Placement of Implants in the Severely Atrophic Posterior Maxilla Using Localized Management of the Sinus Floor: A Preliminary Study

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Purpose: *This retrospective study investigated whether or not implants can be placed successfully without sinus grafts in atrophic posterior maxillary ridges with ≤ 4 mm of bone utilizing the localized management of the sinus floor technique as described by Bruschi and coworkers.* ***Materials and Methods:*** *Fifty-eight implants were placed in 34 consecutive patients with an average vertical height of 2.87 mm of residual bone under the sinus. The implants were placed at the time the sinus membrane was elevated.* ***Results:*** *The sinus was "raised" an average of 9.12 mm without benefit of bone grafts or membranes. The success rate after 22 months of loading was 91.4%.* ***Discussion:*** *The localized management of the sinus floor (LMSF) technique permits osseointegration of titanium implants by an endosteal-periosteal continuum that is unhindered by the need of graft material to resorb.* ***Conclusion:*** *This preliminary study demonstrated that it is possible to place implants in an atrophic alveolar ridge with ≤ 4 mm of bone without the need for a traditional sinus graft.* (INT J ORAL MAXILLOFAC IMPLANTS 2002;17:687–695)

Key words: *atrophic maxillary ridge, bone grafts, dental implants, membranes, secondary healing, sinus graft*

Placement of dental implants in the posterior maxillary region is often hampered by atrophic ridges that result from bone resorption following tooth removal or from the effects of periodontal disease. When tooth loss occurs in the maxilla, it usually results in bone resorption both apically and palatally. In addition to the problem of a compromised alveolar ridge, the maxillary sinus can vary in size and shape, making implant placement impossible without surgical modification. It is known that maxillary sinuses can pneumatize after tooth loss and expand in such a way as to compromise or prevent implant placement without an augmentation procedure. Regardless of anatomic variations or pathologic deterioration, lack of bone volume to receive dental implants without surgical intervention is a common occurrence.

Since Tatum[1,2] and then Boyne and James[3] first described alteration of the maxillary sinus to receive metal implants, several techniques and a variety of materials have been reported to increase posterior maxillary bone to permit successful dental implant placement.[4–30] These include augmenting the maxillary sinus with autogenous bone, allografts, xenografts, synthetic grafts, and various combinations of any of these. Regardless of the material or materials used, most authors describe specific requirements for their surgical studies and techniques including:

- The resorbed alveolar crest under the maxillary sinus must have a minimum height of 5 mm to consider placing implants at the time of the augmentation procedure.
- When sinus augmentations are performed as a first stage (without simultaneous implant placement), a minimum of 8 to 9 months of healing are usually required before implants can be surgically placed.
- Maxillary posterior "site development" for the atrophic ridge—whether a sinus graft or ridge augmentation procedure—requires some recipe of materials consisting of a bone graft (autograft, allograft, xenograft, or synthetic material) and is often accompanied by the use of a guided tissue membrane.

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Bruschi and coworkers[28] described a surgical technique for augmenting an atrophic alveolus under the maxillary sinus without utilizing bone grafts or membranes and termed it *localized management of the sinus floor* (LMSF). As described, the LMSF technique offered the advantage of placing implants in a single stage in the posterior maxilla with as little as 5 mm of residual bone. These authors reported on 303 patients with 499 implants who were followed 2 to 5 years after prosthetic loading. While their success rate was 97.5%, they recommended using the LMSF technique with at least 5 to 7 mm of bone under the sinus.

The purpose of this retrospective study was to evaluate the clinical success of placing titanium implants in the maxillary posterior with ≤ 4 mm of alveolar bone, utilizing the surgical principles of the LMSF technique. All implants were placed following a 1-stage protocol (elevating the sinus floor and placing the implant at the same time) without the use of bone grafts or guided bone regeneration (GBR) membranes.

