Early Implant Loading in Severely Resorbed Maxilla Using Xenograft, Autograft, and Platelet-Rich Plasma in 97 Patients

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Early Implant Loading in Severely Resorbed Maxilla Using Xenograft, Autograft, and Platelet-Rich Plasma in 97 Patients

*Chawket Mannai, DDS, PhD**

Purpose: We studied the reconstruction of the maxilla with the simultaneous placement of International Team for Implantology (ITI) implants with the combined use of a small amount of intraoral autogenous bone providing the necessary viable stem cells, and a larger amount of xenogenic bone used as a scaffold and a purely autologous platelet concentrate providing the growth factors for optimal bone formation.

Patients and Methods: Ninety-seven consecutive patients, 57 females and 40 males, with severe maxillary atrophy necessitating bone grafting for implant and fixed bridge reconstruction were treated between 2001 and 2003. A total of 314 implants ITI sand-blasted large-grit acid-etched type were placed simultaneously in the anterior, posterior or both parts of the maxilla.

Results: Of all the cases, 97.8% healed uneventfully with excellent hard and soft tissues healing. Bone maturation was excellent at 3 months as seen on x-rays and CAT scans.

Conclusions: The use of autologous platelet concentrate combined with autogenous and xenogenous grafts allowed fast soft and hard tissue healing.

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Until recently, autogenous bone grafts were considered to be the gold standard for the reconstruction of extensively resorbed maxillas prior to receiving implant placement.

Gazdag et al[1] have summarized the ideal characteristics of the graft material:

An osteoconductive matrix, which is a nonviable scaffolding conducive to bone ingrowth.
Osteoconductive factors, which are the chemical agents inducing the various stages of bone repair.
Osteogenic cells, which have the potential to differentiate and facilitate the various stages of new bone formation.
Structural integrity.

Autogenous bone grafts satisfy all these criteria, and new bone formation often results in a mature, dense bone in a 6- to 12-month period.[2,3]

When a considerable amount of bone is necessary for extensive reconstruction of the maxilla, bone grafts are obtained from extraoral sources (eg, iliac crest, parietal bone). Despite the excellent healing process, bone resorption often occurs and is unpredictable.

The use of guided-tissue regeneration and barrier membranes provides more predictable results, but healing time remains unchanged and complications such as infection of the membrane sometimes occurs, necessitating its early removal.

With the introduction of autogenous platelet concentrates, a new era in soft and hard tissue reconstruction has emerged.

Autologous platelets can be sequestrated, concentrated, and mixed to thrombin and calcium to yield a viscous coagulum called autologous platelet gel (APC+) or platelet-rich plasma (PRP) (10^6 platelets/μL in a 5-mL volume of plasma).

Tayapongsak et al[4] reported in 1994 on the use of autologous fibrin adhesive (AFA) in conjunction with particulate cancellous bone in mandibular reconstruction and concluded that AFA seemed to accelerate the

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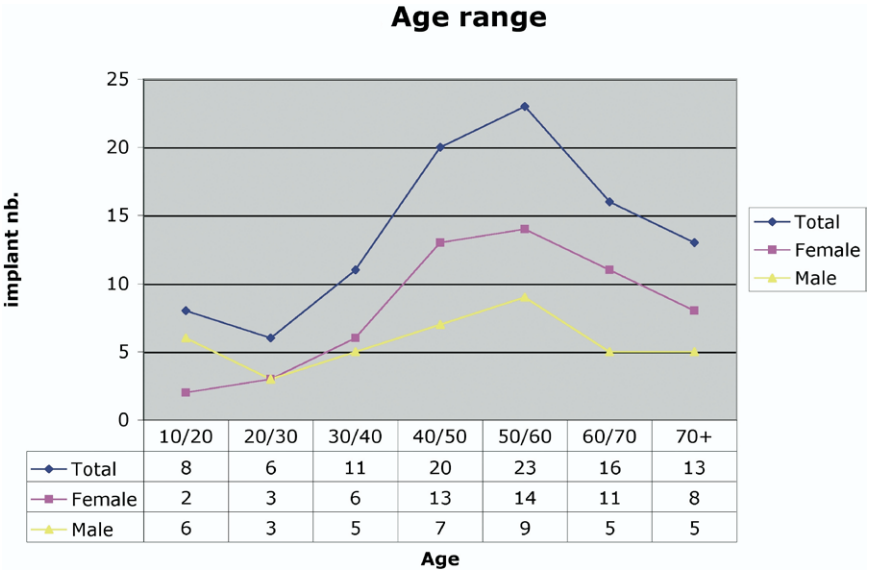

