The Bone-Added Osteotome Sinus Floor Elevation Technique: Multicenter Retrospective Report of Consecutively Treated Patients

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A retrospective clinical evaluation of patients consecutively treated from multiple centers was performed. The treatment of these patients utilized the bone-added osteotome sinus floor elevation (BAOSFE) procedure with immediate implant fixation. The BAOSFE method employs a specific set of osteotome instruments to tent the sinus membrane with bone graft material placed through the osteotomy site. A total of 174 implants was placed in 101 patients. Implants were of both screw and cylinder shapes with machined, titanium plasma-sprayed, and hydroxyapatite surfaces from various manufacturers.

The 9 participating clinicians used autografts, allografts, and xenografts alone or in various combinations, and the type of graft was selected by the individual clinicians. The choice of graft material did not appear to influence survival rates. Loading periods varied from 6 to 66 months. The survival rate was 96% or higher when pretreatment bone height was 5 mm or more and dropped to 85.7% when pretreatment bone height was 4 mm or less. The most important factor influencing implant survival with the BAOSFE was the preexisting bone height between the sinus floor and crest. This short-term retrospective investigation suggests that the BAOSFE can be a successful procedure with a wide variety of implant types and grafting procedures.

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Key words: bone-added osteotome sinus floor elevation, Caldwell-Luc surgery, osteotomes, retrospective clinical evaluation, sinus membrane

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The technique of sinus floor elevation has expanded prosthetic options by enabling the placement of additional implant support in maxillary segments with atrophic ridges and pneumatized sinuses. While other regenerative procedures, such as onlay and interpositional (Le Fort I osteotomy) grafts, have been utilized for this purpose, these operations are limited in applicability and often involve significant postoperative morbidity.[1]

The most commonly utilized augmentation method for sinus reconstruction was presented in 1977 by Tatum[2] and published in 1980 by Boyne and James.[3] In Tatum's initial technique, access to the sinus floor was through the ridge crest. This approach was gradually abandoned in favor of a window through the lateral wall of the alveolus

Fig 1 Summers osteotomes numbers 1 to 5 (Implant Innovations), which are utilized for immediate implant placement procedures. By their design, these osteotomes shave and compact bone as the instruments are advanced. Graft materials are used to backfill the osteotomy.

(Caldwell-Luc operation), which seemed more versatile and practical.[4] Tatum's crestal method involved a variety of instruments, including burs, channel and socket formers of his design, and special sinus curettes. In this technique, removing bone exposed the sinus floor. Then the residual thin wall was infractured with a small osteotome, instrument handle, or socket former. The sinus membrane was tented and a bone graft was placed in the altered site. When possible, an implant of Tatum's own design was placed.[4] If conditions did not permit immediate implant fixation, tenting of the membrane was accomplished with the graft material, and implants were placed at a later time.

The Caldwell-Luc operation offered advantages compared to the original crestal approach, including access through a larger window into the sinus. The osteogenic potential of the infractured lateral wall did not appear to be of major concern to clinicians, since autogenous bone was imported to the site from distant locations. Numerous authors have documented the technical details and grafting options for the lateral window method.[5–10] Immediate and delayed fixation of varied implant designs have been investigated using the Caldwell-Luc operation, with success seen with both options.[11,12] The quantity of pre-existing bone required for success with simultaneous implant placement and the ultimate influence of the pre-existing bone on success remain unresolved.

A less invasive alternative for sinus floor elevation with concurrent grafting and immediate implant placement was introduced by Summers in 1994.[13] The bone-added osteotome sinus floor elevation procedure (BAOSFE) employs a specific set of osteotomes (Fig 1) (Implant Innovations, Palm Beach Gardens, FL). The tips of these instruments have a concave nose and a sharpened edge, which can be used to shave bone from the side wall of the osteotomy. The shaved bone, added graft materials, and trapped fluids create pressure as the osteotomes are inserted, resulting in elevation of the sinus floor.

