Simplified Onlay Grafting with a 3-dimensional Block Technique: A Technical Note

Michele Jacotti, DDS[1]

Block allografts can serve as effective alternatives to block autografts but are more brittle and can easily break if not properly contoured to fit the defect site. The need to make such preparations during surgery can prolong the invasive procedure and may result in a less-than-optimum graft preparation that can compromise success. The sterile 3D block technique allows block allografts to be prepared and attached to a stereolithography model of the patient's jaw prior to surgery and then stored in a sterile environment until surgical delivery. Int J Oral Maxillofac Implants 2006;21:635–639

Key words: *allografts, bone grafts, corticocancellous bone, stereolithographic models*

In cases of deficient ridge height or severe ridge atrophy, block bone grafting is often necessary to restore the hard tissue anatomy prior to dental implant placement. The use of a mineralized, corticocancellous bone allograft can eliminate the additional surgical procedure required to harvest an autograft, but the precision modeling required to adapt the tissue to the defect site can add significant time and stress to the surgical procedure. This can result in a less-than-optimal fit between the allograft and the ridge defect. Alternatively, data from a computerized tomographic (CT) scan can be used to fabricate a precise 3-dimensional (3D) stereolithographic model of the patient's jaw using a nylon polyamide thermoplastic material that is capable of withstanding autoclave sterilization. The allograft can be prepared on a sterile field, screwed to the sterile model, and held in sterile packaging until the surgery. This enables the clinician to evaluate the allograft from different viewpoints without the typical intraoral visual obstacles, such as bleeding, flaps, and limited access. During surgery, the allograft can be transferred from the sterile model directly to the same location in the patient's jaw without the need for additional preparation. This technique can significantly shorten the actual surgical procedure for the patient and result in a better fitting graft than chairside preparation may allow.

Diagnostic Imaging

A CT scan of the patient's jaws is obtained to assess the residual hard tissue anatomy. All bone grafting and implant cases require a thorough radiographic examination because the contour and thickness of the oral mucosa can mask the actual dimensions of the underlying alveolar ridge. Standard imaging techniques can provide valuable 2-dimensional (2D) information on the vertical (panoramic or periapical radiography) or horizontal (occlusal radiography) volume of available bone, the trajectory and angulation in the midsagittal region of the residual ridge (lateral cephalometric radiography), and the surrounding bone trabeculae and adjacent anatomy (periapical and panoramic radiography). However, they cannot provide information on the 3D structure of the jaw.[1] For this reason, 3D imaging has become the diagnostic standard for treating severely resorbed jaws.[1]

CT scans provide important data on the density of cancellous and cortical bone and help identify the precise dimensions of the bone. A CT scan can help determine characteristics such as the positions of the genial tubercles, the direction of bone resorption in the anterior mandible, the location of the mylohyoid

[1]Private Practice, Brescia, Italy.

Correspondence to: Dr Michele Jacotti, Via Solferino 55, 25121 Brescia, Italy. Fax: +39 030 45650. E-mail: michele@jacotti.it

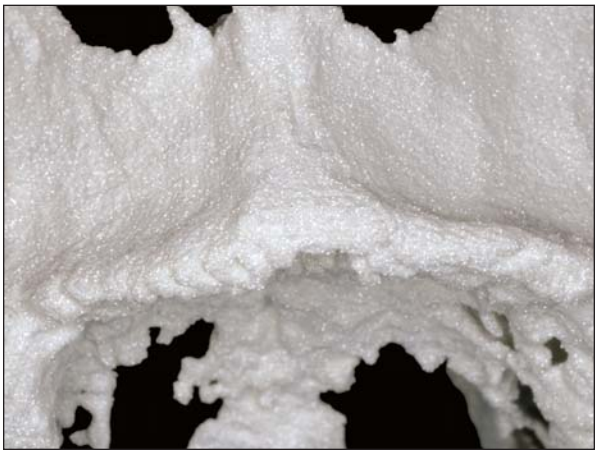

Fig 1 The sinterized model of a severely resorbed maxilla shows a classic "knife-edge" residual ridge.

line and lingual depression in the inferior border of the mandible, the resorption patterns of the buccal and labial cortical plates of the maxilla, and the bone width between the palatal and labial/buccal cortices.[2–4] CT scans are not subject to distortion or the superimposition or overlapping of images that can occur in standard radiography[1] and are a highly effective imaging modality for patients undergoing bone graft rehabilitation, especially in the maxilla.