FIGURE 1. Age range.

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bone graft healing process. Healing time was decreased by half, according to his studies. In 1997, Whitman et al[5] were the first to report on the successful use of platelet gel in the area of reconstructive oral and maxillofacial surgery. Marx et al,[6] in 1998, presented their results with the use of PRP, describing in detail the mechanism of action of the growth factors contained in PRP in conjunction with the use of autogenous bone graft. Their results were a definite enhancement of bone regeneration both in rate and amount. Autogenous bone grafts were used in their studies.

Rodriguez et al[7] recently presented a clinical study concluding that the use of PRP in combination with deproteinated bovine bone was effective for maxillary sinus augmentation with simultaneous insertion of endosseous implants in the severely resorbed posterior maxilla.

The purpose of our prospective study is evaluation of the reconstruction of the maxilla with the simultaneous placement of International Team for Implantology (ITI) implants. The reconstruction of the maxilla was achieved in all cases with the combined use of a small amount of intraoral autogenous bone providing the necessary viable stem cells, a larger amount of xenogenic bone used as a scaffold, and a purely autologous platelet concentrate providing the growth factors for optimal bone formation.

Materials and Methods

During the period from 2001 to 2003, 97 consecutive patients, 57 female and 40 male, with severe maxillary atrophy necessitating bone grafting for implant and fixed bridge reconstruction were treated. Ages ranged from 16 to 87 years, with a mean age of 54 years (Fig 1).

A total of 314 ITI sand-blasted large-grit acid-etched (SLA) type implants (Straumann, Waldenburg, Switzerland) were placed simultaneously in the anterior, posterior, or both parts of the maxilla (Fig 2). All patients were operated on under local anesthesia with no sedation. Follow-up ranged from 6 to 30 months after fixed bridge placement.

All patients had simultaneous placement of ITI implants and bone grafting mixed to APC+. Bone grafting was composed of 25% to 30% of autogenous bone and 70% to 75% of xenogenous bone (bovine). Autogenous graft was solely taken from an intraoral source (tuberosity, chin, retromolar areas).

About 7 mL of APC was obtained using the Smart-Prep II (Harvest Technologies, Plymouth, MA and Munich, Germany), which is a dual-spin fully automated machine and provides a concentration of up to 700% of baseline. Autologous blood and thrombin were used in all cases.

A gel was obtained mixing 1 mL of 10% calcium chloride with the autologous thrombine and APC+. The APC+ was immediately mixed to the bone and formed a very easily moldable substance that was applied to the patient (Fig 3).

In the posterior maxilla, bone height of less than 3 mm was sufficient for implant and graft placement. A routine sinus lift procedure was performed (Fig 4). After initial placement of bone mixed to APC+ at the lower part of the sinus, the implants were gently driven through the graft and stabilized with additional graft material to cover the entire implant (Fig 5). Additional APC+ gel was applied above the graft and avoided placement of any additional membrane (Fig 6).

