The Inlay Osteotome Sinus Augmentation Technique for Placing Short Implants Simultaneously with Reduced Crestal Bone Height. A Short-Term Follow-Up

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ABSTRACT

Objective: To display an inlay technique of osteotome sinus floor elevation using a trephine combined with simultaneous short implant placement where the residual bone height (RBH) is less than 5 mm, as well as to evaluate the clinical effect in a prospective study.

Material and Methods: Fifty short implants were installed in 32 patients in the severely atrophic posterior maxilla immediately after sinus floor elevation between January 2010 and October 2012. An inlay osteotome sinus augmentation technique using a trephine was applied in the operation. The mean residual bone height adjacent to or beneath the sinus was 3.34 mm, ranging from 0.96 mm to 4.96 mm. It was rarely necessary to add graft material from bovine sources in this therapy. With the purpose of bite training and soft tissue reforming, the temporary crowns were fixed after 6 months. The final prostheses were restored 3 months later. The stability and osseointegration of the implants were clinically evaluated, also the bone height gain around the implants was measured.

Results: The survival rate was 100% during the study period with this procedure. Each of the implants, loaded without pain or any subjective sensation, was clinically stable. No implants had detectable sinus membrane perforation during operation. The radiographic results demonstrated that the bone height gain was 5.38 mm after the surgery.

Conclusion: Based on the results and within the limits of the present study, it can be suggested that short implant placement in conjunction with this inlay osteotome sinus augmentation technique could yield predictable clinical results for edentulous posterior maxillary region with RBH less than 5 mm. Besides, from the clinical point of view, these techniques may reduce the indication for complex invasive procedures and simplify treatment in the posterior.

KEY WORDS: clinical prospective study, implant survival, maxillary sinus floor elevation, short dental implants, simultaneous implant placement

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INTRODUCTION

In the posterior maxlilla, implant insertion is often limited due to an insufficient amount of bone volume in cases with severe atrophy and/or increased pneumatization of the maxillary sinus.[1] Investigation revealed that mean residual bone height (mRBH) values for second premolar, first molar, and second molar sites were 5.9 ± 2.5 mm, 3.3 ± 2.2 mm, and 4.5 ± 2.4 mm, respectively. Representations of groups with residual bone height (RBH) less than 5 mm in these edentulous regions were 31.6%, 73.1%, and 54.2%, respectively.[2] The anatomic limits bring about great challenges in their restoration.

Tatum first described alteration of the maxillary sinus to receive dental implants, which consists of the preparation of a bony window in the lateral maxillary sinus wall.[3,4] Since then, several techniques and materials have been proposed to increase posterior maxillary bone to allow successful dental implant placement. The osteotome technique that utilizes a crestal approach was proposed by Summers in 1994.[5–8] Numerous positive study results led to the firm establishment of these procedures.[9] Compared with the lateral sinus floor elevation (LSFE), the technique of osteotome sinus floor elevation (OSFE) was a less invasive procedure without ostectomy.[10] Following progressive preparation of the bone using a pilot drill and burs up to the sinus floor, the bony floor and the membrane are elevated with a hand osteotome by pushing the graft material forward. The primary stability of the implant can be increased by compression of the spongiosa. The elevation is obtained with a reduced operative time compared with other sinus graft procedures. RBH (whether it is greater or less than 5 mm) is the deciding factor between the two methods. According to a traditional point of view, this OSFE technique is an option for predictable implant installation in maxillary bone above 5 mm in height for the sake of initial stability.[11,12]

Sinus lift grafting and implant placement can be accomplished as a one or two-step procedures. Implants are installed simultaneously with the bone graft (one-stage approach) or after a delay to allow for bone healing (two-stage approach). The advantage of immediate installation is a reduction in total treatment time by eliminating a second surgical procedure, allowing a coordinated consolidation of the graft around the implant. A minimum of 5 mm of RBH is traditionally recommended for a simultaneous implant placement procedure to ensure adequate implant stabilization and parallelism. When the RBH is less than 4 mm, a delayed implant placement is traditionally advocated as described by Smiler DG et al.[13] Although it allows the assessment of the amount of new bone formed prior to implant placement, the disadvantage includes a longer treatment time and difficulty in assessing the amount and position of graft material that will be required for future implant placement. However, Peleg et al.[14] reported that simultaneous implant placement into grafted sinuses can be a predictable treatment option for patients with at least 1~2 mm of RBH when careful case planning and meticulous surgical techniques are used. Their study showed a 95.5% success rate in patients with 1~2 mm of RBH after 9 years of clinical loading.