MATERIALS AND METHODS

Thirty-four consecutive patients who needed at least 1 dental implant in the posterior maxilla and had an atrophic ridge no greater than 4 mm in height under the sinus were included in this study. Informed consent was obtained with a description of the LMSF technique, including potential risks and surgical complications. Patients were excluded if they presented with a medical condition that would contraindicate dental surgery, eg, uncontrolled hypertension, insulin-dependent diabetes, and either uncontrolled or unstable cardiovascular disease. Smokers were not excluded from the study.

As part of a standard protocol, each patient had a periodontal examination, dental radiographs, and in most cases, a dental computed tomographic scan. Active periodontal and endodontic lesions were treated prior to implant surgery.

Measurements of the atrophic alveolar ridge that were accurate to 0.1 mm were made from computed dental radiography (CDR) digitized images (Schick Technologies, Long Island City, NY). This was accomplished with postoperative digitized images obtained using standard Rinn holders (Elgin, IL) for the CDR sensors. The CDR software has a function that permits calibration of measurements against a known standard length. Once calibrated, all measurements would be corrected for any distortion related to sensor angulation. For purposes of this study, the known length of the implant was measured and used to calibrate the computer (Figs 1a to 1e).

All measurements were made by one examiner (AW), with each measurement repeated twice and an average obtained for use in calculations. The side of the implant with the least amount of bone under the maxillary sinus was used to record the height of the existing alveolar bone. All implants were uncovered 4 to 6 months after initial placement.

Surgical Technique

Preoperative antibiotics were prescribed as a single peroral dose of either amoxicillin (2 g) or clindamycin (600 mg) 1 hour prior to surgery. Postoperative antibiotics were not prescribed. In addition, ibuprofen (600 mg) was given (when not contraindicated) at chairside prior to or after the surgery. Each patient rinsed with 0.12% chlorhexidine for 15 seconds prior to surgery.

Surgeries followed protocols outlined by Bruschi and associates.[28] Using local infiltration anesthesia, partial-thickness flaps (PTFs) were developed from initial incisions on the palatal aspect of the residual ridge and reflected to the buccal. Tension-free release was obtained with the aid of vertical relaxing incisions at the mesial and distal extremes. Partial-thickness dissection of the palatal tissue was also carried out to visualize the underlying ridge and to release a shallow palatal flap. Osteotomy sites were prepared either using drills or manually, or by a combination of both, following the protocols established for this technique by Bruschi and associates.[28] However, whenever possible, implant osteotomy site preparation was performed manually.

Different sized osteotomes and/or bone expanders were struck with a surgical mallet to lengthen and widen each surgical site. As the osteotomy progressed, small squares of collagen sponge (CollaCote, Colla-Tec, Plainsboro, NJ) were placed at the apical extent to absorb the impact from the hammering, acting as a cushion when displacing the sinus floor and aiding in hemostasis.

Most osteotomy sites in this investigation were rounded and tapered, consistent with the width and length of the implants that would be placed in them. In some patients, the alveolar bone was too thin to drill or to use osteotomes in a conventional way. When this occurred, a #64 Beaver blade (Havel's, Cincinnati, OH) was used in a variation of the LMSF technique to create a rectangular window along the alveolar crest, akin to a crestal approach to sinus grafting as described by Tatum.[1] Once this window was detached, the sinus membrane was elevated with the same instruments and techniques used to gain access through the lateral sinus windows.

Figs 1a to 1e Digitized image production and measurements. (Patient treated by Dr Alan Winter.)

Fig 1a Preoperative site.

Fig 1b Schick Technology tool bar, used to "calibrate" the ruler.

Fig 1c Note line on implant in premolar area. This was measured against a 15-mm-long implant.

Fig 1d Line on mesial of distal implant, measuring 2.6 mm from head of implant to sinus floor.

Care was taken to not perforate or tear the membrane. In keeping with the principles of the LMSF technique, no graft materials were introduced into the space created. The authors have labeled this the *sinus/alveolar crest tenting* (SACT) technique.

