Maxillary Sinus Augmentation by the Crestal Core Elevation Technique

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Background: The crestal core elevation (CCE) technique is reportedly a less invasive procedure than the lateral window elevation technique. We retrospectively evaluated long-term outcomes of CCE procedures over an 11-year time period.

Methods: Core preparations were made after extractions of 57 upper molars in 45 patients. Extraction sites were drilled with a calibrated trephine bur to an estimated distance of 1 mm from the sinus membrane. The trephined interradicular bone and underlying sinus membrane were imploded into the sinus. The surgical crater and residual extraction socket were filled with deproteinized bovine bone mineral or freeze-dried bone allograft, stabilized, and protected with an absorbable collagen membrane and fully covered with coronally positioned flaps. Implants were placed 4 months later. Success was defined if ≥9 mm available bone height was available. Where the available bone height varied between 7 and 9 mm, implant placement was complemented using the bone-added osteotome sinus floor elevation technique; those sites were defined as a "partial success."

Results: The CCE technique was successful in 31 (68.9%) out of 45 sites, and partially successful in six (13.3%) out of 45 sites. Eight sites failed (17.8%). Surgical failures were caused by core detachment resulting in large tears of the sinus membrane. Implants placed in successful sites presented a 100% survival rate during the study duration.

Conclusions: CCE implemented simultaneously with molar extractions provided therapeutic benefits and clinical limitations. The subsequent implant placement using CCE revealed an excellent survival rate in the study population evaluated. *J Periodontol 2011;82:41-51.*

KEY WORDS

Allograft; bone regeneration; bovine; collagen; dental implants; maxillary sinus.

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Rapid crestal bone resorption after maxillary tooth loss is further accentuated in the posterior regions because of pneumatization and enlargement of the maxillary sinuses. A treatment that enables preservation and augmentation of the available vertical bone at the time of maxillary tooth extraction may offer numerous therapeutic benefits.[1] Grafting the maxillary sinus with autogenous bone or bone substitute materials ("sinus lift") is the most common approach for restoring bone height in this region.[2,3] The techniques most frequently used for sinus augmentation are 1) osteotome sinus floor elevation (OSFE) and bone-added OSFE (BAOSFE),[2,4] 2) crestal core elevation (CCE),[2,5] and 3) the lateral window technique (LWT).[2] Although autogenous bone is still considered by many to be the gold standard,[6,7] a wide variety of bone substitute grafting materials have been successfully used since the early 1980s to augment the maxillary sinus. These include demineralized and non-demineralized freeze-dried bone allografts,[8,9] absorbable and non-absorbable hydroxyapatite preparations,[10,11] xenografts,[12-16] calcium sulfate,[17,18] and growth factors embedded in different carrier materials.[19-21]

Although LWT and BAOSFE have been the focus of much interest and have provided abundant clinical data, there are relatively few publications dealing with the CCE technique,[5,22-27] with but one of them reporting on the application of the CCE technique simultaneously with upper molar extractions.[26] First described

doi: 10.1902/jop.2010.090682

by Summers in 1995,[5] CCE is a modification of the OSFE and the BAOSFE approaches, which are suitable for immediate implant insertion but require ≥6 mm of bone between the sinus floor and the crest of bone. CCE may be a simple alternative to LWT when the quantity of bone does not permit immediate implant placement. Performing CCE involves vertical crestal drilling using a wide trephine bur up to the sinus cortex followed by displacement of the bony plug inward and raising the sinus floor with a wide concave osteotome. The technique may be implemented in patients with residual bone height measuring 3 to 6 mm. A further modification of the Summers technique was suggested by Fugazzotto and De Paoli,[26] who used it concomitantly with extractions of the upper molars. The placement of deproteinized bovine bone mineral‡ covered with absorbable membrane or non-absorbable expanded polytetrafluoroethylene§ membrane minimized the loss of alveolar bone height and width after tooth removal and permitted implant placement after 4 to 8 months.[26]

The present retrospective clinical study evaluated the outcome of 57 sinus lift procedures by means of the CCE technique performed concomitantly with extractions of the upper molars, using allograft material and an absorbable collagen membrane.