We once brought the technique of OSFE for placing short implants simultaneously into practice in cases with RBH of 5 mm or less before. It was approved to be feasible, whereas it usually need long therapy time and extensive use of graft material. In this case series, therefore, the authors attempt to describe and evaluate the feasibility of another inlay technique, which is also a one-step approach in which short implants are inserted simultaneously. The technique uses a trephine instead of traditional burs or a piezosurgery device to perform the osteotome sinus augmentation with a minimally invasive procedure.[15]

The objectives of this clinical prospective study were:

1 To investigate an inlay technique of OSFE using a trephine.
2 To evaluate the short-term performance of this technique combined with simultaneous short implant placement in the minimal edentulous posterior maxilla with 1~5 mm of RBH.

MATERIAL AND METHODS

The prospective clinical study was conducted in accordance with the World Medical Association Declaration of Helsinki and was approved by the regional ethics committee (ethical registration number 2009033). All participants gave their informed consent. Implant placement and prosthetic treatment were exclusively performed at the Dental Implant Center in West China School of Stomatology.

Patient Selection

Between January 2010 and October 2012, a total of 32 patients were consecutively enrolled in this prospective study. They were treated with 50 short implants placed simultaneously in the maxilla, with sinus floor elevation performed with an inlay osteotome technique. The study group comprised 26 men and 6 women, mean age 51.19 years (with a range of 34~74 years).

The medical status of patients regarding current and previous diseases and medications was noted, and only healthy patients were included in this study. All patients were nonsmokers and none of them displayed signs and symptoms of sinus disease, as was confirmed by clinical and radiographic assessments before surgery. Their mRBH adjacent to or beneath the sinus was 3.34 mm, ranging from 0.96 mm to 4.96 mm. It must be clarified that in the present study, for each patient, only implants inserted with the approach to be studied for the sinus floor elevation have been considered even if the same patient received other implants for their rehabilitation.

Preoperative Work-Up

Preoperation work-ups included an assessment of the edentulous alveolar ridges using casts and a diagnostic wax-up. Cone Beam Computed Tomography (CBCT) scans were used as the final investigation of choice because of the complete diagnostic data provided, that is, the width of each implant site could be measured accurately in the cross-sectional images, the thickness, density of the cortical plates and the intervening cancellous bone could also be assessed, and the ridge augulation could be seen.[16,17] On the basis of information obtained from the preoperation work-up, surgical plans were draw up. If necessary, surgical templates were manufactured for edentulous spaces involving more than one tooth.

Surgical Procedure

After local anesthesia and mid-crestal incision, buccal and palatal full-thickness flaps were reflected. Vertical releasing incisions were made if necessary. Preparation of the recipient sites was performed using an appropriate calibrated trephine bur of the same diameter with the implant to be installed. Using preoperative radiographs and the residual ridge morphology as a guide, the trephine ended approximately 1 mm below the sinus floor calculated from the presurgical CBCT. After removal of the trephine bur, the alveolar bone core was found to be there. Then a calibrated hand osteotome was selected to correspond to the diameter of the trephine preparation. It was used under a gentle malleting force to cause initial fracture of the sinus floor. The sinus floor was then elevated to displace the Schneiderian membrane apically. Such measurements were possible due to the calibration of both the trephine and the osteotome. This step was performed manually with special attention to avoid perforation of the membrane.

Two methods were used to ascertain the integrity of the Schneiderian membrane. The elasticity of the membrane should be felt when manually inserting the depth gauge and the Valsalva manoeuvre should be negative. (The Valsalva manoeuvre is performed by forcibly exhaling against the closed airway. First described by the 17th century physician and anatomist from Bologna, Antonio Maria Valsalva,[18] the technique can be used as a method of equalizing pressure between the ear and the outside environment in circumstances of changes in pressure.) It was barely necessary to add allograft or heterograft material. Short implants (Bicon®, Bicon Dental Implants, Boston, MA, USA) were placed immediately after the elevation.

Concerning the healing outcome, the submerged approach was generally preferred for all implants being inserted into less than 8 mm of the initial alveolar bone height. Consequently, a precise tension-free, interrupted suture of the margins was necessary, allowing for a primary wound closure (Figure 1).