All implants (except 2) used in this study were tapered, since tapered implants offer a natural resistance against displacement (into the sinus) by being widest at the alveolar crest and narrowest at the apical end. The final implant size used in each site was selected according to a number of factors. It was based on the width and height of the residual alveolar crest present at the time of surgery, the amount of resistance met when tapping the osteotomes with the surgical mallet, the ease of infracturing the sinus floor, and the ability to elevate the sinus membrane. The clinician weighed these factors and used clinical experience to determine the "best" implant size for each site relative to the size of the tooth being replaced.

Fig 1e One year postoperative view. Measurement indicates 12.9 mm of bone in a site that initially had 2.6 mm of bone.

In this study, an appropriate-sized titanium endosseous implant was placed into each osteotomy site using the surgical mallet. A torque wrench was used for final seating of the implant. In all, 56 acid-etched and sandblasted, tapered Frialit-2 implants (Friadent North America, Irvine, CA) and 2 cylindrical acid-etched Osseotite implants (Implant Innovations, Palm Beach Gardens, FL) were used. Cylindrical implants were used to maintain uniformity in patients who already had them in sites adjacent to the surgical areas in this study.

Primary implant stability was a prerequisite. Implants lacking stability at the time of placement were removed and not included in this study. No bone grafts or GBR membranes were used to help raise the sinus floor or fill in any gaps surgically created between consecutive implants or between an implant and an adjacent wall. All surgical sites were covered with a collagen sponge (CollaCote). The PTFs were displaced apically and buccally to increase the amount of keratinized tissue through secondary healing. The PTFs were secured to the underlying periosteum with 4-0 silk sutures. No effort was made to obtain primary closure.

Postoperative care consisted of rinsing with 0.12% chlorhexidine twice daily until the patient returned for suture removal in 10 days. Pain medication was prescribed as needed. No infections were reported. Surgical sites were allowed to heal 4 to 6 months before stage 2 uncovering procedures.

At stage 2 surgery, the implants were uncovered and abutments were placed using a technique that minimally exposed the implant heads, as described by Bruschi and coworkers,[28] leaving "mini" flaps to heal. In most cases, this was done without the benefit of sutures, so that secondary healing would again increase the amount of keratinized tissue. All stage 2 surgeries healed uneventfully and at approximately 3 weeks postoperatively, patients were asked to return to their restorative dentist.

Most provisional restorations were placed no sooner than 6 weeks after uncovering. The definitive prosthesis was fabricated and generally seated 1 to 4 months after this. There was no attempt at what is commonly known as "provisional loading" in any cases.

Implants were judged to have failed if there was a clinical lack of integration as demonstrated by mobility, pain, or rotation.[31] Since no bone grafts were used in lifting the sinus floor, early bone formation was generally not radiopaque and radiographs were not determined to be of value in determining success of integration at the time of stage 2 uncovering.

RESULTS

Fifty-eight implants were placed in the posterior maxill of 34 consecutive patients who met the criteria of having 4 mm or less of alveolar bone under the maxillary sinus. There were 15 men and 19 women in this study, who ranged in age from 31 to 78 years (average age 60.7 years).

All patients included in this study had ≤ 4 mm vertical height of bone under the maxillary sinus. The average for the 58 surgical sites was 2.87 mm, with a range of 0.6 mm to 4.0 mm.

A variety of implant lengths were used in this study, the most common being 10 and 13 mm. Twenty-nine implants were 10 mm in length, 1 was 11.5 mm, 24 were 13 mm, and 4 were 15 mm.

Fifty-six implants used in this study were Frialit-2, with diameters 4.5 mm (n = 5), 5.5 mm (n = 18), and 6.5 mm (n = 33). Two implants were Osseotite, with diameters 4.0 mm (n = 1) and 5.0 mm (n = 1). The majority of implants used in this patient population (96.5%) were Frialit-2 implants, which may be wider than most standard implants. The average length of implants used was 11.99 mm and the average diameter was 5.94 mm. The net difference between the implant length and the amount of alveolar bone crest present at the time of implant placement was 9.12 mm.

