
Augmentation Grafting of the Maxillary Sinus and Simultaneous Implant Placement in Patients with 3 to 5 mm of Residual Alveolar Bone Height

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This study assessed the efficacy of augmentation grafting of the maxillary sinus with simultaneous placement of dental implants in patients with less than 5 mm of alveolar crestal bone height in the posterior maxilla prior to grafting, although the procedure has traditionally been contraindicated based on empirical data. A total of 160 hydroxyapatite-coated implants was placed into 63 grafted maxillary sinuses in 63 patients whose crestal bone height in this region ranged from 3 to 5 mm. Patients were followed for 2 to 4 years after the placement of definitive prostheses. There were no postoperative sinus complications. Following uncovering of the implants at 9 months after surgery, there was no clinical or radiographic evidence of crestal bone loss around the implants. Histologic examination of bone cores from the grafted sites revealed successful integration and a high degree of cellularity. All patients maintained stable implant prostheses during follow-up. These findings indicate that the single-step procedure is a feasible option for patients with as little as 3 mm of alveolar bone height prior to augmentation grafting, utilizing hydroxyapatite-coated implants and autogenous bone. (INT J ORAL MAXILLOFAC IMPLANTS 1999;14:549-556)

Key words: atrophic maxilla, bone graft, dental implants, sinus augmentation, sinus mucosa

Effectively restoring a grossly atrophic maxilla can be problematic for the implant surgeon. The placement of dental implants in patients who are edentulous in the posterior maxilla can present difficulties because of a deficient posterior alveolar ridge and increased pneumatization of the maxillary sinus, resulting in a minimal hard tissue bed.^{1,2} In many of these patients, such problems can be overcome by increasing the alveolar height with bone grafting of the maxillary antral floors.³⁻⁵ This procedure can provide sufficient quantity and quality of bone for implant placement and subsequent

prosthetic reconstruction.⁶ Sinus augmentation grafting and implant placement are accomplished as either a 1-step or a 2-step surgical procedure.

In the 1-step procedure, the maxillary sinus is augmented and dental implants are placed simultaneously into the grafted site. In the 2-step procedure, implant placement is delayed until there is evidence that the graft material has provided adequate bone in the posterior maxilla. The general consensus, based on empirical observations, has been that the 1-step procedure should be reserved for patients who have at least 5 mm of alveolar bone in the posterior maxilla to stabilize the implants.^{1,7} If there is less than 5 mm of available host bone, it has been considered insufficient to mechanically maintain the endosteal implants, and thus the 2-step procedure has been recommended in these patients.⁷⁻⁹

The purpose of this retrospective study was to assess the efficacy of performing the 1-step procedure in patients whose available alveolar bone height in the posterior maxilla was between 3 and 5 mm prior to grafting.

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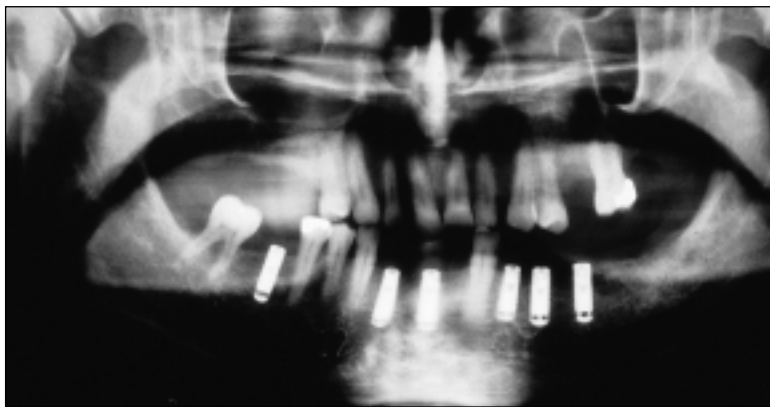


Fig 1a To determine the available bone height in each patient's maxilla, panoramic and sinus radiographs were taken.