MATERIALS AND METHODS

Patient Selection

The files of 45 adult patients were selected from the archives of Clalit Sick Fund Clinics, Tel-Aviv, Israel. Files of patients who underwent the CCE procedure between 1998 to 2009 were screened. Selected cases met the following inclusion criteria: 1) patients were scheduled for implant-supported fixed reconstructions in the upper molar region; 2) patients presented with at least one hopeless molar tooth caused by root fracture, severe periodontal involvement, irreparable endodontic treatment failure, or advanced caries lesions as determined by clinical examination including panoramic or periapical radiographs; and 3) hopeless teeth were associated with reduced sinus floor height measuring 3 to 6 mm, requiring sinus floor elevation before implant placement was possible (Fig. 1).

A total of 45 cases, 21 males and 24 females, aged 30 to 82 years (Table 1), were considered suitable. Fifty-seven extraction/CCE augmentation procedures were performed in 45 sinuses (sites) involving 37 first and 20 second molar extraction sockets (Table 1). Patients received a thorough explanation about the sinus floor CCE technique and alternative treatment plans and signed an informed consent to undergo the CCE technique.

Files of patients with a history of chronic steroid therapy, uncontrolled diabetes, cardiovascular disease, irradiation of the head and neck within the previous year, maxillary sinus cysts, active chronic sinusitis, uncontrolled periodontal disease, or inability to perform proper oral hygiene were excluded from this study. Radiographic bone dimensions were measured using a 1-mm calibrated periodontal probe.‖

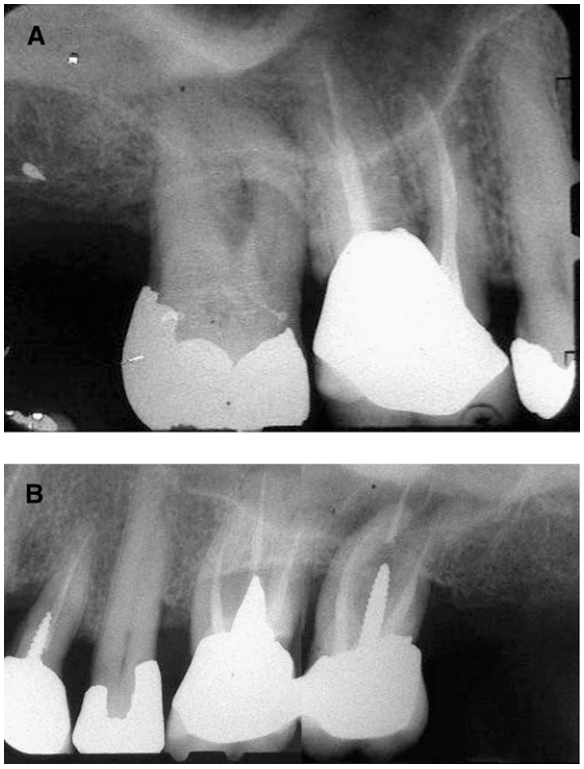

Figure 1.
Periapical view of hopeless upper left and upper right molars associated with a thin sinus floor in a 65-year-old male (site #6 in Table 1). ***A)*** *Upper right side.* ***B)*** *Upper left side.*

Patients had undergone a thorough presurgical evaluation, including a full-mouth periodontal chart, occlusal analysis, study of the mounted casts, and diagnostic wax-ups. All patients were treated by initial periodontal therapy, including oral hygiene instructions and training, scaling, and root planing. Additional periodontal therapy was administered to achieve adequate periodontal health and satisfactory oral hygiene.

Surgical Technique

Before surgery, the patients were premedicated with 8 mg dexamethasone¶[28] and 875 mg amoxicillin and clavulanate potassium.# Penicillin-sensitive patients were premedicated with clindamycin HCL,** 300 mg, starting 1 hour before surgery. All patients rinsed

‡ Bio-Oss, Geistlich Pharma, Wolhusen, Switzerland.
§ GORE-TEX, W.L. Gore & Associates, Flagstaff, AZ.
‖ Kramer-Nevins IMP6578, Hu-Friedy, Chicago, IL.
¶ Dexamethasone, Rekah Pharmaceutical Products, Holon, Israel.
# Augmentin, GlaxoSmithKline, Brentford, UK.
** Dalacin-C, Pfizer NV/SA, Puurs, Belgium.

Table 1.