Fifty-four implants were deemed to be integrated at the stage 2 uncovering based on the absence of clinical mobility, pain, or rotation in the socket. Four implants were not integrated and therefore removed (and subsequently replaced at a later date). After crown placement, a fifth implant was lost, for a total of 5 failed implants, ie, 91.4% survived.

The average length of time implants were uncovered and restored in this study was 22 months (range 15 to 28 months). A portion of most implant heads was exposed during the healing time prior to stage 2 uncovering. Implant survival was calculated from the time of implant uncovering and was defined as being symptom-free without mobility, rotation, or radiographic evidence of increasing bone loss. The average time of implant survival with occlusal loading (after prosthetic placement) ranged from 12 to 25 months.

DISCUSSION

Bruschi and associates[28] described a technique, the LMSF, that augments atrophic maxillary ridges without either bone grafts or membranes. The

patients studied in this report were treated using the LMSF technique, whereby the sinus floor is elevated incrementally using blunt-ended osteotomes driven superiorly with a surgical mallet. The bone gathered from the lateral walls of the osteotomy is used, along with pieces of CollaCote, as a plunger to lift the bony floor of the sinus and elevate the membrane. The space created by this lift fills with a blood clot, and healing progresses as in a tooth extraction socket (see Bruschi and associates[28] for more details).

To the authors' knowledge, with the exception of Peleg and coworkers,[5] no other studies have described the successful immediate placement of dental implants in atrophic ridges with 1 to 2 mm of bone under the maxillary sinus. Rosen and colleagues,[26] for example, stated that dental implants could predictably be placed using the Summers technique at the time of a sinus graft when there is at least 5 mm under the maxillary sinus. These authors described how success rates taper off when implants are placed in ≤ 4 mm of bone along with a simultaneous sinus graft.[26]

The elevation technique (LMSF) used in this study differs from the Summers osteotome technique in 4 significant ways. First, the osteotomy site using the LMSF technique is prepared solely with manual manipulation, or in some instances, with both manual manipulation and the use of rotary burs; the Summers technique develops the first part of the osteotomy site by using a trephine to remove a core of bone. In the LMSF technique, the osteotomes can and do extend beyond the sinus floor once the membrane is raised; in the Summers technique, the osteotomes do not extend beyond the sinus floor. Third, while no bone graft is used in the LMSF technique, bone particles are forced into the osteotomy site and used to help displace the sinus membrane. And lastly, while the LMSF technique can be used with a high degree of success in ≤ 4 mm of bone, the Summers technique is recommended for sites with at least 5 mm of bone.

Paradoxically, Gray and coworkers[32] recently reported a case utilizing Surgicel (Ethicon, Somerville, NJ) as a "graft" material for lifting the sinus membrane. Surgicel, an oxidized, regenerated cellulose, was used to assist hemostasis and was not considered a graft material. Yet when magnetic resonance imaging was performed 3 months after the space below the Schneiderian membrane was packed with Surgicel, new augmented bone was discovered. This was verified at 7 months, when the implants were placed in the surgical site.

What makes the present retrospective study unique is that all implants were placed in atrophic maxillary ridges with ≤ 4 mm of bone without utilizing bone grafts or GBR membranes, following the protocol of Bruschi and associates[28] and similar to the case report by Gray and colleagues.[32]

The results of this preliminary study demonstrate that 53 of 58 implants survived for an average of 22 months after stage 2 uncovering. The longest time an implant was uncovered and loaded was 28 months; the shortest was 15 months. While the average time period (22 months) is too short to determine the long-term success of this procedure, it indicates the potential viability of this technique.

The inherent benefits of utilizing the LMSF technique, in comparison to other accepted therapies for augmenting atrophic maxillary ridges, include the lack of bone grafting and membranes. Secondary surgical sites are not needed to harvest autogenous bone. This reduces the risk from added surgical trauma and potential infections. An added benefit is that no "foreign" substances, such as allografts or xenografts, are used as alternate graft sources.