The (BAOSFE) technique attempts to reposition existing crestal bone under the sinus, along with graft materials, therby elevating the sinus floor and increasing osseous support for an implant.[13] Use of drills is minimized or avoided completely. Pretreatment crestal bone is displaced toward the sinus floor as the special osteotomes are inserted. A combination of graft materials and autogenous particles—from the same segment if possible—are added into the osteotomy. The osteotomes do not enter the sinus (Figs 1 to 9). This combined mass, which has a semi-solid consistency, acts like a hydraulic plug to push up the sinus boundary. Concurrently, implants are placed with the apical end of the implant in the tented space. The graft materials do not provide immediate support for the implant. Initial fixation is from the pre-existing bone under the antral floor (Figs 2 and 8).

For a procedure to gain widespread acceptance, however, it must show efficacy for a large number of clinicians. It is the purpose of this multicenter experience to provide a retrospective evaluation of early treatment with the BAOSFE technique as a means of sinus floor elevation with immediate placement of implants.

Materials and Methods

Eight centers with 9 clinicians (Table 1) participated in this clinical evaluation. The patient population consisted of 37 males and 64 females ranging in age from 31 to 81 years (mean age 56.1 years). Patients were excluded if they had a history of immune disease, uncontrolled diabetes, ongoing chemotherapy, radiation treatment to the head and neck, alcohol/drug abuse, or psychologic instability. All implants had to be consecutively placed and in function for a minimum of 6 months. It was necessary for all implant sites to demonstrate a minimum of 3 mm of bone beneath the maxillary sinus floor radiographically to allow initial stabilization of the implant. Pretreatment bone height was determined for each site by the treating clinician in a non-standardized manner. The measurement technique involved either a ruler or a periodontal probe to ascertain this dimension from the preoperative periapical radiograph, rounding off to

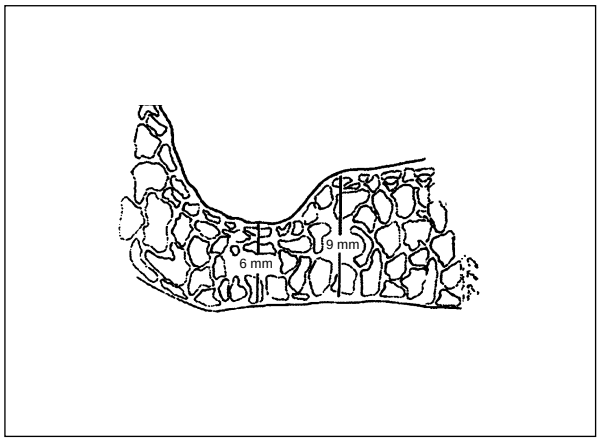

Fig 2 Preoperative bone dimensions beneath the sinus floor suitable for BAOSFE. A 6-mm site can be altered to support a 10-mm implant, and a 9-mm location can be deepened to accept a 13-mm implant.

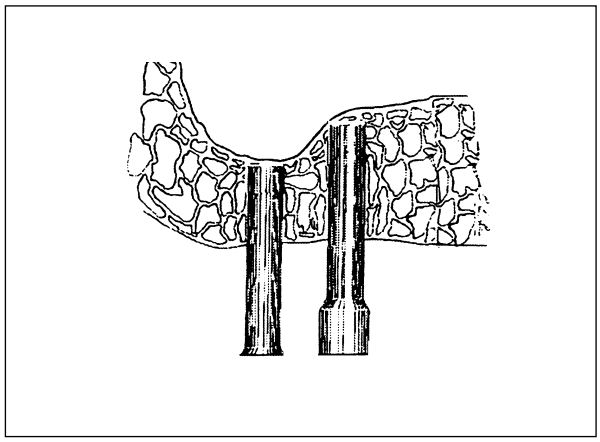

Fig 3 In soft bone, a small-diameter osteotome (Summers Osteotome #1) is inserted with hand pressure or light malleting to the sinus boundary. In denser bone, a drill is used with care to penetrate to this depth. The goal is to stay short of the membrane with the initial osteotomy.