Distribution of Sites by Age, Gender, Grafting Material, Implant Dimensions, and Follow-Up Time*

Site No.	Age (years)	Gender	Grafting Material	Implant Length (mm)	Implant Width (mm)	Time in Function (years)	Tooth No.
1	61	M	FDBA†	10	4.7	1	14
2	54	M	FDBA	11	4.7	1	2
3	61	F	FDBA	13	5	5	3
			FDBA	11.5	4.2	5	2
4	57	M	FDBA	9	5	5	3
5	60	F	FDBA	11.5	3.75	7	3
			FDBA	10	3.75	7	2
6	65	M	FDBA	10.5	5	2	14
			FDBA	10.5	5	2	15
7	68	M	FDBA	13	4.2	1	2
8	53	F	FDBA	11.5	3.75	2	3
9	60	F	FDBA	10.5	5	2	15
10	55	F	FDBA	10.5	5	4.5	14
11	61	M	FDBA	12	5	3	14
12	50	F	FDBA	12	4	1	15
13	58	F	FDBA	10.5	5	1	3
14	42	F	FDBA	13	4.7	1	14
15	66	M	FDBA	12	4.1	11	2
16	60	M	FDBA	13	4.7	1	2
17	35	F	FDBA	13	4.2	1	3
			FDBA	13	4.2	1	2
18	57	M	FDBA	13	4.7	1	2
19	71	M	FDBA	10	4.1	11	3
20	40	F	DBBM‡	13	3.75	3	14
			DBBM	11.5	3.75	3	15
21	35	M	DBBM	13	3.75	1	2
			DBBM	16	3.75	1	3
22	72	M	DBBM	13	5	5	14
23	82	F	DBBM	10	5	1	3
			DBBM	11.5	5	5	15
24	55	F	FDBA	12	4	4	14
25	52	F	FDBA	13	4.7	1	2

Table 1. (continued)

Distribution of Sites by Age, Gender, Grafting Material, Implant Dimensions, and Follow-Up Time*

Site No.	Age (years)	Gender	Grafting Material	Implant Length (mm)	Implant Width (mm)	Time in Function (years)	Tooth No.
26	57	F	FDBA	11.5	4.7	1	3
	57		FDBA	11.5	4.7	1	2
27	55	M	FDBA	13	4.2	1	3
			FDBA	13	4.2	1	2
28	62	M	FDBA	10.5	5	3	3
29	60	F	FDBA	13	5	3	3
30	60	M	FDBA	10.5	5	3	3
31	56	F	FDBA	13	4.2	1	2
32	56	F	FDBA	12	5	3	2
	56		FDBA	12	4	3	3
33	56	F	FDBA	13	5	9	14
34	58	M	FDBA	11.5	4.7	4	14
	58		FDBA	11.5	4.7	4	3
35	60	F	FDBA	11.5	4.7	4	3
36	70	F	FDBA	11.5	4.7	1	2
37	58	M	FDBA	15	4	4	14
	58		FDBA	12	4	4	14
38	76	M	Failure	NA			3
39	58	F	Failure	NA			3
40	40	F	Failure	NA			3
41	39	M	Failure	NA			3
42	30	F	Failure	NA			3
43	35	F	Failure	NA			14
44	70	M	Failure	NA			3
45	78	M	Failure	NA			3

NA = not applicable.
* List of implants:
Maestro/Prodigy Bio-Horizons, South Birmingham, AL.
Spline MTX, Zimmer Dental, Carlsbad, CA.
Screw-Vent, Zimmer Dental.
Implant Direct, Malibu Hills Road, Calabasas Hills, CA.
MIS, seven, BioCom, Shlomi, Israel.
ITI, Institute Straumann, Waldenberg, Switzerland.
† Oragraft, Life Net, Virginia Beach, VA.
‡ Bio-Oss, Geistlich Pharma, Wolhusen, Switzerland.

their mouths with chlorhexidine 0.2% solution†† for 1 minute before the procedure was initiated.

An intrasulcular incision was made around the tooth or teeth to be removed. Mesial and distal releasing incisions extending well up into the buccal fold were placed at the mesial and distal aspects of the mesial and distal papillae, respectively, including the papillary tissue in the flap. The base of the buccal

†† Tarodent mouthwash, Taro Pharmaceutical Industries, Haifa, Israel.