The biologic basis for the LMSF technique is a marriage of classic "socket" healing, as described by Claflin[33] and Boyne,[34] and PTF healing.[35–38] The blood supply to the osteotomy sites created by the LMSF surgical technique is described as an "endosteal-periosteal continuum"[39] that permits osseointegration of the titanium implants without the hindrance of graft material that must first resorb before new bone can be formed. Since bone graft materials are not recommended when performing the LMSF technique, healing proceeds more rapidly than with other augmentation techniques that utilize an assortment of autogenous grafts, allografts, or xenografts. The patient benefits from this rapid healing because the implants are ready for prosthetic restoration sooner than with conventional augmentation techniques that require longer healing periods.

Figures 2a to 2f present a patient included in this study. An implant will be placed where the sinus approximates the atrophic alveolar crest. Two-millimeter directional indicators (Fig 2b) help determine the relative position and inclination of each implant. Note the minimal alveolar crest under the maxillary sinus, which measures 0.6 mm.

Six months later, the implants were uncovered (Fig 2c). The bone on the distal of the most posterior implant (Frialit-2, 6.5×13 mm) appears mineralized (Fig 2d). Figure 2e demonstrates closeups of the same areas, including a positive image created in the Schick Technologies CDR software that highlights the bony trabeculization distal to this implant.[40] The surgery to place this implant followed the protocol established in this preliminary study. The osteotomy

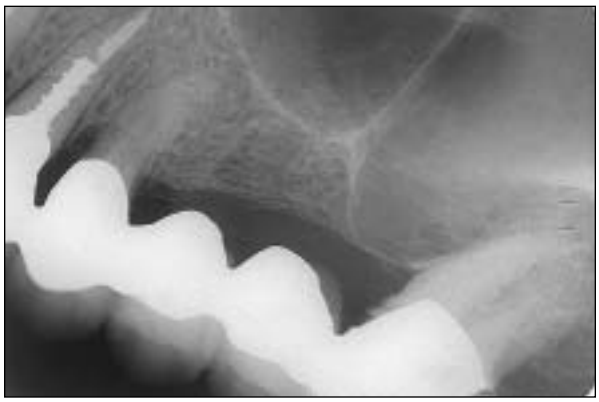

Fig 2a Preoperative periapical radiograph. The implant will be placed where the sinus floor approaches the alveolar crest. (Patient treated by Dr Alan Winter.)

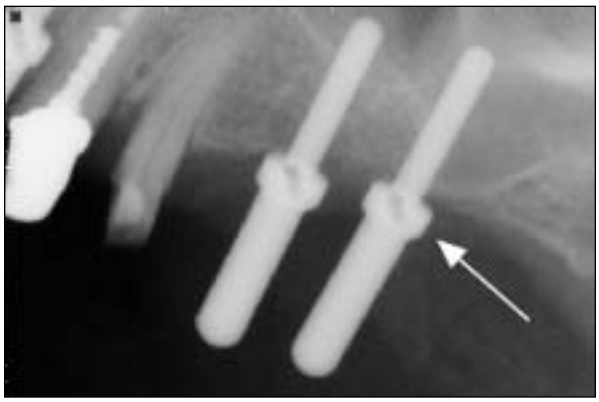

Fig 2b Atrophic alveolar crest is 0.6 mm under the sinus (digital image).

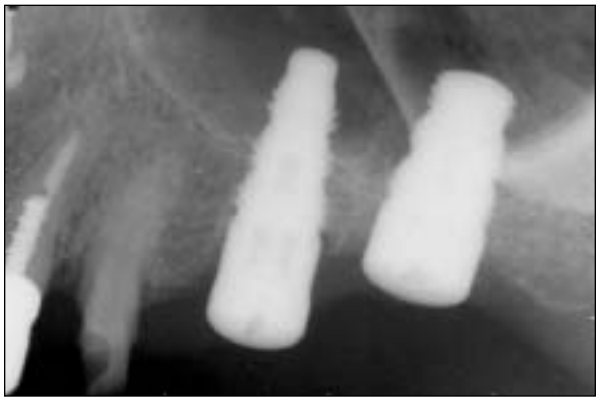

Fig 2c Note apparent bone gain 6 months later, at the stage 2 uncovering (digital image).