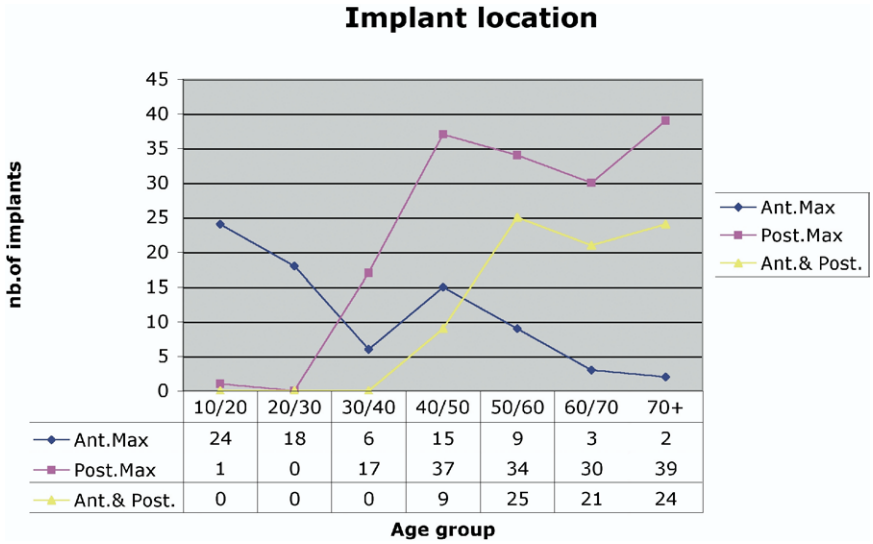

FIGURE 2. Implant location.

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Primary closure around the implants was obtained with periosteal release when necessary and again APC+ gel was applied on the wound to promote soft tissue healing.

In the anterior part of the maxilla, reconstruction was used primarily in the presence of thin ridges where the implant had a primary stabilization and when a posterior or an anterior wall with a normal bone height was present. At this time, full reconstruction of bone height in the anterior region is done in our practice with autogenous blocks from the symphyseal or the posterior mandibular area mixed with autologous platelet concentrate. These cases were excluded from the current study and will be reported in a different study.

A 3-month healing period was allowed prior to implant loading after re-entry when necessary. Preoperative and postoperative computed tomography (CT) scans and panoramic x-rays were performed in all cases (Figs 7, 8). Direct measurements were taken from the preoperative CT scan and compared with the postoperative scan. Bone height in the posterior maxilla was 5 mm or less.

All implants were systematically loaded at 3 months and abutments were tightened at 35 N-cm if the implant was fully integrated (Fig 9).

Fixed porcelain fused to metal bridges was fabricated and placed for full function (Fig 10).

Results

A total of 7 implants was not fully integrated at 3 months (2.2%); 3 implants (1%) were lost and 4 implants were left for 1 additional month and fully

FIGURE 3. A gel is formed using APC+, human thrombine, and bone grafts.

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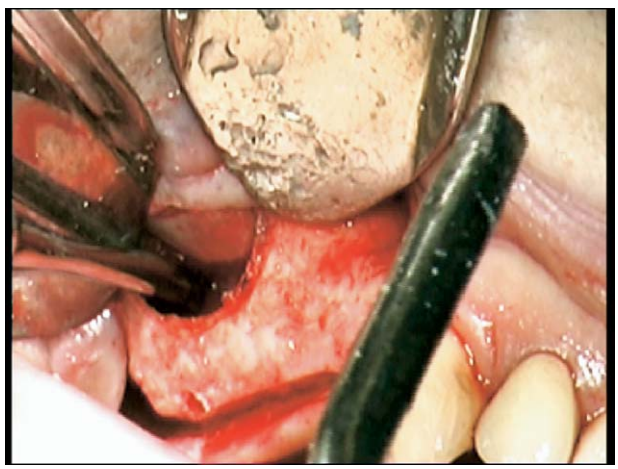

FIGURE 4. Sinus lift procedure. Note the thin cortical bone.