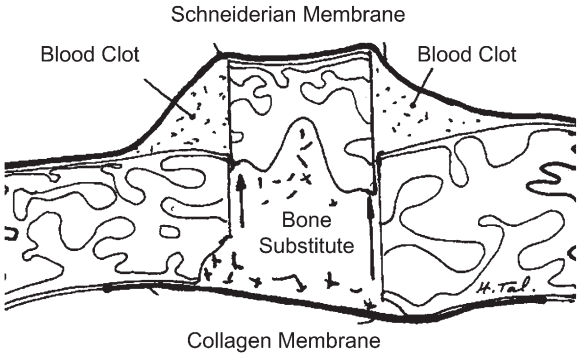

Figure 2.
Schematic drawing of the crestal core elevation technique.

releasing incisions was extended ≈2 to 6 mm horizontally, as previously described.[29] A full-thickness buccal flap was reflected, taking care to completely release the tissue beneath the horizontal releasing incision extensions. The sites of the mesial and distal palatal releasing incisions were positioned to coincide with the buccal releasing incisions, and a palatal full-thickness flap was reflected. Maxillary molars were trisected and the roots were gently removed individually using periotomes.[‡‡] Care was taken to minimize trauma to the hard tissues surrounding the extracted roots, thus preserving the remaining interradicular bone. Extraction sockets were thoroughly debrided.

A calibrated 6-mm external diameter/5-mm internal diameter trephine bur[§§] was placed over the interradicular bone, encompassing both the interradicular septum and part of the extraction socket. Guided by preoperative radiographs, measurements of removed roots, and residual ridge morphology, core preparation was begun by drilling in reverse position at 1,500 rpm under copious irrigation until a 0.5- to 1-mm preparation depth was achieved.[22] Core preparation to the desired depth was completed in the forward position at 1,000 rpm[22] until it extended to an estimated distance of ≈1 mm from the sinus floor in the area of most limited bone height. Care was taken to leave ≥1 mm of intact buccal and palatal bony plates.

A wide-diameter calibrated, concave osteotome[‖‖] with 2-mm markings corresponding to the diameter of the trephine preparation was used under gentle malleting forces to implode both the trephined interradicular bone and the underlying sinus membrane to a depth of ≈1 mm short of the prepared site (Fig. 2). To determine the presence of oroantral communication, the patient was instructed to gently blow through the nose with the mouth open, while finger pressure was applied to the sides of the nose to block the air passage (Valsalva maneuver).[24] In cases in which severe tear of the Schneiderian membrane associated with the detachment of the bony core was diagnosed, the case was considered a failure and treatment was postponed. Coronal positioning of the flap was performed aiming for primary soft tissue closure. In the sites where there was a tear of less than one half of the circumference of the prepared core a bioabsorbable collagen membrane was used to cover the torn sinus membrane and part of the surrounding bony walls within the osteotomy.

The surgical osteotomy and residual extraction socket were filled with either deproteinized bovine bone mineral[¶¶] or freeze-dried bone allograft[##] material using a 6-mm concave osteotome operated with gentle compression force. The site was then protected with a bioabsorbable native collagen membrane,[***24,30] trimmed, adapted, and secured with fixation tacks[†††] or with periosteal absorbable sutures.[‡‡‡] Sites were covered with coronally positioned flaps released by periosteal incisions. The flaps were stabilized by interrupted mattress sutures[§§§] to achieve passive primary closure.

Postoperative Management

After surgery, patients were administered 875 mg amoxicillin with clavulanate potassium[‖‖‖] twice a day or clindamycin HCL, 150 mg, four times a day for penicillin-sensitive patients.[¶¶¶] Antibiotic therapy was continued for the first postoperative week. In addition, 4 mg/day dexamethasone was prescribed for the next 2 days. Analgesic/anti-inflammatory naproxen sodium, 275 mg,[###] was given for pain relief if needed. Chlorhexidine 0.2% mouthrinse was prescribed twice daily for 3 weeks. Patients were instructed to avoid the use of a removable prosthesis until the sutures had been removed (i.e., 10 to 14 days postoperatively).

Healing Time and Success Assessment

Implants were placed 4 months after the CCE procedure. Computerized tomographic (CT) scans made at this stage demonstrated the height and topography of the radiopaque material. Success was defined if the available bone was ≥9 mm. Wherever bone height was estimated at 7 to 9 mm, additional elevation was achieved using the BAOSFE technique simultaneously with implant placement; these were recorded as "partial success" as previously defined by Fugazzotto.[27]

Six months after placement, the implants were exposed and restored with either individual or connected crowns, the latter in cases in which >1 implant had been placed (Figs. 3 through 5). All the patients were

‡‡ Hu-Friedy.
§§ 3i, Biomet 3i, West Palm Beach, FL.
‖‖ Hu-Friedy.
¶¶ Bio-Oss, Geistlich Pharma.
Oragraft, Life Net, Virginia Beach, VA.
*** GORE-TEX, W.L. Gore & Associates.
††† Auto Tac, BioHorizons, Birmingham, AL.
‡‡‡ Ethicon, Somerville, NJ.
§§§ Look Surgically Specialty Corporation, Reading, PA.
‖‖‖ Augmentin, GlaxoSmithKline.
¶¶¶ Dalacin-C, Pfizer NV/SA.
Narocin, Teva Pharmaceutical Industries, Petah Tikva, Israel.

