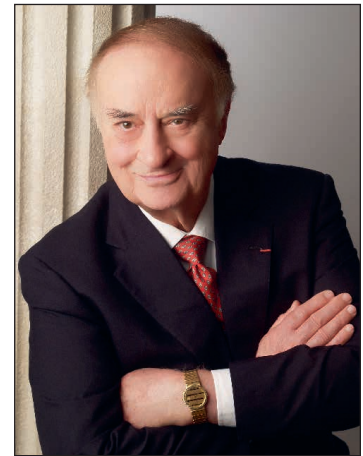


INTRODUCTION

Hilt Tatum Jr, DDS



When Dr Jensen contacted me about contributing to this third edition, I was uncertain. It had not been possible for me to participate in the Sinus Consensus Conference, and at the time I had not read his book. After reading the second edition, I realized it would be an honor to participate in this one.

The Preparation

My journey leading to the sinus augmentation procedure started in 1956, when I attended the first course on oral implants given in an American dental school, the Emory University School of Dentistry. The course was presented by Col Roy Bodine. My clinical experience began with 2 years of service in the Marine Hospital located in Savannah, Georgia. The next 2 years were spent doing full-mouth restorative dentistry in Savannah before I joined my father, Hilt Tatum Sr, and brother, Crawford Tatum, DDS, in Opelika, Alabama. There, our practice quickly became oriented to extensive restorative dentistry.

We recognized patients' and our own dissatisfaction with free-end partial dentures and felt that this need could be met with the use of endosteal implants and fixed restorations. In an attempt to fix the problem, we acquired two sheets of commercially pure titanium, 0.25 inch thick and 0.75 inch thick. Using these sheets, we began to make and successfully use endosteal implants with different shapes that were designed to fit into the available bone found in different patients. After the implants were placed, we waited to load them until after a healing period similar to that used for mandibular fractures. However, because most of these patients had worn partial dentures for extended periods of time, we recognized the severe vertical bone loss and the need to restore the missing bone before the patients could receive implants.

The obvious answer to this need was to restore the missing bone volume with autogenous bone augmentation. However, as we began our preparation period before performing these surgeries, a startling event occurred. I had the chance to meet with Dr Frank Morgan, who had extensive experience doing bone grafting to treat battlefield wounds during the Vietnam War. When I discussed our plans with Frank, he shocked me with the following words: "Hilt, if you do this elective surgery on your private restorative patients, it will bury you with the complications you will encounter." This completely stopped our efforts toward bone construction for some time.

Don Tillery, an oral surgeon and close friend, was aware of the preparation we had done and the effect that Dr Morgan's advice had on our plans. In early 1969, Don called and said that he had seen a technique that he thought would safely meet our goal. He told me about an oral surgeon, Dr James Alley, who had successfully done a series of preprosthetic bone augmentations on edentulous mandibles before denture construction. We contacted Dr Alley, and he invited us to visit his office. We spent a week with him, observed two surgeries, and were able to see several patients who were at different periods of time postsurgically. The technique consisted of placing an autogenous rib (with no screws) on an edentulous mandible. This was followed by a 6-month unloaded healing period and then the construction of a new mandibular denture. He reported no postoperative healing complications.

The secret to Dr Alley's success was in making two vertical incisions in the vestibule of each canine area, tunneling and mobilizing the soft tissue over the entire mandible, decorticating the crest of the mandible, shaping and placing the rib, and closing the remote incisions. The secret therefore was good asepsis, no incisions over the graft material, decortication, and an unloaded healing period. One patient who had worn the postoperative denture for 2 years appeared to have very little of the augmentation left.

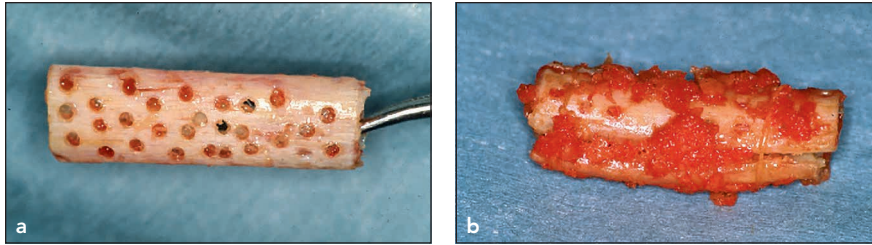


Fig 1 Autogenous rib with one thickness (a) and two thicknesses (b) from 1970.