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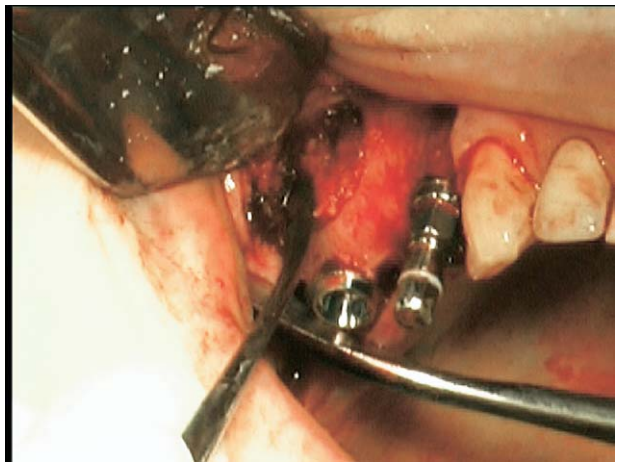

FIGURE 5. Additional graft is inserted and layered directly on the implant surface.

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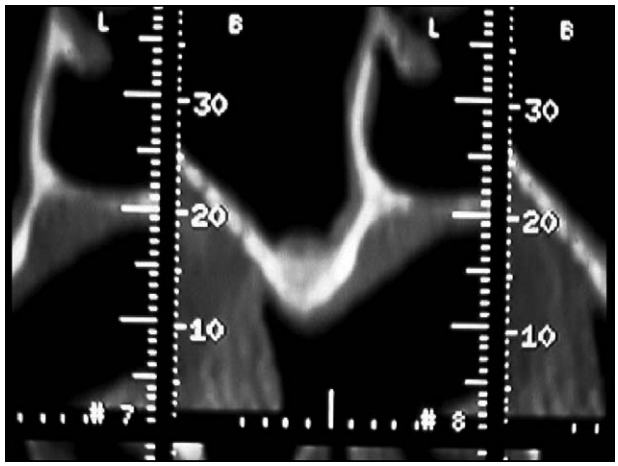

FIGURE 7. Preoperative CT scan showing a limited amount of available bone.

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integrated. A partial explanation for these implant failures is that 2 patients had an early infection (less than 2 weeks after surgery) that was successfully treated with antibiotics but resulted in slightly mobile implants and eventually loss of these implants (1 implant out of 3 in 1 patient and 2 implants out of 5 in another patient); these implants were not replaced. The surgical site healed perfectly and no sequelae were observed, but the graft had resorbed.

Four additional implants, on 3 other patients, showed a slight rotation upon loading and were left and monitored for full integration, which occurred within a month.

All the other cases healed uneventfully (97.8%) with excellent hard and soft tissue healing. Bone maturation was excellent at 3 months (Fig 10), as seen on x-rays and CT scans.

It was interesting to note no significant statistical differences between submerged and nonsubmerged implants. ITI implants were submerged in the anterior part of the maxilla for esthetic purposes but were left unsubmerged in the posterior part of the maxilla.

After loading and abutment placement, the patient was sent to his restorative dentist for immediate fabrication of fixed prostheses. After prostheses placement, the patients were followed at 1, 3, and 6 months the first year, and each year afterwards.

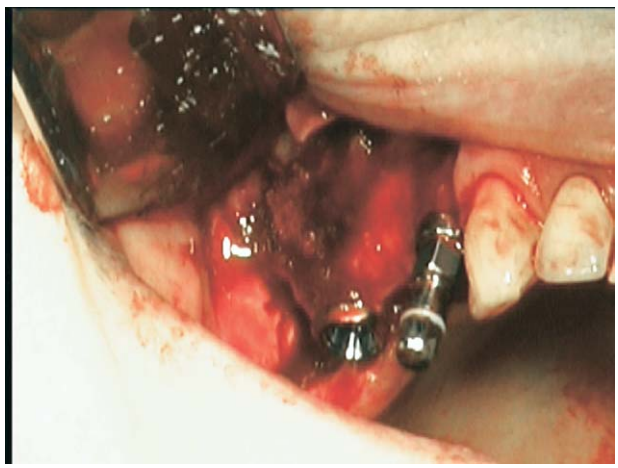

FIGURE 6. Platelet-rich plasma is added over the graft to form a "biologic membrane."