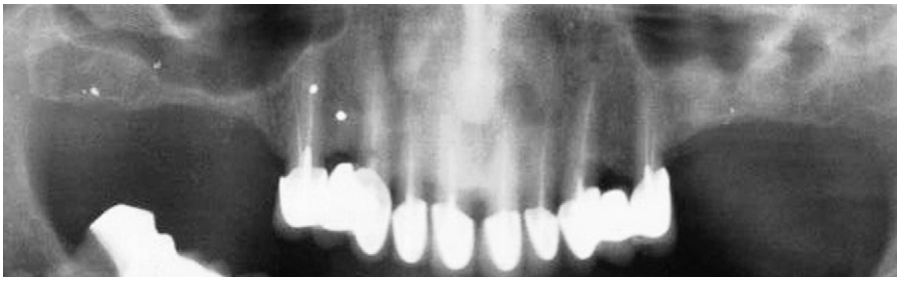

Figure 3.
Panoramic view of the maxilla showing radiopaque material in the upper left molar region after crestal core elevation, compared to a contralateral thin sinus floor caused by sinus pneumatization and bone loss after teeth extractions.

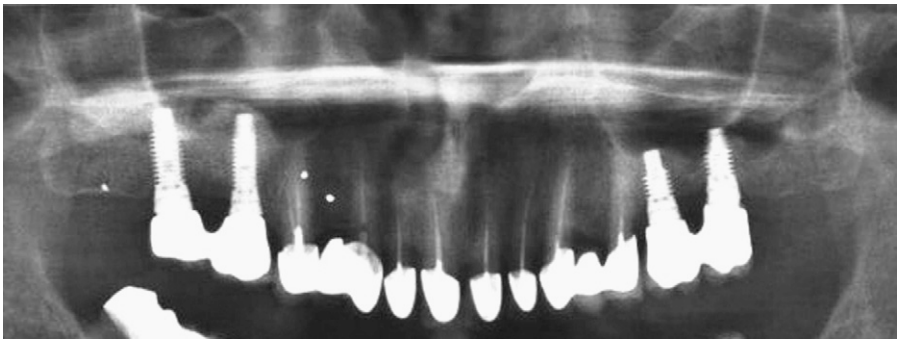

Figure 4.
Two implants were placed at 9 months after right lateral window sinus floor elevation, and two at 4 months after CCE in the upper left side (site #6 in Table 1).

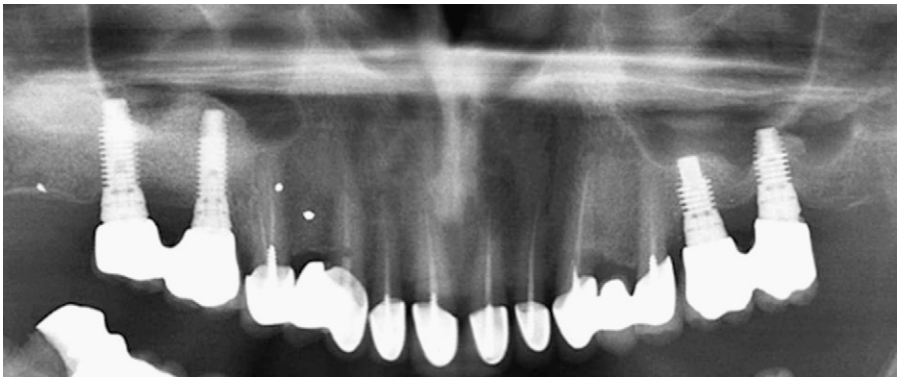

Figure 5.
Panoramic view at the 2-year follow-up showing graft stability and unchanged crestal bone level in two CCE sites at the left sinus.

enrolled in a maintenance program that included a full-mouth periodontal chart, oral hygiene instructions, and scaling and root planing at least twice a year. The implants were examined at 6 months and 1 year after being loaded, and once again at the time of this study (i.e., 1 to 11 years later). An implant was considered successful if it met the criteria set by Albrektsson et al.:[31] immobility; absence of periimplant radiolucency (periapical x-rays); bone loss ≤0.2 mm after the first year of functional loading; and absence of persistent or irreversible signs and symptoms, such as pain, infections, and neuropathies.