Postsurgical Treatment

As a prophylactic measure, all patients received three *1000 mg Amoxicillin for 3~5 days and analgesics as required. Oral hygiene was performed as normal, except for tooth-brushing around the implants for 7 days. Sutures were removed 7~10 days after surgery.

Healing Period

During the study period, a healing period of 6 months was observed for all the implants inserted into the maxilla with a simultaneous sinus floor elevation. Implants inserted with a submerged approach needed a second-stage surgery to uncover the implants, and an additional healing period of 3~4 weeks was necessary to achieve proper soft tissue healing. With the purpose of bite training and soft tissue reforming, the temporary

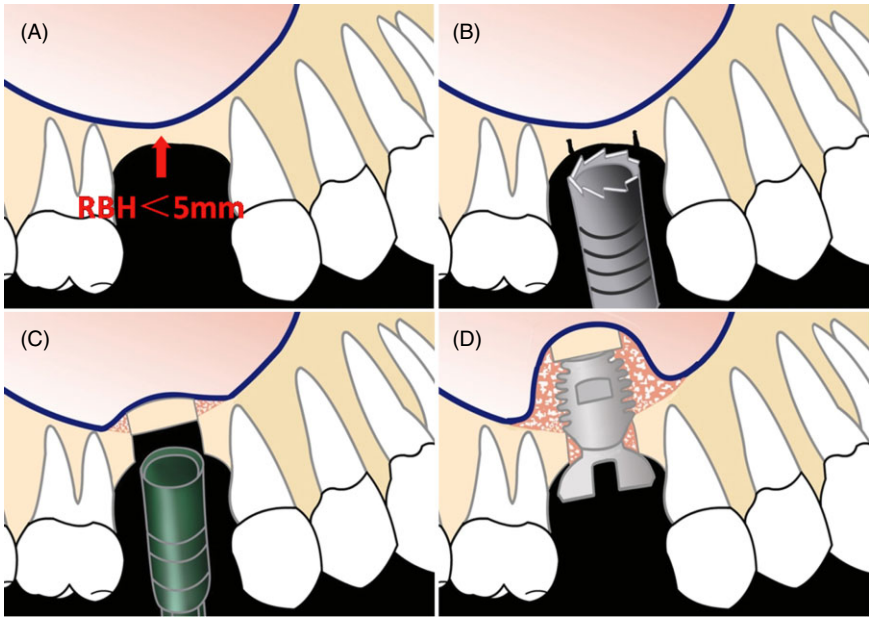

Figure 1 Diagram of the surgical procedure. Initial situation (A); a trephine is used to prepare a bone core to within 1 mm of the sinus membrane at the recipient site (B); an appropriately sized osteotome is used to implode the prepared alveolar bone core (C); a short implant is installed immediately after the sinus floor elevation (D).

crowns were applied during this period. The final prostheses were restored 3 months later.

Annual Examination and Data Collection

Follow-up visits were scheduled for 2 weeks, 1, 3, 6, and 12 months during the first year post-operatively, and annually thereafter. At each recall, patients were given a clinical and CBCT examination to check (a) peri-implant soft tissue condition, (b) mobility of implant, and (c) marginal bone loss. Implant survival was defined as being symptom free and stable without mobility or radiographic evidence of severe bone loss; it was calculated from the time of implant surgery.

According to measure the CBCT images, the RBH of the implant sites was first calculated: this was the mean value of the mesial (M), the central (C), and the distal (D) alveolar residual crest (RBH = 1/3(M + C + D)) of the implant site. The bone height after the surgery (ASBH) and that before the prosthesis restoration (BRBH) was measured with the same method. The vertical increase in height of the implant site (VI) is the difference of ASBH/BRBH and RBH (VI = ASBH/BRBH-RBH), which is also the part of implant inserted above the sinus floor plus the height of the bone located apically to the implant.

Surgery and follow-up were performed by two surgeons. One of the surgeons and another dentist who was not involved in the study evaluated the CBCT images taken 6~9 months after surgery for the presence or absence of bone gain at the apical aspect of the implants. Any disagreement was resolved by choosing the less favorable result.

RESULTS

The survival rate of the implants was 100% during the study period with this inlay procedure. Each of the implants was clinically stable and was loaded without pain or any subjective sensation. No implants had detectable sinus membrane perforation during operation. The radiographic results demonstrated that the mean bone height gain was 5.38 mm after the surgery, which is also the mean amount of the sinus membrane elevation performed. Resorption of the bone core located apical to the implant could be observed by CBCT image evaluation 6 months later. However, a gratifying mount of bone was reconstructed around the implants (Figures 2–4, Table 1).