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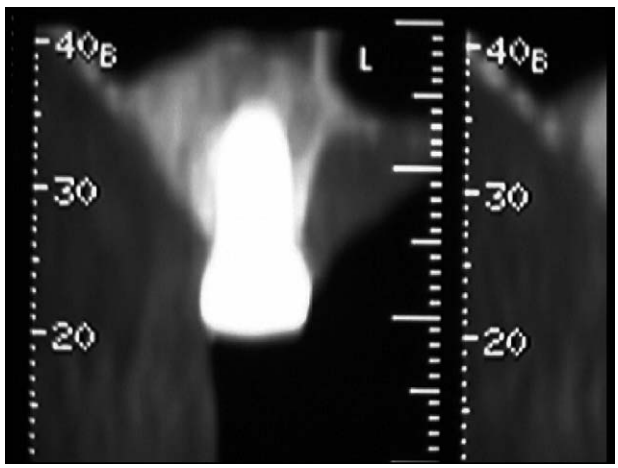

FIGURE 8. Postoperative CT scan of the same patient with good bone healing at 3 months.

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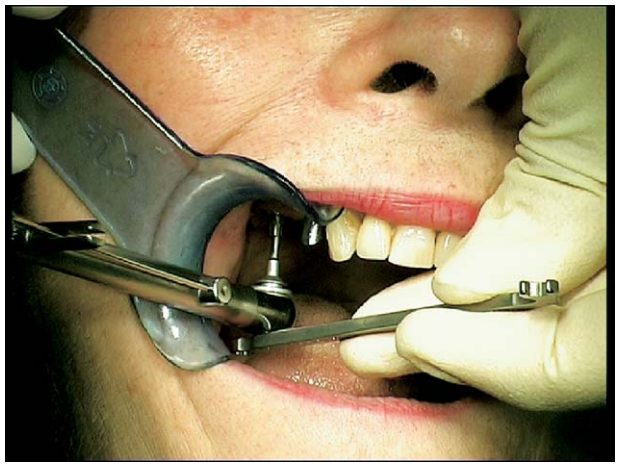

FIGURE 9. Implant loaded and tightened at 35 N-cm.

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Discussion

Refined surgical procedures and patient demand have expanded the possibilities of functional and esthetic rehabilitation with implants.

In severely resorbed maxillas, bone graft procedures have now become a routine prior to and sometimes in conjunction with implant placement. When large amounts of bone are required, autogenous iliac crest grafts is the most frequently used procedure, although some authors recommended the use of cranial bone instead, because of its membranous origin.

In a series of articles, Ozaki and Buchman[8-11] challenged the accepted theories of the superior volume maintenance of membranous versus endochondral bone and its preferred clinical use as an onlay grafting material in the craniofacial region. From their studies, they determined:

Cortical bone was a superior onlay grafting material to cancellous bone independently of its origin and there was no difference in the 3-dimensional ultrastructure of cortical and membranous bone.

Cancellous onlay bone grafts develop a more dense, less trabecular, more organized, and more interconnected internal ultrastructure over time.

Nevertheless, this technique required a hospital setting and needed an extraoral donor site with the accompanying morbidity, and simply did not meet patient acceptance in most cases. Additionally, results are not predictable and bone resorption may occur. The introduction and use of barrier membranes has limited early soft tissue ingrowth into the graft and improved bone healing while limiting bone resorption. Barrier membrane, whether resorbable or not, also carried its own limitations and complications.

A minimum of 6 to 8 months is necessary for bone maturation prior to implant placement. If simultaneous implant placement was sometimes achieved, higher implant failure was observed because of revascularization time of the bone graft.