Statistical Evaluation

Each patient was treated as a single site. In patients in whom two adjacent implants were placed, their average length represented the implant length. The correlation between age and success was tested using an independent samples *t* test. The correlation between sex and success was tested using Fisher exact test.

RESULTS

The CCE procedure was successful in 31 (68.9%) out of 45 sinuses/sites in which it was performed (Table 2). In six sites (13.3%) ≥1 extraction site presented with 7 to 9 mm of bone height, requiring complementary BAOSFE procedure at the time of implant placement. These sites were recorded as a partial success. In eight sites (17.8%) (Table 2) treatment was postponed because of surgical failure (i.e., displacement of the core or severe tear of the Schneiderian membrane occurring during the malleting phase).

Four extraction sites in four patients presented small tears of the sinus membrane during the malleting phase; these were treated by covering the torn membrane and part of the surrounding bony walls with collagen membrane. Fifteen patients (33.4%) experienced nosebleed during the first week after surgery, and 23 patients (51.1%) had mild swelling or petechiae at the site of surgery 3 to 5 days later: these resolved spontaneously within 1 to 3 weeks. Pain relief medications were consumed by almost all the patients mainly during the first and second postoperative days. Primary soft tissue healing was observed at the time of suture removal in 33 (89.2%) of 37 surgical sites. Four patients (10.8%) presented with small soft tissue dehiscence and exposure of the collagen

Table 2.

Summary of Success and Failure Rates

Total number of patients/sites	45
Number of successfully treated sites (%)	31 (68.9)
Number of partially successful sites (%)	6 (13.3)
Number of failing sites (%)	8 (17.8)
Number of successful implants (%)	49 (100)

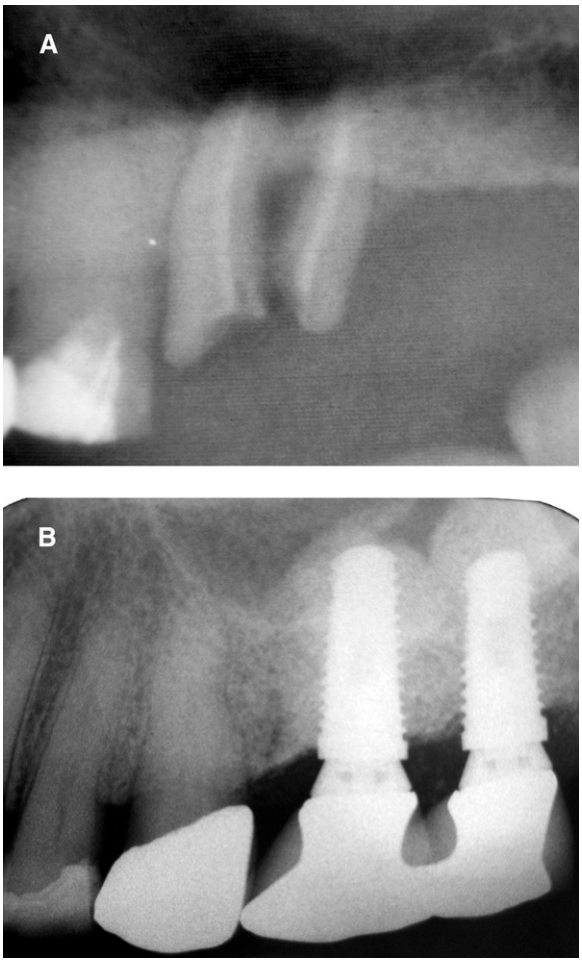

Figure 6.
A) *Periapical view of a hopeless left first molar with a thin sinus floor in a 72-year-old male (site #22 in Table 1).* ***B)*** *Periapical view 5 years after tooth extraction and CCE elevation at first molar and implant placement complemented by BAOSFE procedure at second molar site.*

membrane. They were instructed to gently clean the site using chlorhexidine gluconate dental gel 1%**** until closure was achieved.

The dimensions of the implants were dictated by the available bone contours as viewed on CT scan. Implant length ranged between 9 and 16 mm (average, 11.78 ± 1.23 mm) and implant width ranged between 3.75 and 5 mm (average, 4.54 ± 0.44 mm) (Table 1).