DISCUSSION

The OSFE is preferred rather than the LSFE in the atrophic posterior maxilla if an implant supported prosthesis is the final treatment goal, because it causes less tissue trauma and provides faster recuperation of the patient.[19,20] The traditional use of osteotomes to apically

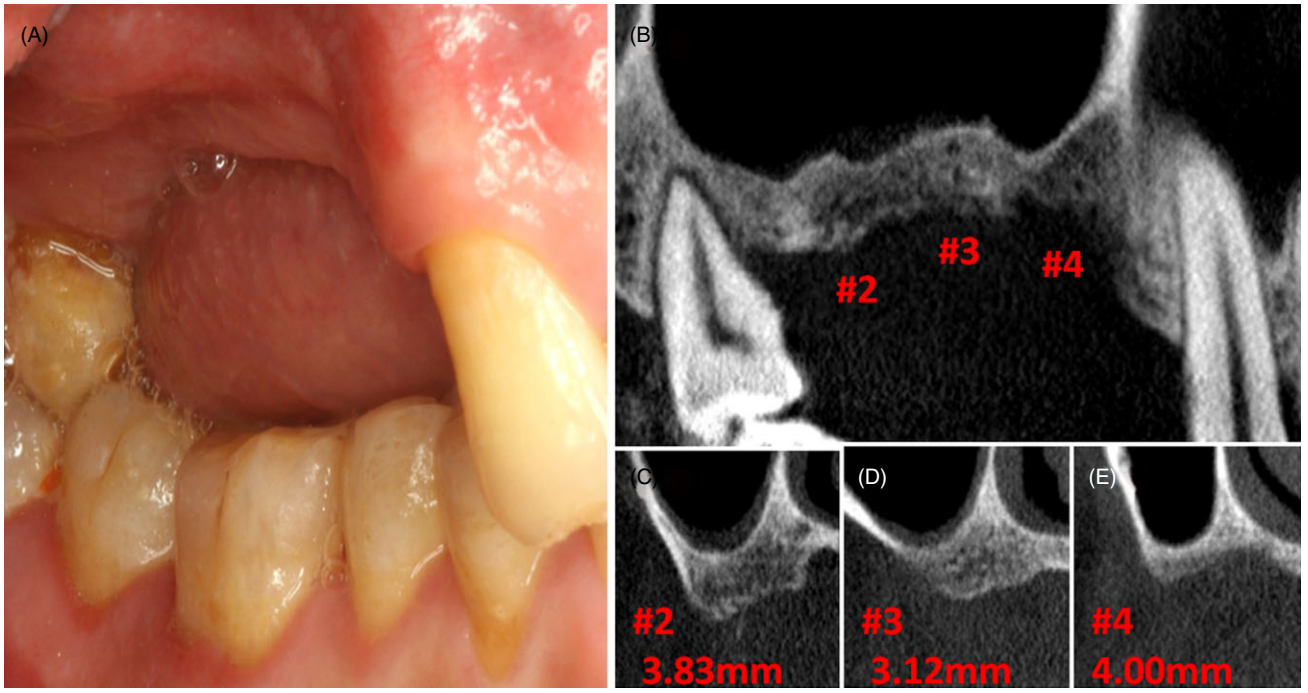

Figure 2 The edentulous posterior maxilla before the surgery. Photograph (A); cone beam computed tomography image (B); the residual bone height (RBH) of site #2 is 3.83 mm (C); the RBH of site #3 is 3.12 mm (D); the RBH of site #4 is 4.00 mm (E).