The introduction and the use of autologous platelet concentrate in oral and maxillofacial surgery seems to have changed and challenged our approach toward extensive reconstruction of resorbed maxillas and mandibles for implant reconstruction. With a simple office procedure and with proper technology, platelets can be sequestrated and concentrated. Platelets are carriers of proteins called PGF (protein growth factors) involved in regeneration of injured tissues. PGF are active signals for attracting stem cells into the site of injury and triggering proliferation of these cells. Chemotactic and mitogenic stimulation of these mesenchymal stem cells occurs and leads to an enhancement of bone repair and regeneration. Bone regeneration seems to be proportionate to platelet concentration, thus proper technology and selective automated device is necessary to obtain good results. Marx et al's studies confirmed that viable platelet concentrate levels of 300% to 600% above baseline were necessary to achieve optimal bone and soft tissue healing.[12-14]

Recent in vitro studies by Haynesworth et al[15] confirm the clinical results obtained with the use of APC+. These authors studied the cellular mechanism of action of PRP leading to enhancement of bone repair. They concluded that PRP releasate stimulates chemotactic migration and proliferation of human mesenchymal cells in a dose-dependent manner and without loss of their osteogenic developmental potential.

Rodriguez et al[7] recently published a report on the sole use of bovine bone in conjunction with autolo-

FIGURE 10. A fixed porcelain bridge is inserted. Note the excellent soft tissue healing.

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gous platelet concentrate and simultaneous placement of implants. They speculated that immature osteocompetent cells could be recruited from the local environment and that PRP in combination with Bio-Oss (Geistlich, Zurich, Switzerland) possesses osteoinductive properties. Our early experience with the sole use of PRP in combination with bovine bone alone led to poor clinical results in maxillary reconstruction.

Resorbable bone mineral (RBM) onlay may provide a scaffold for bone formation, and RBM is solely osteoconductive and gradually resorbs by multinucleated osteoclast-like cells. Merkx et al,[16,17] in other studies of incorporation of particulated bone implants in the facial skeleton, concluded that RBM granules as solitary implant in a critical-sized defect do not stimulate osteoconduction but give rise to an extensive osteoclastic activity stimulated by mutual loose relation.

However, various studies by Hallman et al,[18] using a mixture of 80% bovine bone, 20% intraoral autogenous bone, and fibrin glue showed a positive bone tissue response 6 months and 3 years after augmentation of the maxillary sinus floor prior to implant placement. In another clinical study,[19] they concluded that the effect of adding autogenous bone remains unclear but may allow for a reduction in healing time. In their study, 6 to 9 months were necessary prior to implant placement, followed by another 6 months before loading the implants, which brings the total treatment time to more than 1 year.

Optimal bone tissue regeneration necessitates the combined use of a scaffold, growth factors, and osteogenic cells.[20] In our study, the scaffold is provided mainly by the bovine bone, the growth factors by the autologous platelet concentrate, and the osteogenic cells by the autogenous bone graft. This combination has resulted in an excellent and reliable way of maxillary reconstruction with concomitant implant placement.

The use of rough surface implants, although not compared with smooth surface implants in our study, was instrumental in primary implant stability. The extended bone-implant interface of the SLA ITI implants used may have played a major role in decreasing healing time.

The use of autologous platelet concentrate definitely allows faster soft and hard tissues healing through the mechanism of chemotactic migration, mitogenic stimulation, and osteogenic differentiation of stem cells. Clinical studies have now been implemented by in vitro studies supporting these observations.

When combined with a mixture of autogenous and xenogenous bone, clinically relevant healing time was reduced to 3 months instead of the required 6 to 9 months when APC was not used.

It was also possible to substantially reduce the amount of autogenous bone, thus avoiding the problems of harvesting bone graft from an extraoral donor site. However, it is of utmost importance to use a highly concentrated autologous platelet substrate if optimal results are to be expected.

Because of the easily moldable and manageable paste-like substance obtained, insertion of simultaneous rough-surface ITI implants was also possible and successful, thus considerably reducing the total treatment time and meeting patient satisfaction.

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