Rapid Prototyping

Rapid prototyping (RP) is a term used to describe the fabrication of solid models from 3D computer data.[5] In medicine, such 3D data can be provided by several different technologies, including CT scans, positron emission tomography (PET) scans, single photon emission computed tomography (SPECT) scans, and ultrasonographic scans.[5] Anatomic models of bony structures are most commonly derived from CT scan data. While several RP techniques exist, medical modeling generally uses stereolithography, an optical scanning system that uses a laser to fabricate a 3D model layer by layer in photosensitive resin (layer manufacturing process), rather than by material removal (eg, milling).[5] This technique was first introduced to dentistry nearly 2 decades ago as an alternative to making direct bone impressions for subperiosteal implants.[6–10]

PROCEDURE

A 3D CT scan is obtained and provided on disk (CD-ROM) or digitally transmitted directly to an RP service bureau by the radiologist. The RP service bureau will process the CT data into a solid-to-layer (.stl) file, which dictates the 3D shape of the model to be fabricated in the sintering machine (eg, Delta Prototipi, Milan, IT). An autoclavable sinterized model is constructed in nylon polyamide thermoplastic (DuraForm PA; 3D Systems, Valencia, CA), which is heat-resistant to 184°C (363.2°F) (Fig 1).

Graft Material

A corticocancellous, iliac block allograft (Puros Block Allograft; Zimmer Dental, Carlsbad, CA) is used for this technique. Tissue donors are prescreened for health and lifestyle factors that could engender susceptibility to such pathogens as the human immunodeficiency (HIV) virus, and repeated serological testing is performed to rule out the presence of infectious diseases, such as hepatitis.[11] The bone is harvested according to the good manufacturing practices required by the US Food and Drug Administration by a certified tissue bank and subjected to a 5-step proprietary process (Tutoplast Process; Tutogen Medical, Neunkirchen am Brand, Germany) that includes delipidization, osmotic contrast treatment, oxidation treatment with hydrogen peroxide, solvent dehydration in acetone baths, and limited-dose Gamma irradiation (17.8 Gy).[11–13] This treatment retains the natural mineralization, collagen, and bone morphogenetic proteins (BMPs) of the native bone tissue.[11,13–17]

Technique

Prior to the surgical appointment, the model is wrapped and sterilized by autoclave, and the operating theater is prepared for aseptic preparation of the allograft under the same sterile norms used for implant or bone grafting surgery. The surgical assistant places the sterilized model and allograft on a sterile field. A large, low-speed bur is used to contour the cancellous layer of the block allograft and adapt its V-shape for maximum bony contact with the recipient defect area. The sharp edges of the graft are smoothed, while care is taken to preserve as much of the cortical surface as possible to provide a dense surface for rigid fixation of the graft. Using extreme care, 1.5-mm-diameter drill screw access holes are prepared through the allograft. The prepared allograft section is delivered to the stereolithographic model and stabilized in place with 2 miniscrews (Fig 2). Once all allograft block sections are prepared and affixed to the model in the appropriate locations with screws, final contouring of the graft may be completed.

The sinterized model with attached allograft is packaged according to the double sterile envelope technique: 1 envelope with 1 side left open is sterilized inside another envelope. The nonsterile assistant opens the envelope containing the sterile envelope, and the

Fig 2 The cancellous portion of the allograft is contoured with a rotating bur to fit the ridge defect. Prepared segments are attached to the sterile sinterized model and held in a sterile environment using a double envelope technique.