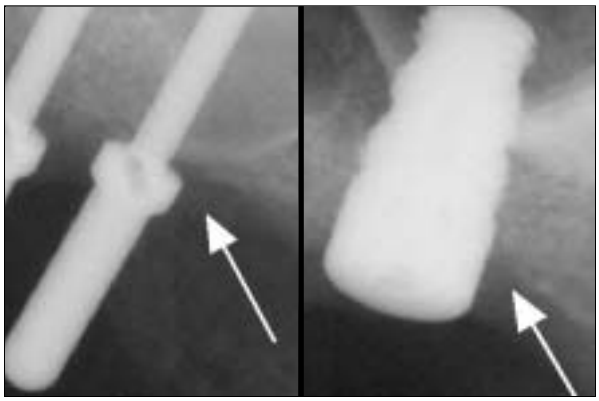

Fig 2d Closeups of atrophic ridge: *(left)* before placement and *(right)* postoperatively (digital images).

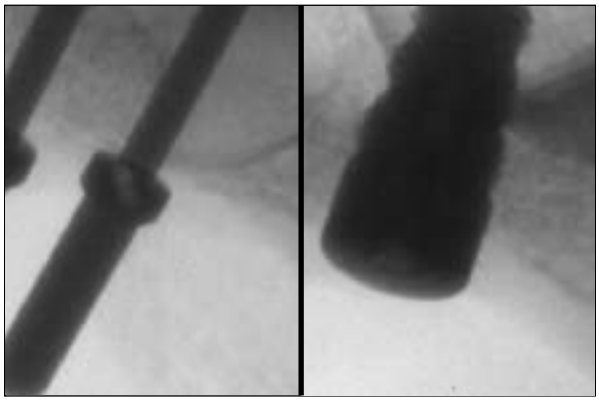

Fig 2e Positive images of Fig 2d highlight bony trabeculization where the sinus was "lifted" without benefit of bone graft material (digital images).

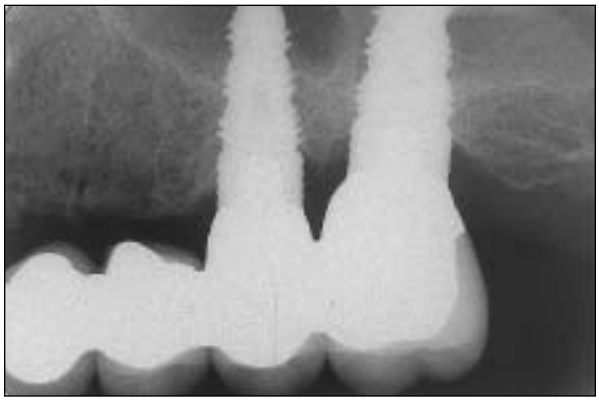

Fig 2f Postoperative radiograph taken 1 year after placement of prosthesis.

site was prepared manually, without the use of burs. No bone grafts or membranes were used. Figures 2b to 2e are digitized Schick CDR images. Figure 2f is a periapical radiograph taken 1 year after the prosthesis was placed. An additional case involving this procedure is documented in Figs 3a to 3d.

All new surgical techniques have their particular learning curve. In this case, the learning curve for the LMSF is rather steep, because the atrophic ridge under the maxillary sinus can be eggshell-thin and the sinus membrane can easily be perforated. If frank perforation does occur, the implant cannot be placed. The site is filled with CollaCote and reentered in 90 days if no complications have occurred.