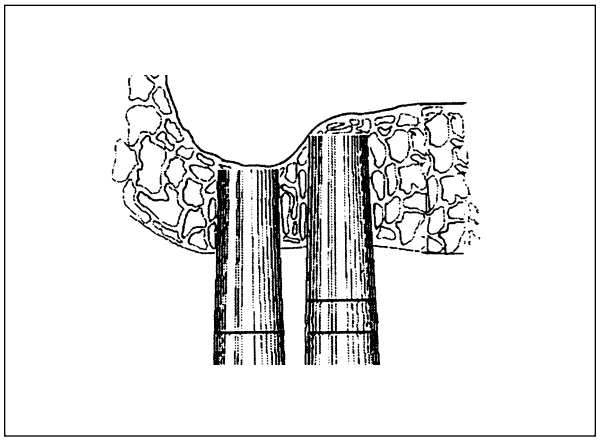

Fig 4 The osteotomy is widened with the #2 and #3 Summers osteotomes. The #3 instrument prepares a slightly undersized osteotomy for a 3.75-mm-diameter implant.

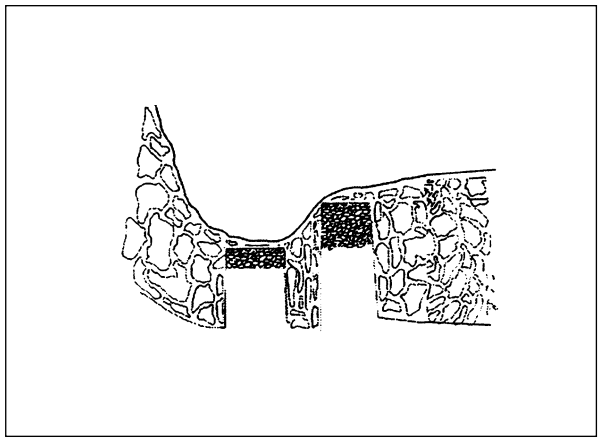

Fig 5 A prepared bone mix is added into the osteotomy with a carrier before any attempt is made to elevate the sinus floor. The mix should contain some autogenous bone obtained from the same segment if possible. A variety of graft materials can be added to the autogenous particles.

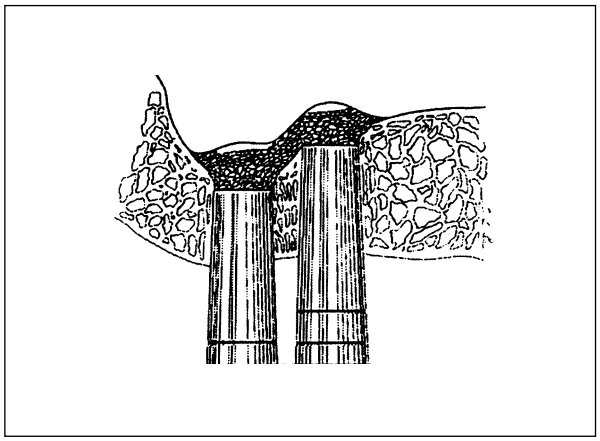

Fig 6 The largest osteotome used previously is reinserted into the sinus floor. Pressure from the instrument causes the added materials and trapped fluids to exert pressure on the sinus membrane.

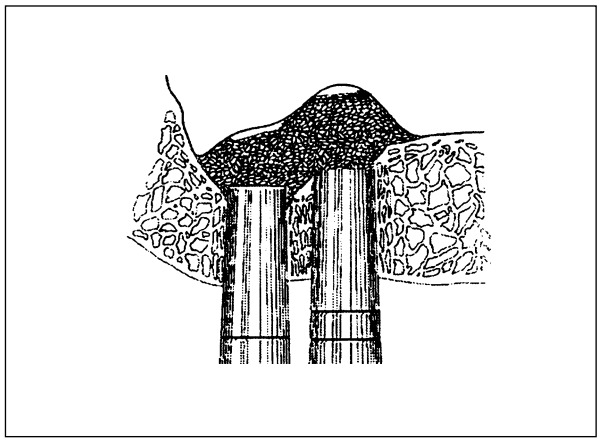

Fig 7 Additional small loads of bone are added, and the osteotome is returned to the sinus floor. Each increment of material will elevate the membrane by 1 to 1.5 mm.