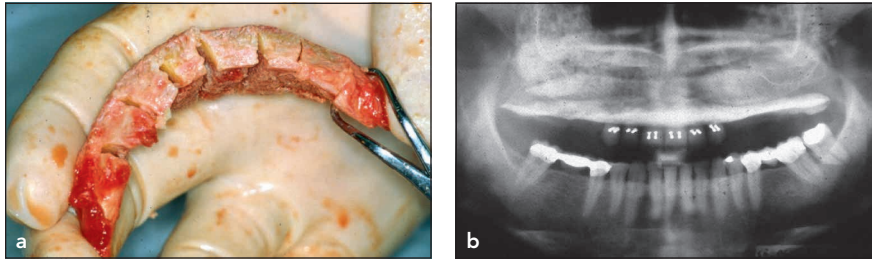


Fig 2 (a and b) By 1980, we were using autogenous iliac bone for the maxilla and bilateral sinuses done with two vertical vestibular incisions.

These were our takeaways from this visit:

- Surgical asepsis would be critical.
- Decortication aided the augmentation union with the mandible.
- Remote incisions had prevented postoperative infections.
- Loading of the denture had largely destroyed the newly formed crestal bone.
- Placement of endosteal implants should not destroy the new crestal bone.
- Placement of endosteal implants should internally load and stimulate new crestal bone.
- Most importantly, we could safely begin to restore alveolar bone.

In January of 1970, we performed the first of four successful autogenous rib augmentations on posterior edentulous mandibles (Fig 1) harvested by Dr William Lazenby. Following his suggestion, we later began using the ilium as a bone source. Over a period of 9 years, Dr Lazenby and Dr Doyle Hanes routinely harvested bone for our augmentation patients (Fig 2) until I relocated my practice to St Petersburg, Florida, in 1979. Because all of these patients were treated in a hospital environment with remote incisions and Millipore filters (MilliporeSigma) over the augmented bone, we experienced a very limited number of postoperative surgical complications.

I have had the opportunity to give more than 2,000 podium presentations demonstrating these principles of creative remote incisions for all augmentation locations. These have been presented to a wide range of dental meetings, practitioners, and specialists. It surprised me that a large majority of alveolar augmentations have continued to be completed with crestal incisions over the augmentation material, sometimes resulting in complications. With good asepsis, remote incisions, adequate tissue mobilization, effective augmentation material, and precise tissue closures, complication rates will be significantly reduced.

We also found that augmented bone remained stable after implant placement, healing, and restoration. We did observe that when large augmentations were done within the esthetic zone, it was wise to maintain patients with provisional restorations in function for a period of 2 years before the definitive restorations were placed. This resulted in the most desirable esthetic results.

The Sinus Procedure

As our augmentation experience progressed, we recognized that it was impossible to do a vertical onlay augmentation in a posterior maxilla with no vertical loss and a severely pneumatized sinus without infringing on the vertical space required for the dental restorations. For the longest time, this seemed an insurmountable challenge. Then, in 1974, the thought occurred to me that we were looking at the problem backward and should be putting the bone inside of the sinus rather than on the crest. Immediately after this epiphany, I had parallel feelings of both exhilaration and fear. I was exhilarated by the thought that it might be possible, but the fear was that which any dentist might have on considering contact with a maxillary sinus.

During the remainder of 1974, we placed a number of posterior maxillary implants in the following way. We would either machine a titanium implant or cast a Vitallium implant that would fit into the medullary space between the sinus floor and the crest of the ridge (Fig 3). We also cast a try-in that had the same side dimensions but was longer than the implant. A remote palatal flap was lifted to expose the ridge crest, and curettes were used to prepare the implant site by removing bone to the floor of the sinus to match the dimension of the implant. The try-in was then fitted into this socket and lightly tapped to release the sinus floor. The floor and mucosal lining were vertically elevated a few millimeters, and some of the curetted bone was

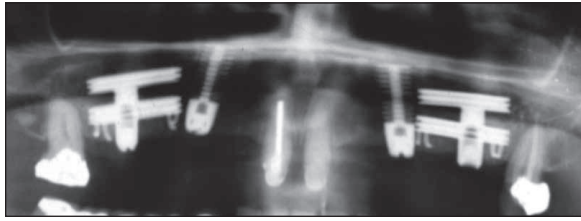


Fig 3 Custom-made implants elevating the sinus floor and custom-made root form from 1974.