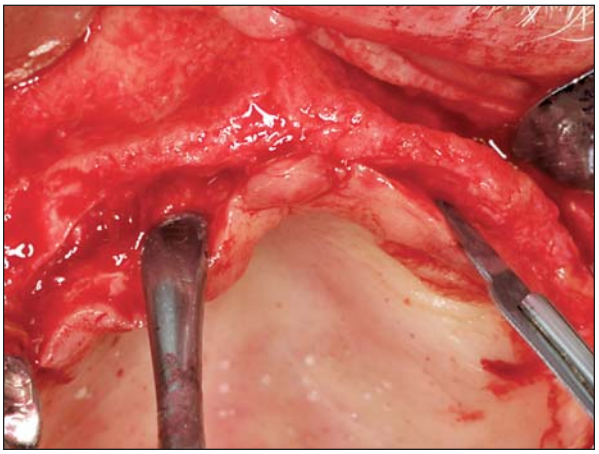

Fig 3a Full-thickness surgical reflection of the mucosa reveals a narrow residual ridge that matches the sinterized model.

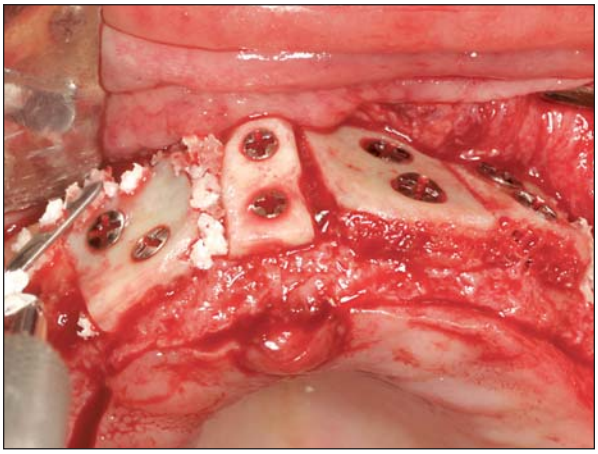

Fig 3b The sterile allograft segments are transferred from the model to the patient, and residual voids are augmented with particulate allograft material.

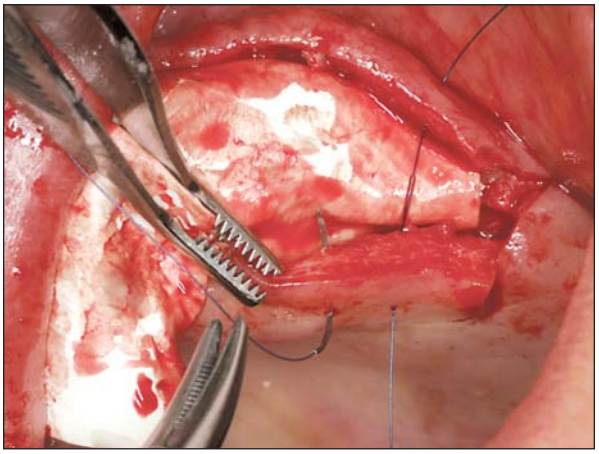

Fig 3c A bioabsorbable collagen membrane is placed over the grafted site, and primary closure is achieved with sutures.

sterile assistant removes the sterile envelope with the open side, inserts the model into it, and seals the envelope to keep the model with the attached graft in a sterile environment until the surgical appointment.

The patient is prepared for surgery and may be anesthetized via local infiltration, nerve block, or general anesthesia, depending on the needs of the patient and preferences of the clinician. Full-thickness flaps are surgically reflected to expose the residual alveolar ridge (Fig 3a), and the graft receptor sites are perforated with a 1 mm-diameter drill prior to graft placement. The prepared allograft is removed from the model and placed into the barrel of a 60-cc syringe with a tip. The plunger is replaced, and sterile saline (0.9%) solution is drawn into the syringe until the graft is completely covered. Excess air is expelled. The tip of the syringe is then occluded, and the plunger is drawn back slowly to help infuse the allograft material with the sterile solution. The excess air is dispelled again, and the graft is allowed to rehydrate for 3 to 5 minutes prior to use.