Overall success and partial success rate of the CCE procedure was 82.2%. At the time of this report, the implants have been in function between 1 and 11 years (average, 3.06 years), with all 57 implants having met the criteria for success.[31] There was no correlation between age or sex and success rate (P = 0.514 and 0.569, respectively). Ten out of the 57 implants were followed-up for over a 5-year period of time (Fig. 6). Follow-up and maintenance visits were scheduled every 3 months. Probing depth and bleeding on probing were measured at mesio-buccal, mid-buccal, disto-buccal, mesio-lingual, mid-lingual, and disto-lingual points once a year.

DISCUSSION

The present retrospective study was taken to evaluate the efficacy and predictability of the CCE technique in a group of patients during a relatively long period of time (11 years). The concomitant extraction and sinus floor elevation via the extraction socket was previously described.[26,27] The present study demonstrated the possibility of placing implants as early as 4 months after CCE, using two different osteoconductive materials and a collagen membrane.

The CCE technique, which is based on the "future site development technique" described by Summers,[5] partially compensates for the marked resorption of the alveolar bone occurring during the first 3 to 12 months postextraction.[1,32] The width of the alveolar ridge was reduced by 50% during this period. Two thirds of this reduction occurred within the first 3 months after tooth extraction. The same study showed that the level of the bone generated into the extraction socket never reached the level of the tooth surfaces distal and mesial to the extraction site.[32] In the present study, crestal bone loss could have been further aggravated because of sinus pneumatization, thus deteriorating the quality and prognosis of the final restoration. Defect morphologies that allow for improved bone regeneration are present shortly after tooth extraction.[33] Therefore, performing a treatment modality that combines atraumatic upper molar extraction, residual socket augmentation and preservation, and local sinus floor elevation in the same surgical session reduces the number of surgical appointments, reducing morbidity and the use of medications. Healing of the CCE site seems to be similar to that of the BAOSFE technique, and may have some advantages over LWT; the peripheral walls of the extraction site with the abundant blood supply of the attachment apparatus of the extracted teeth act as an

**** Corsodyl Dental Gel, GlaxoSmithKline.

additional important source of osteoblastic cells and growth factors.[34]

Buser et al.[35,36] claimed that in the esthetic zone implants may be placed as early as 4 to 8 weeks after tooth extraction. Furthermore, the coronally positioned bone plug, being attached to the Schneiderian membrane, may retain part of its original blood supply, increasing its vitality and osteogenic potential compared to autogenous free bone graft.[5]

In the present study, the radiographic assessment was based on periapical or panoramic radiographs. Although CT scan is considered to be the most accurate means for the diagnosis of sinus pathologies and for the evaluation of sinus membrane thickness, radiodensities and mucosal cysts were frequently diagnosed also by periapical and panoramic radiographs.[37-39] In view of the retrospective nature of this study, no attempt was made to use a reproducible stent. Nevertheless, all panoramic and CT scans were made in similar conditions using the same machines and doses, and when sufficient, all periapical radiographs, being less hazardous, were taken using the parallel technique. The CCE procedure described herein achieved ≥7 mm available bone height at all the augmented sites that did not fail at the time of surgery. A complementary BAOSFE procedure was needed in the 7- to 9-mm sites. In those latter cases, the residual interradicular bone had originally been 3 to 4 mm.

Eight patients had a full or partial detachment of the bony core during the malleting phase, causing a large tear of the sinus membrane with no possibility of repair. Thus, the 82.2% success rate including partial success was considerably lower than the 100% success rate reported by Fugazzoto and De Paoli[26] who performed the CCE technique at the time of maxillary molar extraction using bovine bone and bioabsorbable or nonabsorbable membranes. At the time of their statistical compilation, 167 implants had been placed and 137 had been restored and were in function. Three implants failed during the first year, yielding an implant survival rate of 97.8%. The cumulative success rate after 3 years was the same. In an earlier study, Fugazzotto[27] proposed the clinical advantages of the CCE technique when used concomitantly with maxillary molar extractions. The use of a trephine bur to create a detached core of interradicular bone before malleting considerably reduced surgical trauma, especially in cases when a large portion of the interradicular bone had remained. The concomitant placement of particulate material and a membrane at the time of tooth extraction offers the advantage of minimizing the three-dimensional alveolar bone resorption, which otherwise follows the extraction.[27] A number of studies have reported outcomes of different ridge preservation procedures, including the use of barrier membranes and bone fillers: these confirmed that filling and covering the postextraction alveolus preserves the bone volume more predictably than does spontaneous healing.[40-42] An additional benefit obtained by using an osteoconductive material is the transformation of the low-quality porous bone in the posterior maxilla into a denser type 2 or type 3 bone, which is more favorable for implant placement.[2,8] We preferred to use a native collagen membrane over a non-absorbable membrane in view of the high incidence of exposure in the course of healing that had been reported by others who used expanded polytetrafluoroethylene for ridge preservation or guided bone regeneration procedures and described subsequent colonization by oral bacteria, potentially compromising clinical results.[43-45]