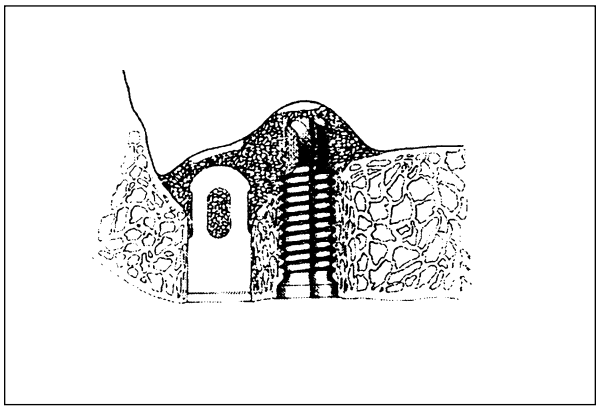

Fig 8 When the antral floor is displaced, the graft will move freely, elevating the membrane without the instrument entering the sinus. The implant becomes the final osteotome, pushing up the membrane to its ultimate height.

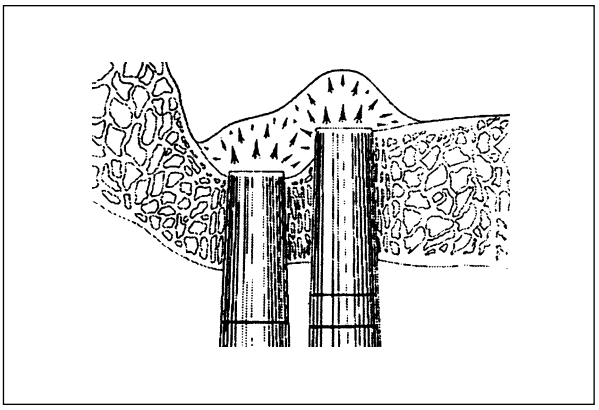

Fig 9 The concave osteotome tip traps bone and fluids as the instrument moves inward. Hydraulic force is created, exerting pressure in all directions. This force elevates the membrane over an area wider than the osteotomy.

Table 1 Participating Clinicians

Clinician	Location
Paul Fugazzotto	Milton, MA
Richard Lazzara	West Palm Beach, FL
Robert Levine	Philadelphia, PA
Manuel H. Marks	Langhorne, PA
Jose R. Mellado	Philadelphia, PA
Paul S. Rosen	Langhorne, PA
Richard Shanaman	Reading, PA
Robert Summers	Ardmore, PA
Mark Weingarden	Allison Park, PA

the nearest millimeter. Surgeries were performed under aseptic conditions. Osteotomies were performed by either osteotome alone according to Summers' original technique or in combination with drilling, where dense bone existed. The osteotomes used to raise the sinus floor came from one manufacturer (Implant Innovations). Clinicians selected the graft material and decided on the particular combinations for its use. Graft materials used in sinus augmentation included autogenous bone, demineralized freeze-dried bone allograft, freeze-dried bone allograft, Osteograf-N (Ceramed, Lakewood, CO), and Bio-Oss (Osteohealth, Shirley, NY). The type of implants placed included a variety of designs and manufacturers: Dentsply standard screws, Implamed standard screws, titanium plasma-sprayed cylinders (Implant Innovations), standard screws (Implant Innovations), Interpore TPS cylinders (Wurmburg, Germany), Nobel Biocare standard screws (Göteborg, Sweden), and Straumann TPS screws (Waldenburg, Switzerland). All implants were submerged with the exception of ITI. The time between stages 1 and 2 ranged from 5 to 11 months (mean, 7 months). Subsequent prostheses included single-tooth restorations, multiple-unit implant-supported restorations, and overdentures. Patients were followed up every 3 to 6 months for supportive care and evaluation.