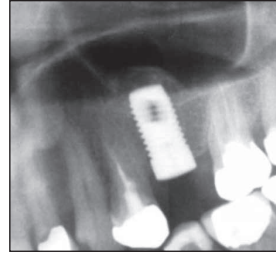


Fig 4 Sinus floor elevated by compressing bone and without entering the sinus.



Fig 5 Inflated Fogarty catheter elevating the sinus membrane.

placed into the space around the elevated floor. The implant was then placed into the deepened socket and additional bone was placed over the implant to the crest of the ridge, with only the implant neck exposed. The flap was rotated and sutured on the palatal wall. The healing around each of these implants was uneventful, and they were restored.

We have always referred to this procedure as a *sinus lift*. By 1980, we had modified the technique into compressing the cancellous bone threads into an intertwined mat that could elevate the floor as it deepened the socket without entering the sinus (Fig 4). We now use these bone manipulation osteotomes to form the sockets, compress the cancellous bone, and elevate the sinus floor.

Our first sinus augmentation with autogenous, particulate, iliac bone was done in February of 1975. This, along with our next four augmentations, was done from the crest of the ridge and opened with a palatal flap. We then began to primarily use a crestal incision and prepare a sinus window anterior to the zygomatic buttress on the lateral wall of the maxilla. However, our fear of the word *sinus* was so strong that in the hospital operative notes, we would describe the operation as an *inverted maxillary bone graft*.

At the 1976 Alabama Implant Congress meeting in Birmingham, Alabama, we reported on the sinus augmentation procedure and the results we had observed during the previous 15 months. I was invited to make a presentation in the fall of 1977 on sinus augmentation at the American Academy of Implant Dentistry annual meeting and asked Dr Philip Boyne to join me. In a 1994 meeting of the Alabama Implant Congress (at the same podium from which I first presented in 1976), he confirmed our success with this procedure before an audience of more than 300 attendees.

During the first several years of sinus augmentations, we had limited instruments and relied heavily on modified Fogarty catheters to aid in the elevation of the sinus membrane. These were shortened to a few inches long and attached to a syringe. When slid under the sinus lining and gently inflated, they could safely lift the membrane (Fig 5). By 1978, we had created suitable instruments and no longer needed the Fogarty catheters.

Until 1984, autogenous iliac bone was our primary augmentation material. However, from 1972 until 1982, we were furnished some frozen human allograft by Dr Bill Hiatt from the VA-funded

study, 1962–1982, for which he was a codirector. We established and maintained the same cryogenic banking capability as was used in the study and would always have a suitable human lymphocyte antigen match between the donor and recipient for anyone treated with this bone. Results comparable with autogenous bone were observed on the sinus augmentation patients treated with this allograft.

From 1978 forward, we began to utilize a titanium root form system I had developed, which became the first titanium root form system with FDA marketing approval (Fig 6). This system also included a selection of designs that were used to elevate the sinus floor and used the curretted bone that was harvested during the socket preparation (Fig 7).

From 1979 until 1983, we did the surgical cases for the US Food and Drug Administration (FDA) preclinical study on tricalcium phosphate ceramic (TCP) as a bone augmentation material. We evaluated and found this product to be successful for sinus augmentations, though slower in its replacement than human bone.

In the summer of 1982, Martin Lebowitz, DDS, MS, left the chairmanship of the OMS Department at the University of Florida School of Dentistry to join me. Following this, many of the Le Fort I surgical cases also had simultaneous sinus augmentations. Martin was left-handed and I was right-handed, which allowed us to both operate at the same time with the following steps:

- Careful attention was given to achieve optimum asepsis within each nasal passageway during preparation and intubation.
- After maxillary downfracture, a careful, meticulous freeing of the nasal mucosa from bone to prevent tears in this tissue was done. This was important to protect the augmentation material from risk of contamination from bacterial flora occurring in the nose.
- We also provided a hyperbaric oxygen chamber within our office to aid in the management of potential anaerobic infections.