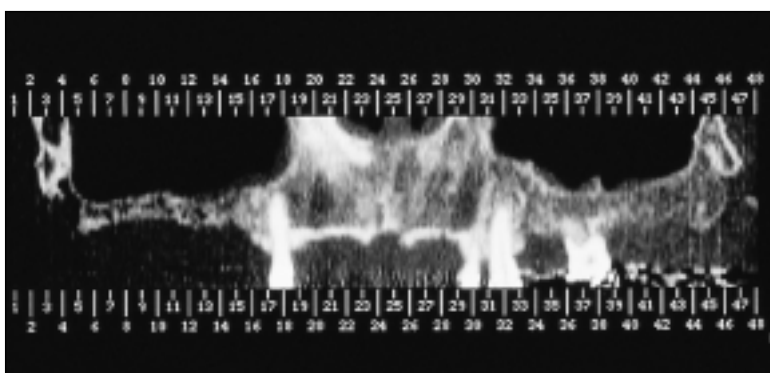


Fig 1b Dental computed tomographic scans were also performed to measure the bone available in each patient.

Materials and Methods

Patient Population. The study population comprised 63 consecutive patients, ranging in age from 40 to 75 years, all of whom were from the authors' private practices. Prior to each patient's selection, his or her medical history was carefully evaluated. Smoking was not considered a contraindication for the treatment. A complete dental examination, which included panoramic and sinus radiographs and dental computed tomography (CT) scans (DentaScan, General Electric, Milwaukee, WI), was performed to help determine the available maxillary alveolar bone height (Figs 1a and 1b). Implants were placed with regard to future restorative treatment regardless of where bone thickness was best. A crestal bone height of only 3 to 5 mm between the sinus floor and the alveolar ridge of the posterior maxilla was a prerequisite for inclusion in this study. As noted in Table 1, 23 patients had 3 mm of available bone, 18 patients had 4 mm of bone, and 22 patients had 5 mm of bone.

Preoperative Evaluation and Preparation. During the oral examination, the location of sinus floor septi and the surgical entry site were identified. Interocclusal space was evaluated to determine the prosthetic restorability of the area. The presence of active disease or disorders (eg, acute sinusitis, retained root tips, polyps, tumors, cysts in the antral cavity) was also determined by clinical evaluation, CT scans, and periapical radiographs, as the existence of any of these entities precludes performing the procedure until they are corrected. No biopsies were needed. None of the patients selected for the study exhibited such disorders. Antibiotics effective against both aerobic and anaerobic organisms were administered prophylactically 2 to 3 days before surgery and were continued 5 to 7 days postoperatively (Augmentin [amoxicillin+clavulanic acid] 500 mg 3 times a day).

Surgical Procedure. Surgery was performed in the dental office using a local anesthetic with a vasoconstrictor for hemostasis (lidocaine 2% with 1:100,000 epinephrine). A maxillary block and

Table 1 Data on Study Participants					
Patient	Age (y)	Sex	No. of implants placed	Implant length (mm)	Amount of residual bone (mm)
1	48	F	3	15	4
2	51	F	2	15	5
3	62	F	3	15	4
4	54	M	3	15	3
5	47	M	2	15	5
6	46	F	3	15	5
7	42	F	3	13	5
8	44	F	3	15	3
9	50	F	3	15	3
10	46	M	2	15	4
11	60	F	3	15	3
12	50	M	2	15	4
13	44	F	3	15	4
14	50	F	3	15	5
15	64	F	2	15	5
16	40	F	2	15	4
17	48	F	2	15	5
18	46	M	3	15	4
19	42	F	3	15	3
20	63	F	3	15	3
21	40	M	3	15	5
22	46	F	3	15	3
23	52	M	2	15	4
24	49	F	3	15	3
25	64	F	2	15	4
26	40	F	2	13	5
27	44	F	3	15	3
28	59	M	3	15	3
29	50	F	2	13	4
30	49	F	3	15	3
31	46	F	4	15	3
32	56	F	2	15	5
33	52	F	2	15	5
34	55	M	2	13	5
35	75	M	3	15	4
36	68	F	2	15	4
37	46	F	3	15	3
38	47	F	3	15	3
39	50	F	3	15	5
40	52	F	3	13	5
41	46	F	2	15	3
42	49	M	2	13	5
43	61	F	4	15	3
44	71	F	3	15	4
45	60	F	3	15	3
46	68	F	2	15	4
47	57	F	3	15	5
48	50	M	3	15	3
49	48	F	4	15	3
50	49	F	3	13	5
51	60	F	2	15	5
52	41	F	3	15	5
53	52	M	3	15	4
54	54	F	2	15	3
55	60	F	3	15	5
56	42	F	2	15	3
57	44	F	2	15	3
58	46	F	3	15	4
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61	57	F	2	15	5
62	58	F	1	15	5
63	43	F	1	15	4