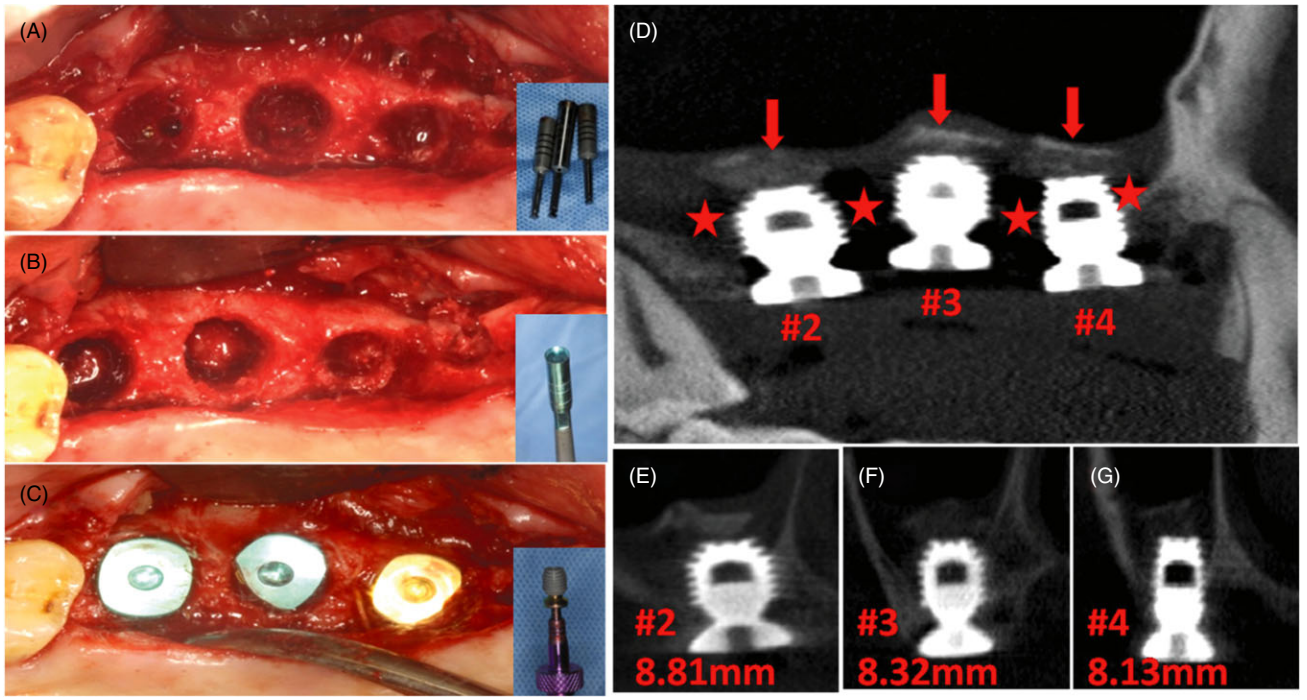

Figure 3 Surgical procedure. Flaps reflection and sites preparation using an appropriate calibrated trephine bur (A); elevation of the prepared alveolar bone core with an osteotome (B); simultaneous placement of short implants (C); the cone beam computed tomography image shows the elevated bone cores (red arrows) and space made by them (red five-pointed stars) (D); the bone height after the surgery (ASBH) of site #2 is 8.81 mm (E); the ASBH of site #3 is 8.32 mm (F); the ASBH of site #4 is 8.13 mm (G).