While the stated goal of the LMSF procedure is to place the widest and longest implants—6.5 mm wide

Figs 3a to 3c Patient documentation with digitized image application. (Patient treated by Dr Alan Winter.)

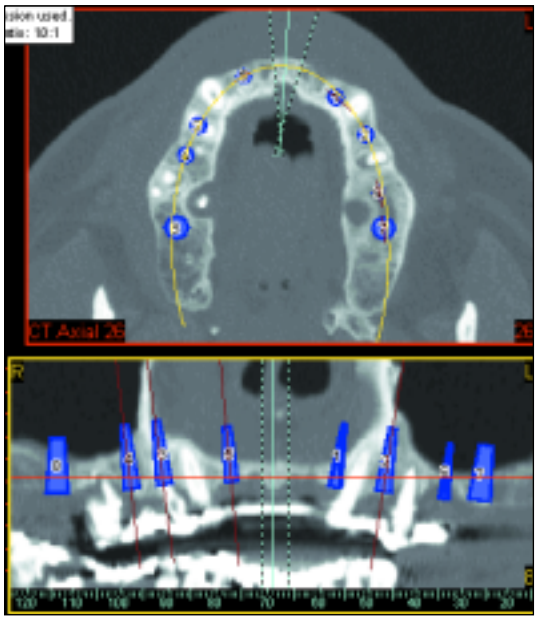

Fig 3a Preoperative evaluation. Icons represent the actual location and size of the implants.

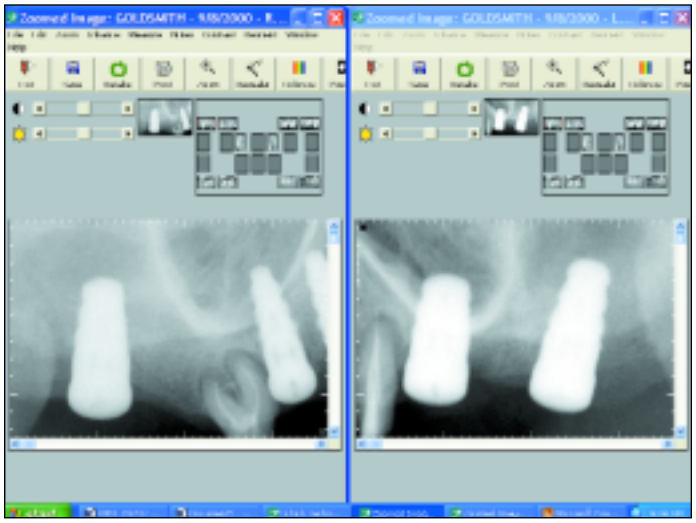

Fig 3b Images obtained the day of implant placement.

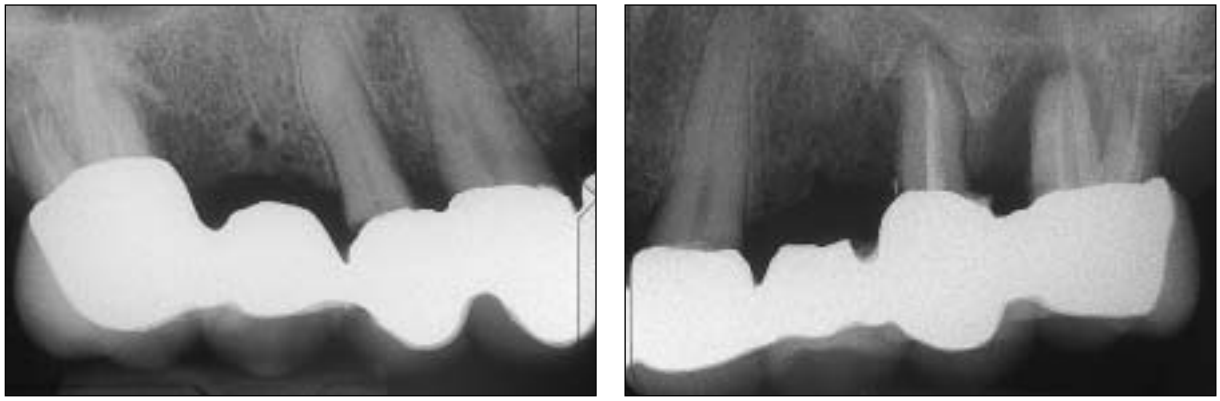

Fig 3c Preoperative radiographs.