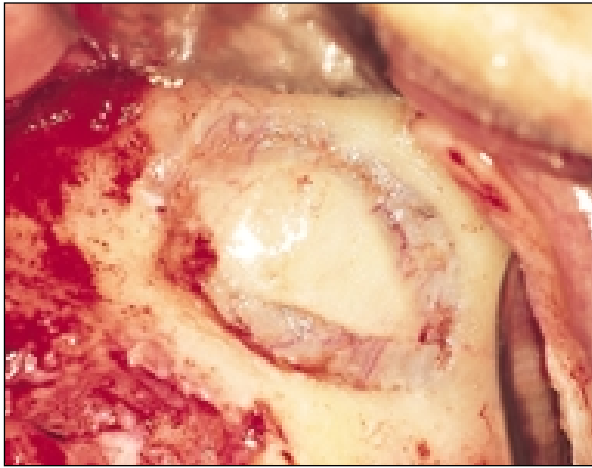


Fig 2a An oval-shaped osteotomy was created in the lateral wall of the maxillary sinus for access. Note the slight bluish hue around this access window, indicating the underlying Schneiderian membrane.

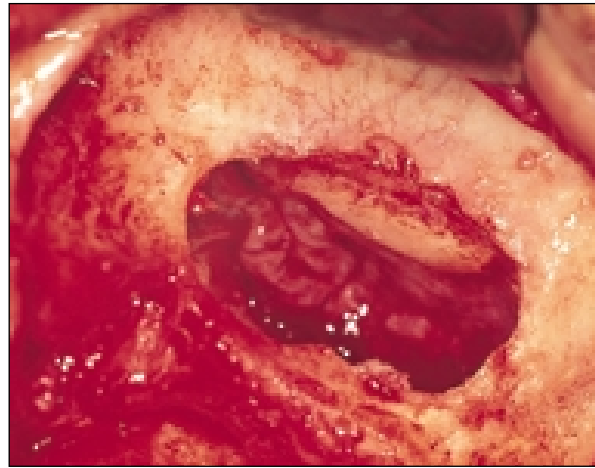


Fig 2b After the oval outline was completed, the island of bone was pushed inward and upward and then rotated into the sinus.

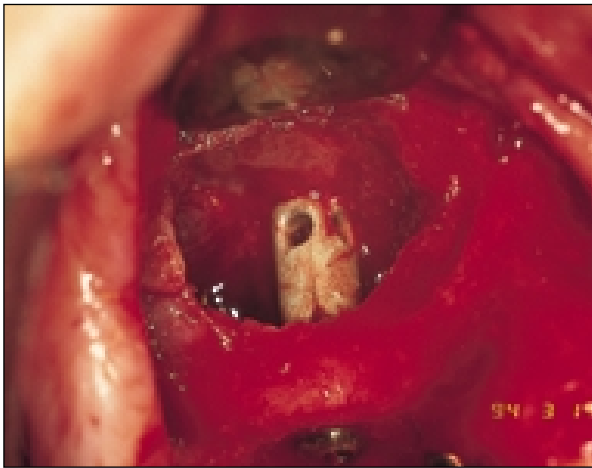


Fig 3 Implants, 13 to 15 mm in length, were placed halfway into the augmented sinus.

bilateral mandibular blocks were performed to ensure anesthesia of the maxillary surgical site and the symphysis donor site.

Sinus Augmentation Grafting Technique. The sinus augmentation technique was performed using a modified Caldwell-Luc procedure as described by Kent and Block.¹⁰ A horizontal incision was made on the palatal aspect of the edentulous ridge, with extensions beyond the areas of the osteotomy and with consideration of the amount and position of the attached gingiva. The incision was carried forward beyond the anterior

border of the sinus. Additional vertical releasing incisions were then made in the buccal vestibule to facilitate reflection of the full-thickness mucoperiosteal flap, to expose the bone, and to ensure soft tissue closure over the bone. The mucoperiosteal flap was reflected superiorly to the level of the malar buttress to expose the complete lateral wall of the maxilla. Elevation of the periosteum adjacent to the implant site was minimized to preserve blood supply to the alveolar crest. The periosteum was reflected superiorly to the anticipated height of the lateral maxillary wall infracturing.