In 1984, my son, Hilt Tatum III, DMD, joined our practice. During that same year, multiple augmentation products became available with the freeze-dried demineralized bone products reported as the most favorable. We used multiple products for

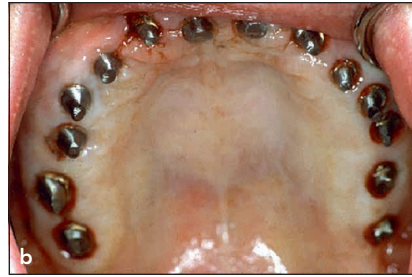
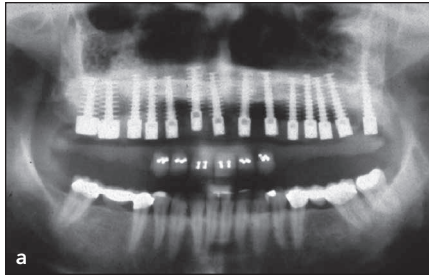


Fig 6 (a and b) Transmucosal implants and soft tissue reconstruction in augmented maxilla and bilateral sinuses.

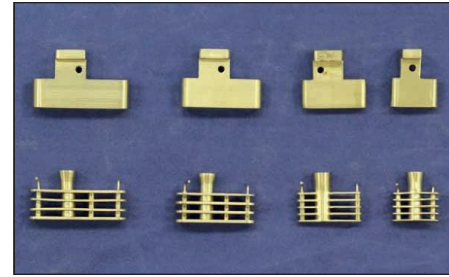


Fig 7 Sinus implant selection and try-ins. This photograph shows 4 of the 16 sizes made.

sinus augmentations during this period, but by 1986, our clinical results were varied and confusing. We decided to evaluate each class of products by comparing results with histomorphometric evaluations taken from bilateral sinuses in the 4th postoperative month. We obtained three to five results from each type of the tested materials and were surprised by what we found. The best results (37% new bone) were obtained from irradiated cancellous human bone (ICB, Rocky Mountain Tissue Bank), and the second best was from 1- to 2-mm demineralized freeze-dried cortical bone chips (12% new bone).

Since 1988, the ICB from Rocky Mountain Tissue Bank has been our product of choice for sinus augmentations. This recognition that ICB provided a sinus augmentation product comparable with autogenous bone permitted a readily available and reliable material for in-office surgical procedures. Also, this product allowed us to perform lateral wall augmentations and place root-form implants rather than the special sinus implants. The average amount that we have used for each sinus has been 7 g.

In the mid-1990s, I designed and made a number of instruments to improve our ability to perform sinus procedures. These included flap retractors to fit over different shapes found on zygomatic buttresses and curettes made to fit the different anatomical areas found within sinuses. These instruments have significantly simplified and improved the precision of the surgeries.

Even when following a strict protocol under exact specified patient conditions, complications may occur. When a tear is present in the mobilized mucosal lining, excess tissue is folded over the tear and stabilized with a shaped collagen tape just prior to placing the bone. The tape will momentarily adhere to the lining, and by placing the bone immediately against the tape, it will stabilize the tape and hold the torn tissue in position. When postoperative infections occur, they will typically become symptomatic within a few days after the surgical procedure. Immediate attention, including culture and sensitivity testing, modification or expansion of antibiotic coverage with therapeutic doses, and further modification as directed following sensitivity testing, has proven to be effective in the majority of patients. If this does not completely eliminate the symptoms within a period of 7 to 14 days, removal of all augmentation

material is usually indicated. If implants were placed during the augmentation procedure, this regimen would not be expected to be successful as a result of the biofilm-shielded bacterial colonies growing and shielded on the implants. In our 43 years of sinus augmentations, we have lost the grafts in less than 1% of the sinuses treated.

Vascularized Osteotomies

By 1980, we recognized that sinus and interpositional bone augmentations as well as free-flap procedures were safer and more precise than onlay procedures. Hoping to demonstrate this, I took a training course in microvascular surgery. We then attempted to replace onlay autogenous procedures with free-flap microvascular procedures using autogenous iliac sources. Though we could make the microvascular connections, we found that developing the correct bone shapes in the precise locations needed on the alveolar ridges was like fitting a square peg in a round hole. Still, the idea fascinated me, and in early 1982, we did a maxillary vascularized osteotomy procedure attempting to achieve a free-flap result by using the natural alveolus with its blood supply and without the need for microvascular surgery.