The criteria for survival were based not only on the implant being in function but also had to meet the following conditions, which were modifications of Albrektsson et al[14] success criteria. Evaluation, though non-standardized, was made by each individual clinician, with the criteria for survival being as follows:

1. The individual, unattached implant was immobile when tested clinically after removal of the prosthesis from the implants.
2. A non-standardized radiograph demonstrated no evidence of peri-implant radiolucency.
3. Vertical bone loss, as measured on a non-standardized radiograph, was less than 2 mm annually following the implant's first year of service.
4. The individual implant's performance was characterized by the absence of persistent and/or irreversible signs such as pain, infection, neuropathy, or paresthesia/anesthesia.

Results

A total of 174 implants was placed in 101 patients. Sixty-six of the implants were placed in 37 male patients, while 108 were placed in 64 females. One hundred sixty-six implants were

Table 2 Survival Rate by Shape and Surface

Shape/surface	Total placed	Surviving	Percent
Standard screw	45	42	93.3
TPS screw	35	34	97.1
HA screw	6	6	100
TPS cylinder	88	84	95.5

TPS = titanium plasma-sprayed; HA = hydroxyapatite.

Table 3 Survival Rate by Pretreatment Bone Height

Pretreatment height	Implants placed	Surviving	Percent
4 mm or less	14	12	85.7
5 to 6 mm	50	48	96.0
7 mm or greater	110	106	96.4

Table 4 Analysis of Failed Implants Versus Months of Loading

Months loaded	Implants	Failures	Percent failed
6 to 12	171 (15)	3	1.8
13 to 18	156 (77)	1	0.6
19 to 24	79 (36)	0	0.0
25 to 36	43 (39)	0	0.0
37 or more	4	1	25.0

( ) = subtotal of implants for each time period.
Note: 3 of 8 total failures occurred prior to loading.

Table 5 Implant Width Data

Width (mm)	Total in study	Survived		Percent survival
		No	Yes	
2.9	1	0	1	100
3.10	30	2	28	93.3
3.75	27	1	26	96.3
3.8	6	0	6	100
4	81	3	78	96.3
4.1	14	1	13	92.9
5	10	0	10	100
6	5	1	4	80.0

loaded for a minimum of 6 months, for an overall survival rate of 95.4%. The average period of implant loading was 20.2 months, with a range of 6 to 66 months. There were a total of 27 implants placed in 17 patients who smoked, and of these, 2 failed, for a survival rate of 93% of the implants in smokers. The nonsmokers contributed 147 sites, with 6 failures, for an overall survival rate of 96%.

A summary of the survival rates for the various implant types is seen in Table 2. All types of implants in this retrospective review had a survival rate of 93% or better. Table 3 summarizes the survival rate of the implants by pretreatment bone height. When presurgical bone height beneath the sinus is compared to implant survival, the data demonstrate that in sites of 4 mm or less, there was a survival rate of 85.7%, which improved to 96% in locations with more than 4 mm of initial bone height.

The failure rate according to the months loaded is summarized in Table 4. Three of the 8 failed implants (37.5% of overall failures) failed prior to loading. The majority of failures of the loaded implants occurred between 6 and 12 months, with 2 of the 8 implants failing after the first year of loading.

Table 5 summarizes the survival rate of implants based on implant diameter. All implant diameters except 6 mm (80%) showed survival rates of better than 90%.

Discussion

Bone-added osteotome sinus floor elevations were performed by 9 experienced clinicians at 174 sites in 101 patients of both sexes with a wide age range. Many of the involved clinicians included their initial experiences with the procedure, which makes the overall survival rate of 95.4% quite acceptable. It may be implied from this review that in experienced hands a variety of implants and grafting materials can be utilized successfully with this technique. The protocol can be modified to include the use of drills if necessary to create the initial osteotomy.