After the lateral maxillary wall was exposed, a round bur was used in a slow-speed, high-torque straight handpiece at 2000 rpm with copious sterile saline irrigation to create an oval-shaped outline in the lateral wall of the maxillary sinus (Fig 2a). Once the access was delineated, the bur was used to continue outlining the osteotomy with a brush-stroke approach until a bluish hue was observed all around the access window, indicating the approaching underlying Schneiderian membrane. Care was taken not to penetrate this membrane. To ensure that the island of bone had been penetrated all around the oval osteotomy, it was tapped gently with a blunt instrument until movement was noted.

After the outline was completed, the oval bone island was then pushed inward and upward and rotated into the sinus to provide an adequate compartment for the graft material and implants (Fig 2b). The sinus floor septi were not altered.

Bone Harvest of Graft Material. All of the patients received an autogenous composite bone graft consisting of a combination of 50% membranous bone harvested from the symphysis and 50% demineralized freeze-dried bone allograft (DFDBA).

An intraoral vestibular incision was made from the mandibular canine-to-canine region, along with vertical release incisions (if needed), and a full-thickness mucoperiosteal flap was reflected. The mental nerve and mental foramen were dissected out and identified.

Monocortical bone blocks were harvested from the symphysis area using a #14 straight bur with constant irrigation. The bur was positioned to minimize the risk of damaging mandibular tooth roots or the mental nerve. The blocks of bone were removed using a curved osteotome. Hemostasis was achieved using electrocautery, thus minimizing the need for bone wax. Once a sufficient quantity of bone had been removed (as determined during the preoperative evaluation), the area was sutured in a 2-layer closure and in a tension-free manner. The mucoperiosteal flap was sutured with 3-0 vicryl suture material.

After sufficient autogenous graft material was harvested, the bone was ground in a minibone mill and mixed with reconstituted DFDBA at a 1:1 ratio in sterile saline. Excess saline was wicked away using 4 × 4-inch gauze. The mixture was then placed into 1-mL tuberculin syringes and set aside.

One-Step Augmentation Grafting and Implant Placement. The implant sites were prepared using a surgical guide. Care was taken to protect the sinus membrane during this procedure. Once the implant sites had been prepared, the tops of the tuberculin syringes containing the graft mixture were cut off, and the mixture of autogenous bone and DFDBA was "injected" into the maxillary sinus and packed against the intact medial wall.

After the medial portion of the sinus was grafted, hydroxyapatite- (HA) coated Integral cylindrical dental implants (Sulzer Calcitek, Carlsbad, CA), 13 to 15 mm in length, were placed in the augmented sinus (Fig 3). Initially, the implants were pushed in only half of their total length. The bone graft was then placed at the apical aspect of the implants and between the implants. Care was taken to maintain proper positioning of the implants so as not to compromise subsequent prosthetic restoration. The implants were then pushed fully into the grafted compartment and the remaining exposed surface of the implants (the lateral aspect) was firmly packed with the graft mixture. Care was taken to achieve intimate adapta-

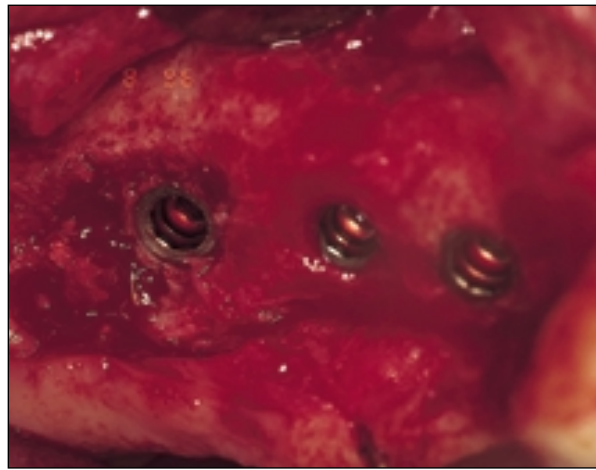


Fig 4 Following an average of 9 months of integration, the implants were uncovered. There was no indication of clinical mobility of any implant.

tion of the graft material to the implant surface. The maxillary sinus buccal window was covered with a sheet of laminar bone as a resorbable barrier membrane. The mucoperiosteal flap was closed primarily over the graft and the implants using 3-0 vicryl vertical mattress sutures.