After rehydration, the prepared allograft is delivered to the surgical site and stabilized in place with miniscrews. Remaining voids around the graft are filled in with particulate allograft material (Puros Cancellous; Zimmer Dental) (Fig 3b), and the entire graft site is covered with a bioabsorbable, Type-1 collagen membrane (BioMend; Zimmer Dental) (Fig 3c). Soft tissue closure is achieved without tension using 4-0 sutures (Vicryl; Johnson & Johnson/Ethicon, Somerville, NJ). A provisional removable prosthesis may be placed, provided it does not impinge on the block allograft. Postoperative antibiotics, antimicrobial rinses, and analgesics may also be prescribed.

After a healing period of 5 to 6 months (Fig 4a), the patient is examined. Graft incorporation and

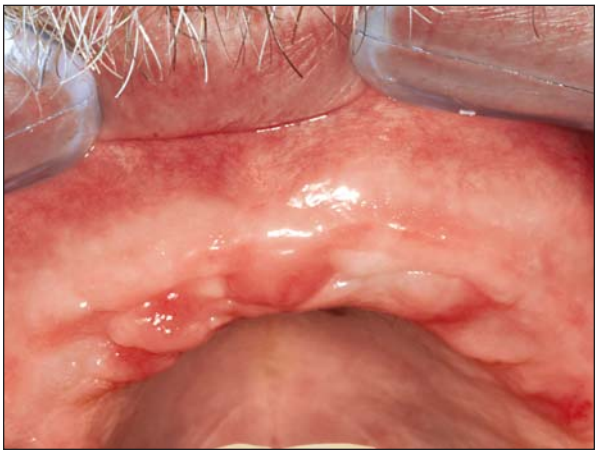

Fig 4a After 6 months of healing, the patient demonstrates no residual tissue deficits prior to tissue reflection.

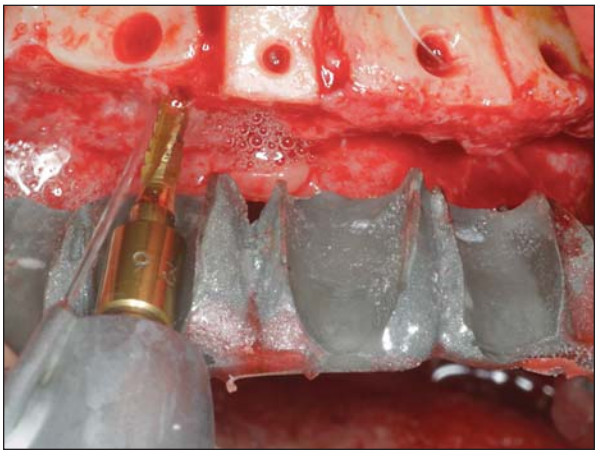

Fig 4b An acrylic resin surgical template is placed on the residual ridge to guide surgical preparation of implant receptor sites.

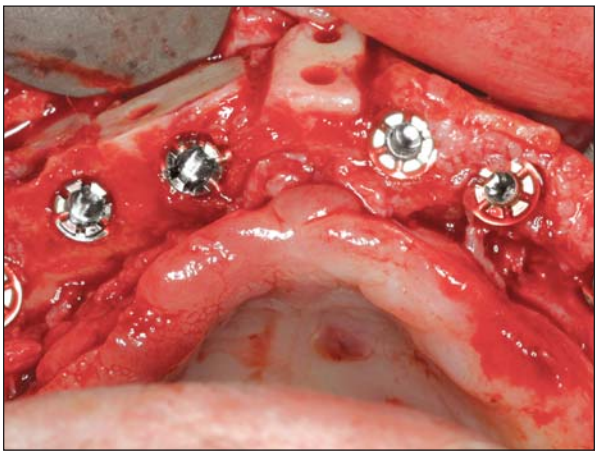

Fig 4c The augmented ridge remained stable after the placement of 6 dental implants.