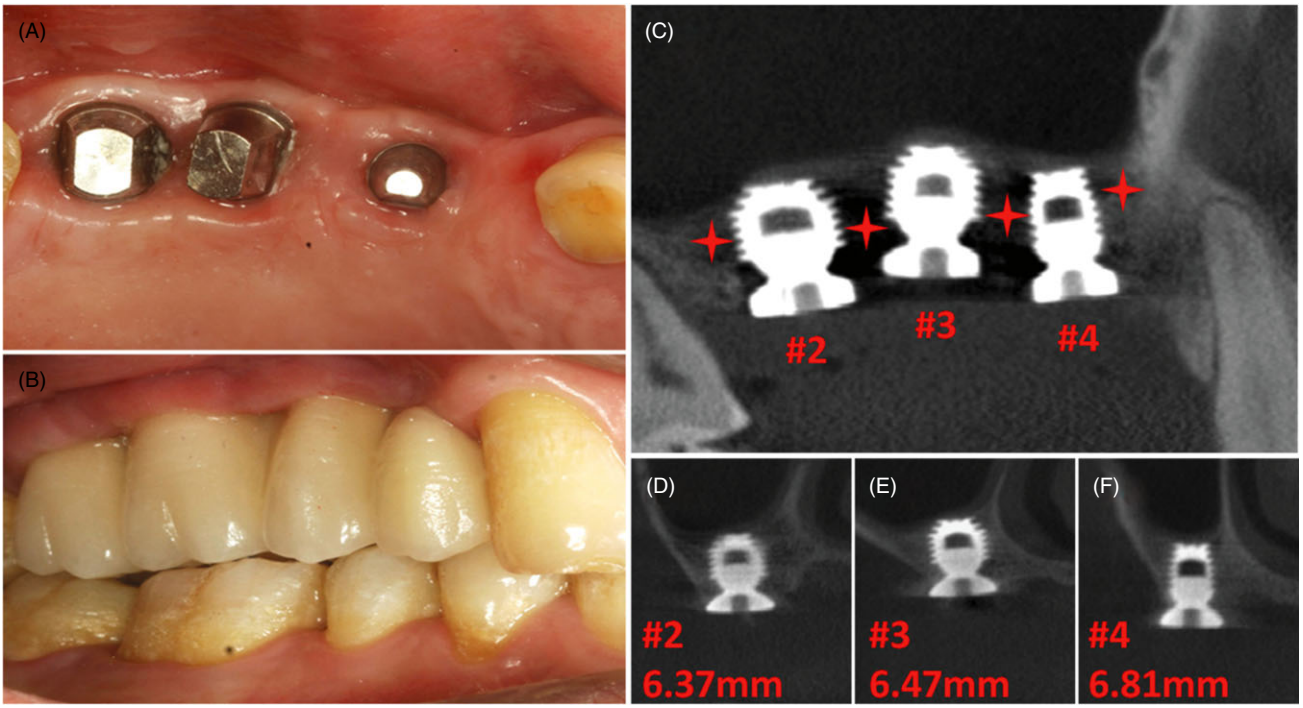

Figure 4 Prosthetic phase. Second-stage surgery and abutment fixation 6 months after the surgery (A); restoration of the definitive prostheses 9 months after the surgery (B); bone reconstruction around the implants on cone beam computed tomography image before the second-stage surgery (red four-pointed stars) (C); the bone height before the restoration (BRBH) of site #2 is 6.37 mm (D); the BRBH of site #3 is 6.47 mm (E); the BRBH of site #4 is 6.81 mm (F).

displace the floor of the sinus generally begins with twist drills or burs to lessen the trauma to the patient. However, alveolar bone is prepared and removed from the site, which might otherwise be imploded when the floor of the sinus is lifted.

Compared with the traditional OSFE, which uses twist drills to prepare a channel for the osteotomes, this inlay technique presented offers a number of advantages. First, the use of a trephine in combination with osteotomes is less traumatic and disconcerting to the patient than repeated hammering in an attempt to compact the bone and lift the floor of the sinus. Such an approach helps to minimize the chances of sinus perforation and unpredictable core displacement. Second, this technique would conserve the maximum amount of alveolar bone at the precise site of anticipated implant placement, reducing the use of bone material and saving the cost of the therapy. Third, better blood supply from the attached membrane would be ensured. Besides, the inlay bone core provides the space for bone growth. Forth, the autogenous bone core could play an important role in the temporal course of regeneration through its osteoinductive properties, meaning that it leads to a better initial bone formation as has been observed in animal experiments.[21]

It should be noted that a meticulous surgical technique should be followed. The trephine is used to prepare an alveolar bone within 1 mm of the sinus membrane, in an effort to ensure that the core remains held in place by surrounding residual alveolar bone and contained beneath an intact sinus membrane. Besides, the surface of the bone core should be flat for the sake of a uniform malleting force. Forming burs can be used when necessary.

The existing anatomical condition is one of the different variables which will affect the ability to achieve primary stability of the newly placed implants. Anatomic variations in the sinus, such as septum, narrow walls, which usually complicate the traditional LSFE, can provide distinct advantages with the protocol proposed in this inlay technique. For example, better anchorage in bone can be achieved by using an available septum or the medial wall of the sinus. The distance between the buccal and lingual surface of the sinus is usually 6~10 mm. A narrow buccolingual width of the sinus cavity can maximize the bone to implant contact along the lateral walls.

The alternative therapy includes the simultaneous placement of short implants, defined as implants with an intrabony length of 8 mm or less.[22] This strategy