Postoperative Care. Patients were instructed not to blow their nose for 2 weeks after surgery and to cough or sneeze with an open mouth. Other recommended postoperative instructions included pressure at the site of surgery, ice, elevation of the head, and rest. Analgesics were used to control pain or discomfort. Preoperative prophylactic antibiotic therapy was continued postoperatively for 5 to 7 days. An average of 9 months was allowed for the implants to integrate in each patient. During this period, patients were able to wear a conventional prosthesis that had been modified with a soft lining material. Because the graft donor site was intraoral, a recuperation period of 1 to 2 weeks was normally needed, after which the modified conventional prosthesis was usually well tolerated.

At the time the implants were exposed, they were assessed for stability and crestal bone loss (Fig 4), and the source of any pain or discomfort reported by the patient was evaluated. Panoramic and periapical radiographs (Fig 5a) and dental CT scans (DentaScan) (Fig 5b) were obtained to assess bone support of the implants.

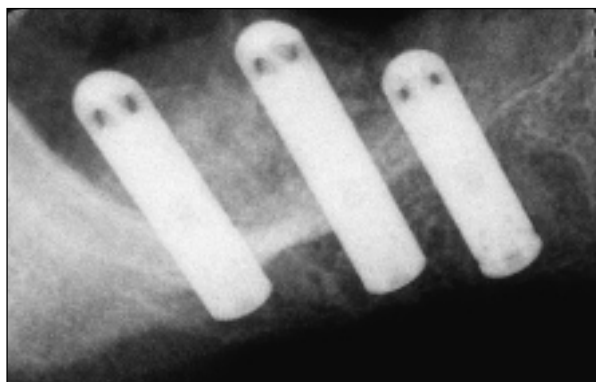


Fig 5a Radiographs indicated adequate integration of the implants. Note the bone consolidation visible on this radiograph, which was typical of all cases in this study.

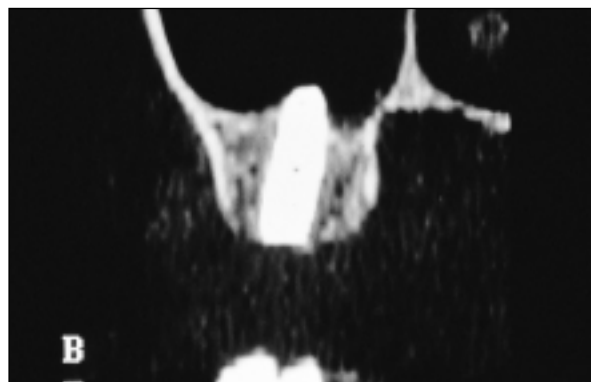


Fig 5b Dental computed tomographic scans also indicated good bone support for the simultaneously placed implants in this study.

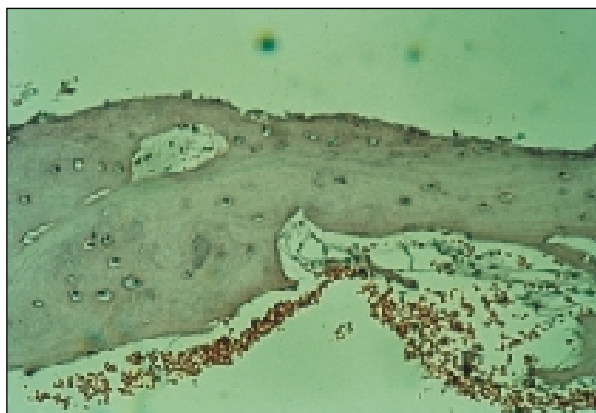


Fig 6 Histologic view of the bone core showing lamellar bone with a high degree of cellularity and plump osteocytes reamed by flat osteoblasts.

Results

A total of 160 Integral HA-coated dental implants were placed into 63 grafted maxillary sinuses in 63 patients during a 3-year period (1993 through 1995). The mean length of follow-up after loading was 31 months, with a range of 23 to 48 months.