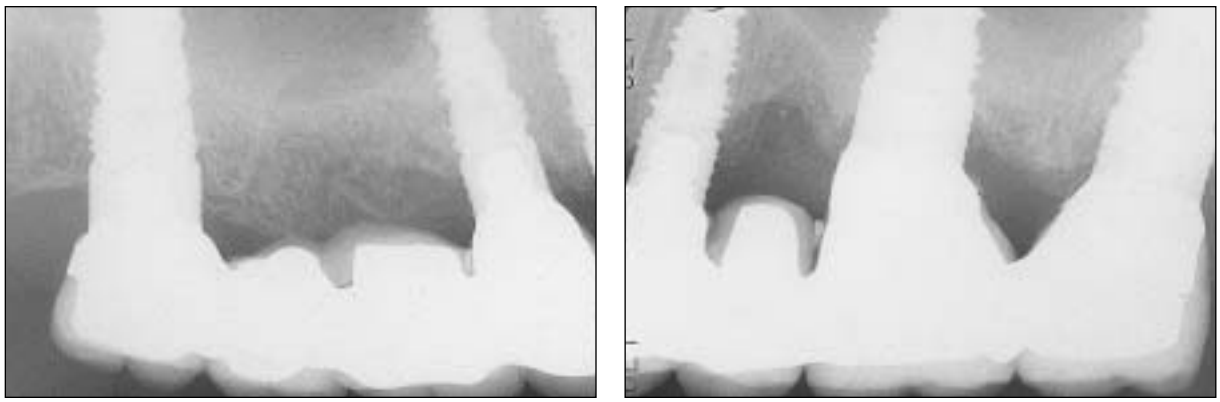

Fig 3d One-year postoperative 3-D radiographs.

and 13.0 mm long—this was not possible for every site in this study. With the initial patients, the authors needed to gain a comfort level (their learning curve) and firsthand experience as to the limits of the LMSF technique. Implants placed earlier in this study tended to be shorter than those placed more recently.

Four failures occurred during the healing stage after initial placement or at the stage 2 uncovering. These were marked by a lack of integration, evident as clinical mobility. A fifth implant was removed when it had become mobile 2 months after placement of a cemented crown. The cause of this failure was apparent occlusal overload and may not have been the result of an initial lack of osseointegration.

The occurrence of 5 failures in this preliminary study is not surprising. Early studies of Adell and coworkers[41] reported 85% success in the maxilla when titanium implants were placed in the anterior zone (Zone 1) and were totally supported by bone. The survival rate of 91.4% in this retrospective study is consistent with other studies.[42,43] In contrast, the initial report of the LMSF technique by Bruschi and colleagues[28] demonstrated a 97.5% long-term success rate with 5 to 7 mm of bone under the maxillary sinus. While 22 months survival may be too short to draw conclusions about long-term success, the preliminary data presented here are encouraging in the use of the LMSF technique in the severely atrophic (≤ 4 mm) posterior maxillary alveolus.

CONCLUSIONS

In a retrospective study, 58 implants were placed in 34 patients with ≤ 4 mm of residual alveolar height utilizing the LMSF technique described by Bruschi and associates,[28] whereby the sinus floor was elevated and implants placed in the same procedure. Five implants failed. The short-term results (22 months after stage 2 surgery) demonstrate that the LMSF procedure permits placement of implants in 4 mm or less of bone under the maxillary sinus without the use of bone grafts or membranes. The average amount of sinus floor elevation achieved in this study was 9.12 mm. Additional clinical research is underway to study the long-term success of these procedures.

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