This was successful, so we published a paper on maxillary augmentations with the technique and have developed and expanded its utilization through the years.¹ It instantly produces the results sought with a distraction osteogenesis procedure with minimal or no hardware. Typically, a long titanium screw (ie, 18 to 24 mm) is used to stabilize the vertically moved bone. ICB and irradiated corticocancellous (ICC) blocks are used for the interpositional material (Fig 8). Alternative vertical stabilization can be achieved with miniplates or ICC blocks. It is true that the shape of a healed alveolar ridge is not the shape of an alveolus surrounding teeth. However, the plasticity of vascularized alveolar bone, combined with the correct instruments, knowledge, and skill of bone manipulation, makes it possible to transform the vertically corrected but misshaped bone into a perfect socket. An implant can then be crestally positioned within the same location previously occupied by the root it is



Fig 8 (a to d) Tatum vascularized osteotomy (TVO). The goal is to regain bone attachment in the mandible by using a vertical fixation screw and implants.

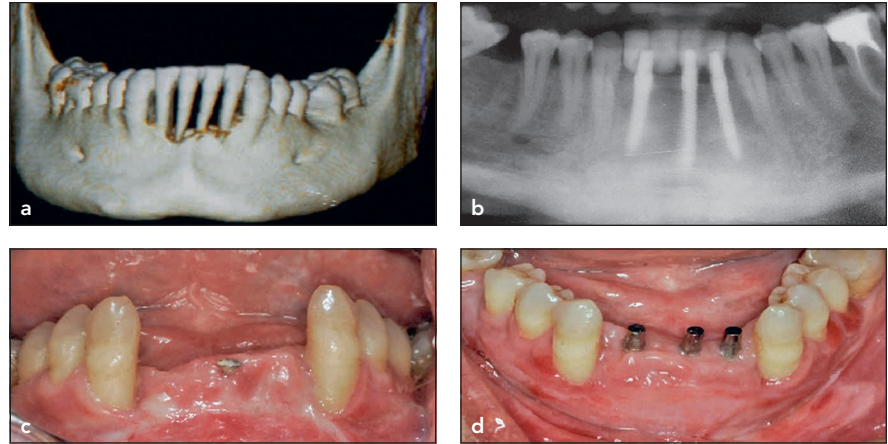


Fig 9 (a to d) Bone expansion, implant, and restorative treatment by Dr Jose Pedroza.

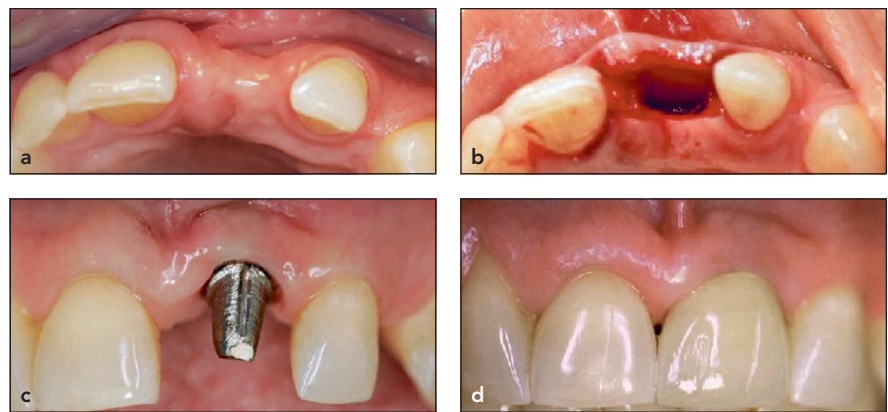
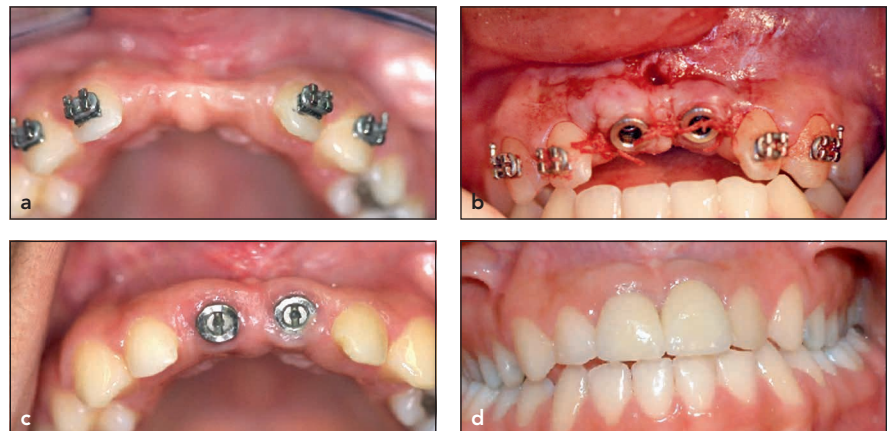