None of the 63 patients experienced postoperative sinus complications (eg, sinus congestion, graft infection, poor wound healing). Five patients experienced sensory disturbance, a result of injury to the incisive nerve branch during the bone harvesting surgery, that lasted for 6 to 8 months postsurgery.

Following uncovering of the implants an average of 9 months after placement, there was no evidence of crestal bone loss around any of the implants. All implants were clinically integrated,

and bone consolidation was observed on radiographs. Bone cores were obtained at uncovering of the implants 9 to 10 months after sinus augmentation (Fig 6). Altogether, 120 cores were obtained. Histologic examination of the bone cores in each of the 63 patients' implant sites showed lamellar bone with a high degree of cellularity and plump osteocytes rimmed by flat osteoblasts. A few foci of nonvital bone surrounded by living bone were noted. All 63 patients maintained stable implant prostheses during their 2- to 4-year follow-up periods. No implants were lost.

Discussion

Results from this study indicate that the 1-step procedure of grafting the maxillary sinus and simultaneously placing HA-coated implants is a feasible option for patients with as little as 3 to 5 mm of alveolar bone height prior to grafting.

The technique of antral floor grafting was originally developed by Tatum and coworkers in the early 1970s.^{5,11} Initially, an alveolar crest access to the maxillary sinus was used. Later, a modified Caldwell-Luc procedure was developed, in which the sinus was approached by infracturing the lateral wall of the maxilla and using the wall to elevate the maxillary sinus membrane. Autogenous bone was then placed in the area previously occupied by the inferior third of the sinus. This procedure provided adequate bone in the posterior maxilla, which permitted various implant placement options. In 1980, Boyne and James reported a similar surgical procedure and demonstrated the potential of the maxillary antrum as a site of bone formation after the placement of autogenous marrow and cancellous bone in the maxillary sinus.¹²

In 1984, Misch modified the technique and developed a combination sinus augmentation and blade-vent placement, in which both are accomplished in the same procedure.¹³ Recent histologic and histomorphometric studies of various types of grafting materials used to augment the maxillary sinus floor indicate that particulate grafts that contain autogenous bone may be particularly suited to earlier implant placement of implants because of relatively quick healing periods.^{14,15} Optimal graft and implant materials and techniques are still an area of study and debate, however.

Since the mid-1980s, a variety of techniques have been described for augmenting the maxillary sinus with grafting material to accommodate implant placement.^{1,3-5,7-10,16-27} The procedures vary in terms of the initial surgical approach, the type or site of grafting material, and the type of implant material. The criteria for determining when either the 1-step or 2-step procedure should be used, however, have generally been universal. As mentioned, these criteria, based largely on empirical evidence, have called for the 2-step procedure to be used for situations involving anything less than 5 mm of alveolar bone height and for the 1-step procedure to be reserved only for patients with bone heights of 5 mm or more.^{1,6,8,9}

In the 2-step procedure, after the sinus is completely filled with the desired level of bone grafting mixture (as in the 1-step procedure), the mucoperiosteal flap is repositioned and the incisions are closed with interrupted nonresorbable sutures. After the bone has matured, approximately 6 months after the graft procedure, the implants are placed in this area, according to the surgical protocol for the particular implant system being used. Then, there is an additional 6-month osseointegration phase before the implants are uncovered and the abutments are placed. The 1-step procedure offers the advantages of less surgical treatment for the patient and a coordinated consolidation of the graft around the implants during healing, thus reducing both the surgical and healing times for the patient. Six to 12 months after the simultaneous grafting and implant placement procedure, most patients are able to wear fixed, implant-supported prostheses.

Over the last decade, the success of sinus floor graft augmentation for the placement of implants has increased significantly and has become an excellent procedure for treating selected patients with severely atrophic posterior maxillae. Many authors have reported good initial results with both the 1-step and 2-step procedures.^{1,3-5,7-10,16-27}

Conclusion

Considering the satisfactory results obtained in this patient population using the 1-step procedure with HA-coated implants for patients in whom there was only 3 mm to 5 mm of available alveolar bone height prior to augmentation, a greater number of patients should perhaps be considered as potential candidates for maxillary sinus grafting and simultaneous implant placement into the grafted site. This option will allow the dental practitioner more flexibility in deciding which surgical approach is best for individual patients.

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