The most important negative factor that can be inferred from the results is that BAOSFE becomes less predictable when there is 4 mm or less of pre-existing alveolar bone height beneath the sinus. The pre-existing bone height inference would have been strengthened had calibration of the examinations and standardization of radiographs been planned. The sample size is also very small. Additional clinical research is required before conclusions, which can be subjected to the rigors of statistical analysis, can be made.

While the survival rate of 95.4% in this retrospective review may seem good, the reader should bear in mind that the average length of loading reported is only 20.2 months. Bone-added osteotome sinus floor elevation has yet to stand the test of time, and standardized prospective studies are required.

Conclusions

The BAOSFE procedure appears to be a safe method for augmenting bone at the sinus floor. This initial short-term retrospective investigation shows the BAOSFE can be successfully completed using a variety of implant types and grafting materials. Less than 4 mm of pre-existing bone height beneath the sinus and smoking appear to reduce the likelihood of implant survival. Further long-term evaluation via prospectively designed studies is needed to better evaluate this technique.

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References

1. Fugazzotto PA, Vlassis J. Long-term success of sinus augmentation using various surgical approaches and grafting materials. Int J Oral Maxillofac Implants 1998;13:52–58.
2. Tatum OH Jr. Cited in Smiler DG, Johnson PW, Lozada JL, Misch C, Rosenlicht JL, Tatum OH, et al. Sinus lift grafts and endosseous implants. Treatment of the atrophic posterior maxilla. Dent Clin North Am 1992;36:151–186.
3. Boyne P, James R. Grafting of the maxillary floor with autogenous marrow and bone. J Oral Surg 1980;38: 613–616.
4. Tatum OH Jr. Maxillary and sinus implant reconstruction. Dent Clin North Am 1986;30:207–229.
5. Misch CE. Maxillary sinus augmentation for endosteal implants. Organized alternative treatment plans. Int J Oral Maxillofac Implants 1989;4:49–58.
6. Breine U, Brånemark P-I. Reconstruction of the alveolar jaw bone. An experimental and clinical study of immediate and pre-formed autologous bone grafts in combination with osseointegrated implants. Scand J Plast Reconstr Surg 1980;14:23–48.
7. Wheeler SL, Holmes RE, Calhoun CJ. Six-year clinical and histologic study of sinus lift grafts. Int J Oral Maxillofac Implants 1996;11:26–34.
8. Wagner JR. A 3½-year clinical evaluation of resorbable hydroxylapatite OsteoGen (HA Resorb) used for sinus lift augmentations in conjunction with the insertion of endosseous implants. J Oral Implantol 1991;17:152–164.
9. Wetzel AC, Stich H, Caffesse RG. Bone apposition onto oral implants in the sinus area filled with different bone substitutes [abstract]. J Dent Res 1995;74(special issue):21.
10. Hurzeler MB, Kirsch A, Ackermann KL, Quinones CR. Reconstruction of the severely resorbed maxilla with dental implants in the augmented maxillary sinus: A five-year clinical examination. Int J Oral Maxillofac Implants 1996; 11:466–475.
11. Jensen OT, Greer R. Immediate placement of osseointegrating implants into the maxillary sinus augmented with mineralized cancellous allograft and Gore-Tex: Second-stage surgical and histologic findings. In: Laney WR, Tolman DE (eds). Tissue Integration in Oral, Orthopedic, and Maxillofacial Reconstruction. Chicago: Quintessence, 1992: 321–333.
12. Fugazzotto PA. Maxillary sinus grafting with and without simultaneous implant placement: Technical considerations and clinical reports. Int J Periodontics Restorative Dent 1994;14:545–551.
13. Summers RB. The osteotome technique: Part 3: Less invasive methods of elevating the sinus floor. Compend Contin Educ Dent 1994;15:698–708.
14. Albrektsson T, Zarb GA, Worthington P, Eriksson AR. The long-term efficacy of currently used dental implants: A review and proposed criteria of success. Int J Oral Maxillofac Implants 1986;1:11–25.