Fig 10 (a to d) Bone expansion, implants, and restorative central crown restorations by Dr Ana Ayala.



replacing (Figs 9 and 10). The correct use of this concept will produce the safest, simplest, and most precise correction of a vertical deficiency.

We have used this to perform office procedures with intravenous sedation and local anesthesia, including the following:

- Move healed implants (Fig 11)
- Move segments of teeth and bone (Fig 12)
- Correct single implant sites (Fig 13)
- Move multiple edentulous segments (Fig 14)

- Correct vertical defects simultaneously with sinus augmentations (Fig 15)
- Move full maxillary arches (Fig 16)

The safety lies in the maintained vascularity and vitality of the bone, surgical asepsis, the interpositional location of the augmentation material, and the remoteness of the incisions. We have described this procedure as a *Tatum vascularized osteotomy* (TVO).



Fig 11 (a to d) TVO used to move an implant.

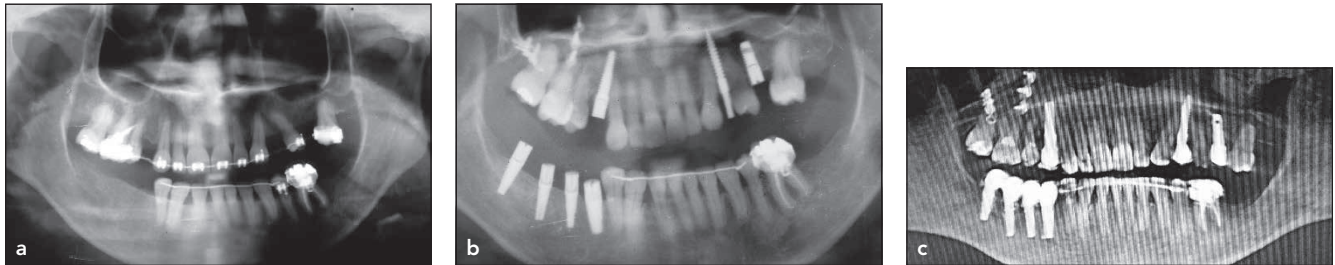


Fig 12 (a) Preoperative maxillary extrusion and an extreme buccal relationship. (b) TVO to correct abnormality and with implants placed. (c) Completed case with restorations by Dr Jose Pedroza.



Fig 13 (a and b) Preoperative. (c to e) Using TVO. (f and g) Implant and restoration by Dr Jose Pedroza.



Fig 14 (a and b) TVO correction before implant placement.



Fig 15 Simultaneous sinus augmentation and TVO, implants with bone expansion and manipulation of gingiva. (a) Preoperative. (b) Postoperative.