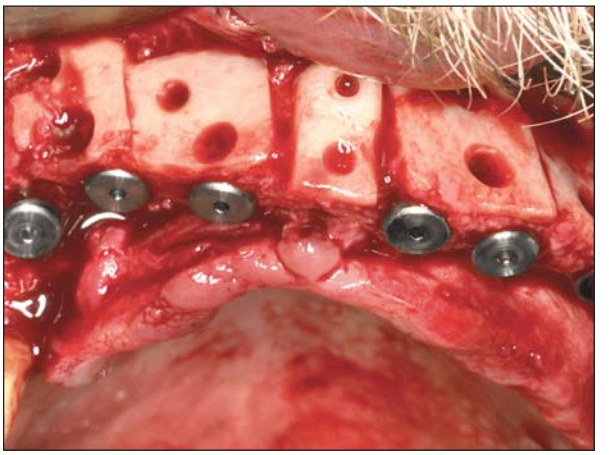

Fig 4d Surgical cover screws are attached to the tops of the implants during the submerged healing period.

healing can be verified via CT scan, periapical radiography, and visual inspection of the surgically exposed ridge. In some cases, it may be advisable to perform a biopsy of the incorporated tissues. Each miniscrew is removed from the incorporated graft at this time. If the graft is fully incorporated and stable, dental implant placement may be commenced (Figs 4b, 4c, and 4d).

DISCUSSION

The 3D block technique requires a CT scan and fabrication of a 3D sinterized model, which add to the cost of the procedure. In addition, conventional CT scans emit a higher radiation dose than conventional radiography.[17] In view of these considerations, one might reasonably question the value of the technique relative to patient cost.

CT scans are now widely used for implant and bone augmentation cases in Europe because they provide precise 3D imaging of the entire jaw, which can be less time-consuming and more accurate than conventional 2D radiography, especially when multiple surgical sites are required.[17] Newer CT technologies (eg, cone-beam CT, flash CT) can also significantly reduce both cost and radiation.[17] Information provided on the CT scan can be more easily visualized and used by the clinician through fabrication of the sinterized model.

Block allografts are more brittle than fresh autogenous block grafts, and improper contouring can result in block allograft fracture and/or failure to incorporate with the host tissue after placement. The ability of the clinician to use the 3D model as a template in preparing the block allograft without the visual impediment of open flaps, concerns about hemostasis, and the pressure to work rapidly can

help to greatly enhance the accuracy and fit of the preparations. This provides a direct benefit to the patient by reducing the risk of complications and failure from improperly contoured allografts.[18] In numerous cases, the author has found that some allograft preparations are difficult or impossible to accurately accomplish in the patient's mouth, but easy to do on a model, and that there has been such a high correspondence between the solid 3D model and the patient's anatomy that no graft has had to be modified during surgery. The precision of this technique has also enabled the author to use a single block allograft to treat multiple patients, because there is no risk of cross-contamination when working on more than 1 sterile sinterized model. Sharing the cost of 1 block allograft among 2 or more patients can help to mitigate the additional costs associated with this technique. The ability to index each prepared allograft to its corresponding defect site by attaching it directly to the 3D model with screws can help eliminate errors in transferring the prepared block allografts to the patient.

Eliminating the need to prepare the block allograft during the invasive procedure can shorten surgical time from hours to minutes, which helps to justify the additional costs required for the technique. Further research is needed to determine whether the 3D block technique results in higher incorporation and survival rates than block allografts prepared chairside. As with any regenerative technique, however, treatment of the soft tissue will play a crucial role, and the surgeon must treat it skillfully to achieve optimum success.

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