One of the limitations of the CCE procedure is the lack of direct visibility of the Schneiderian membrane. Despite this limitation, the incidence of tears during malleting and detachment of the bony core (26.6%) was only slightly higher than the 19.5% perforation ratio reported in the lateral approach technique.[46] To partially overcome this limitation we used a wide (6-mm diameter) trephine bur to produce the core. In comparison to the OSFE technique, this relatively large core enhances the detection of perforations; indeed, the difficult direct inspection conditions when the OSFE is used may stand for the relatively low perforation rates (3.8%) detected in this transalveolar technique.[47] Small tears of the sinus membrane can be covered by placing collagen membrane through the socket, covering the base of the elevated core. Unlike the possibilities of repairing relatively large tears of the membrane during the LWT technique,[48] in the CCE technique such tears lead the surgeon to abandon the procedure and lead to primary closure of the surgically created oroantral fistula. Indeed, Toffler[23,24] used one-third round circle osteotomes that were fitted to the boundaries of 5- or 6-mm core preparations and applied them by rotation around the core under gentle malleting forces, retaining the tactile sensation, which is lost while using the trephine bur. The combined use of those osteotomes and trephines achieved a relatively low perforation ratio of 4 (5.5%) per 73 sites.[24] Toffler[22,25] applied this technique in edentulous areas using a mixture of autogenous grafts and xenografts or alloplasts. The implants placed in the CCE sites were followed-up to 35 months (mean, 15.5 months). Fugazzotto[25] also reported a 100% success rate using the CCE technique in edentulous regions in 71 cases, applying a complementary BAOSFE in two cases. Toffler[22] further improved the CCE technique by starting the core preparation with a reversed trephine direction at 1,500 rpm under copious irrigation until a shallow groove (0.5- to 1-mm deep) had been established, followed by a forward

position at 1,500 rpm until the desired depth had been achieved. This obviated the initial difficulty of achieving trephine stability before obtaining a bite in the crestal cortical core. The high incidence of perforations in the present study (26.6%) compared to Toffler's[24] perforation ratio of 5.5% or Fugazzotto's[25] success rate (perforations were not mentioned) may be explained by irregular anatomy of the sinus floor in the presence of molar teeth in comparison to the relatively flat anatomy observed in edentulous regions.

All the implants that were placed in the present study were of the rough-surface type. This is in line with del Fabbro et al.,[49] who claimed that the performance of rough-surface implants is superior to that of smooth implants when placed in the grafted maxillary sinuses. The implants studied in the present work have been functioning between 1 and 11 years (average, 3.06 years). All the patients were committed to a maintenance program of at least twice yearly, and their outcomes reflect the well-documented long-term success rate of implants placed in regenerated bone.[50,51]

The CCE procedure is less invasive compared to the LWT procedure because it is performed simultaneously with molar extractions and carried out through the extraction site. In addition, CCE avoids the need for a lateral window osteotomy and avoids damaging the blood supply to the bony wall, specifically the arterial supply of the lateral wall of the maxillary sinus.[52,53]

CONCLUSIONS

The CCE procedure offers a less invasive alternative to LWT, it is easier to perform, and it results in less morbidity when performed simultaneously with teeth extractions. Although the total complications ratio, including large and small tears of the sinus membrane, is comparable to that of LWT (26.6%),[54,55] and although it provides less additional bone, the authors find CCE advantageous in cases of upper molar extraction associated with reduced amounts of residual crestal bone that would require a future lateral approach (Figs. 3 and 4). Gaining more experience and the use of special osteotomes[24] may further reduce the incidence of complications reported in the present study. Prospective clinical assessment and histologic evaluation are advised before the procedure is considered as a routine clinical practice.

ACKNOWLEDGMENTS

This study was supported by the Gerald A. Niznick Chair of Implantology at Tel Aviv University. The authors are indebted to Ms. Esther Eshkol, Sorasky Medical Center, Tel Aviv, for editorial assistance. The authors report no conflicts of interest related to this study.

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Submitted December 6, 2009; accepted for publication June 27, 2010.