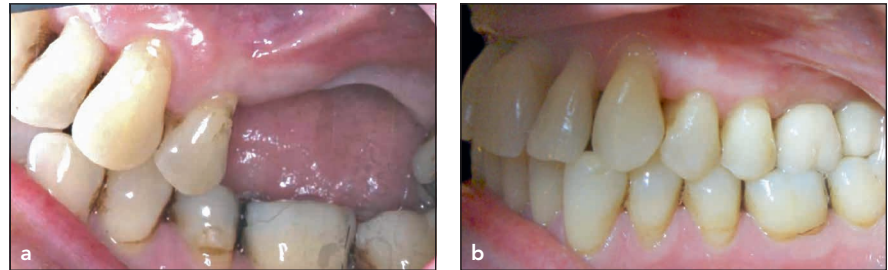
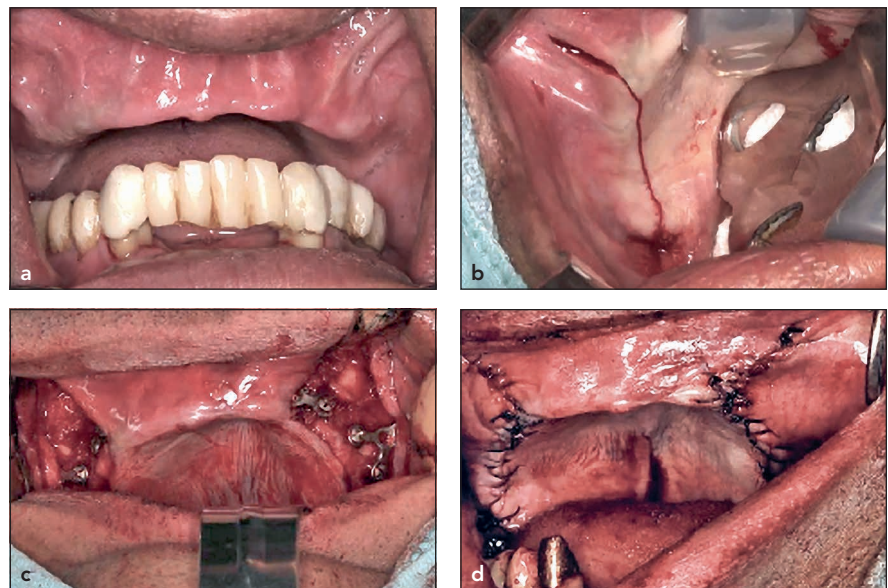


Fig 16 (a to d) Full maxillary alveolus moved 8 mm down and 4 mm forward and crossbite correction all as in-office procedures.



The Future of Sinus Augmentations

It is our opinion that the future of the sinus augmentation procedure will include the simultaneous correction of vertical deficiencies. For a number of years, over half of the sinuses we have augmented have had simultaneous vertical corrections. These have been accomplished with either a TVO or an onlay block, and we will describe both. When a block is to be placed, an incision is made one tooth and one papilla anterior to the edentulous area and the same palatally to the midline or beyond, and a full-thickness flap is rotated over this tooth to prevent any incision from being present over the block. This flap must be completely elevated from the maxilla, including a buccal cut through the periosteum.

When the TVO is indicated, it can be correctly done and the implants later placed with bone manipulation. The TVO is safer than an onlay and produces the most precise results. The greater challenge here is that this requires the implant placements to be done with bone manipulation; this is a skill and an art that requires patience and training. The further complication is that we have a limited number of instructors with these special skills.

The TVO technique

Bone cuts are made with a set of microtomes that are designed for this procedure. The greater palatine vascularity to the soft tissue and bone should be preserved. The sinus elevation is completed as described previously and must be above the level of the hard palate. All bone cuts are made from the buccal without penetrating the palatal soft tissue and with progressive

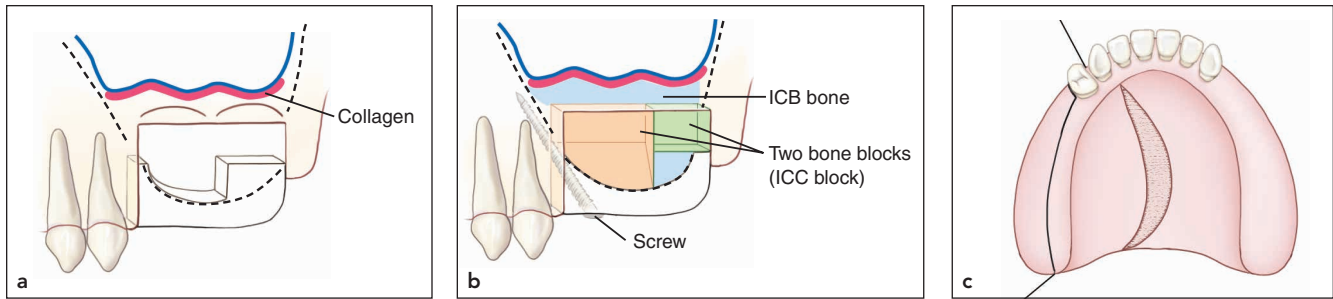


Fig 17 (a) After the elevation, collagen is placed against the lining. (b) ICB is placed, and a stent is added to allow placement of bone blocks with a screw for stabilization. (c) Palatal view of completed surgery and area to granulate.

