)의 많은 부분이 조기 형성된 것에 기인한다.

핵심 단어: 즉각적, 비기능적 매식, 이식된 상악동, 혈소판 농축 혈장(PRP), 살아있는 조직의 골형성, 임플란트 생존율.

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