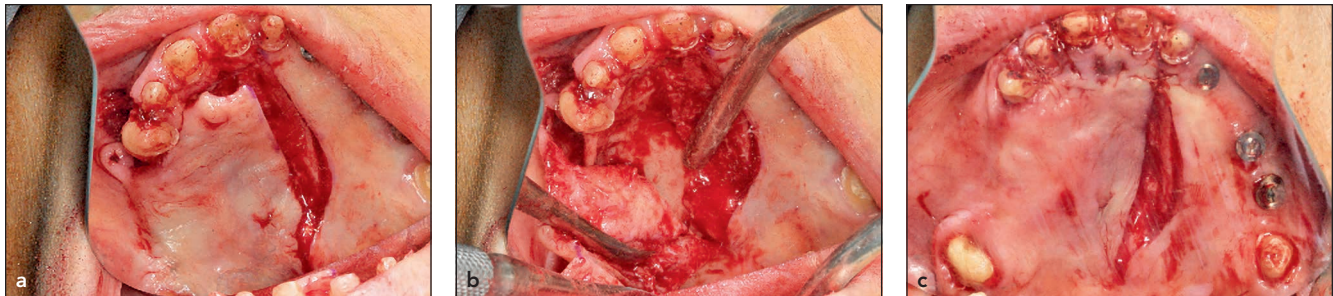


Fig 18 Onlay block and sinus augmentation showing (a) incision, (b) remote vascularized flap elevation, and (c) occlusal view of block in place, palatal tissue, and area to granulate.

microtomes (5 mm, 7.5 mm, 10 mm, 12.5 mm, and 15 mm) to produce a straight cut.

The anterior vertical cut is anterior to the vertical deficiency and is made through the alveolus to the level of the hard palate. Note that roots are never stripped of bone. A horizontal cut is made through the sinus and palatal slope just below the hard palate and anterior to the greater palatine foramen. The distal vertical cut is made through the tuberosity to the level of the hard palate or as a separation between the pterygoid plates and the maxilla to that level.

A superficial horizontal bone cut to protect the greater palatine bundle is made with a wide microtome to the distal vertical cut in the area of the greater palatine foramen. The microtome is then rotated downward to complete the horizontal fracture.

A periosteal elevator is slid through this horizontal cut (anterior to the greater palatine) to elevate and mobilize the soft tissue from the hard palate over to or across the midline (artery is safely within this tissue).

A semicircular incision is made (facing the surgical site) in the tissue over the hard palate. This permits the segment to be moved downward as this flap slides laterally—the greater palatine artery is avoided and always protected. The exposed bone will granulate over in 2 weeks.

The shaped collagen tape is placed against the sinus lining. A layer of ICB mixed with antibiotic is placed against the collagen tape to stabilize the collagen. A premade stent will be used to vertically position the mobilized bone, and it will be stabilized with ICC blocks, vertical screws, plates, and ICB to complete filling the sinus space below the elevated lining. A stent or

dressings will be placed to hold this advanced soft tissue flap against the hard palate to create a fibrin seal (Fig 17).

When a vertically deficient maxilla is indicated for a sinus augmentation and the shape is not appropriate for a TVO, an ICC onlay block is indicated. The best results will be achieved by designing the flap to have no incisions over the augmentation and for the flap to be fully vascularized. There are a number of creative incision designs that can be used to provide access, maintain vascularity, reposition gingiva, or all of these tasks (Fig 18).

Conclusion

In 1977, we included this quote in our presentation: “The goal of modern implantology is to accept for treatment a patient at any stage of dental disease, atrophy, or trauma and—with general health permitting—restore them to normal contour, comfort, function, esthetics, and health.” Carl Misch opened each of his books with these goals. After 42 years and our over 2,800 sinus augmentations, this procedure has allowed us and many others to achieve these goals for countless patients.

Reference

1. Tatum H Jr. Endosteal implants. *CDA J* 1988;16(2):71–76.