TABLE 1 Variables and Results of 50 Implants during the Study Period

					Implant		Initial Situation	After the Surgery		Before the Restoration	
No.	Sex	Age (Years)	Time of the Surgery	Implant Site	Diameter (mm)	Length (mm)	RBH (mm)	ASBH (mm)	VI (mm)	BRBH (mm)	VI (mm)
1	M	34	2010-1-3	#14	4.5	6	4.00	7.84	3.84	6.34	2.34
2	M	56	2010-9-18	#14	5	6	3.77	8.50	4.73	7.02	3.25
				#15	6	5.7	3.67	7.48	3.81	6.75	3.08
3	M	36	2010-11-22	#3	5	6	3.89	8.17	4.28	7.40	3.51
4	M	52	2010-12-10	#13	5	6	2.44	9.72	7.28	8.47	6.03
				#14	5	6	2.09	9.40	7.31	9.65	7.56
				#15	5	6	3.67	10.51	6.84	8.73	5.06
5	M	48	2010-12-14	#3	6	5.7	4.96	8.25	3.29	6.73	1.77
6	M	44	2010-12-16	#2	5	6	3.85	9.58	5.73	9.27	5.42
7	M	59	2010-12-23	#3	5	6	4.03	9.59	5.56	10.21	6.18
8	F	47	2011-3-9	#3	5	6	2.93	9.89	6.96	7.80	4.87
9	M	44	2011-3-11	#4	4.5	6	4.00	8.13	4.13	6.81	2.81
				#3	6	5.7	3.12	8.32	5.20	6.47	3.35
				#2	6	5.7	3.83	8.81	4.98	6.37	2.54
10	M	61	2011-3-15	#3	5	6	3.58	10.01	6.43	8.88	5.30
11	F	46	2011-4-28	#3	5	6	4.36	8.21	3.85	6.43	2.07
12	M	48	2011-5-27	#14	6	5.7	2.34	6.94	4.60	6.85	4.51
13	M	50	2011-6-10	#14	6	5.7	4.38	9.67	5.29	9.46	5.08
14	M	49	2011-6-15	#3	5	6	4.41	9.09	4.68	8.13	3.72
				#2	5	6	2.25	9.08	6.83	8.23	5.98
15	M	66	2011-6-19	#14	5	6	1.83	9.27	7.44	7.38	5.55
				#15	6	5.7	2.50	8.63	6.13	6.87	4.37
16	F	37	2011-7-7	#14	5	6	3.09	8.13	5.04	7.93	4.84
17	M	45	2011-7-26	#3	5	6	4.00	8.50	4.50	7.00	3.00
				#14	5	6	3.42	6.93	3.51	6.85	3.43
18	M	50	2011-7-30	#3	6	5.7	2.50	7.10	4.60	6.90	4.40
19	M	60	2011-9-30	#14	5	6	4.82	9.26	4.44	7.97	3.15
				#15	6	5.7	2.90	9.08	6.18	7.96	5.06
20	M	50	2011-12-2	#15	6	5.7	2.41	8.01	5.60	7.77	5.36
21	F	62	2011-12-23	#13	5	6	4.25	9.67	5.42	9.18	4.93
				#15	5	6	3.43	9.17	5.74	8.06	4.63
22	M	74	2012-1-5	#14	6	5.7	4.43	9.67	5.24		
				#15	5	6	4.85	7.76	2.91		
23	F	58	2012-1-11	#2	6	5.7	0.96	6.67	5.71		
24	M	34	2012-2-3	#3	5	6	2.83	8.04	5.21		
				#14	5	6	4.63	6.50	1.87		
25	M	51	2012-2-16	#14	6	5.7	4.75	9.17	4.42		
				#15	6	5.7	2.42	9.30	6.88		
26	M	50	2012-2-18	#3	6	5.7	2.75	8.97	6.22		
27	M	56	2012-5-5	#3	6	5.7	2.42	9.41	6.99	9.42	7.00
				#2	6	5.7	3.67	9.58	5.91	7.76	4.09
28	F	51	2012-5-9	#13	5	6	4.00	8.71	4.71	7.75	3.75
				#15	5	6	3.52	9.86	6.34	7.94	4.42
29	M	50	2012-5-16	#3	6	5.7	2.73	8.57	5.84	6.75	4.02
				#2	6	5.7	1.43	8.96	7.53	7.90	6.47
30	M	52	2012-5-20	#15	6	5.7	1.47	9.34	7.87		
31	M	65	2012-9-19	#14	5	6	2.87	7.69	4.82		
				#15	5	6	2.25	9.25	7.00		
32	M	53	2012-10-8	#3	4.5	6	3.60	8.36	4.76		
				#2	4.5	6	4.90	9.25	4.35		
TOTAL				***50***							
AVERAGE		***51.19***					***3.34***	***8.72***	***5.38***	***7.77***	***4.40***

[Correction added on October 22 after first online publication: Length and Diameter column headers were transposed.]
The computing methods used for the following parameters are described in the text.
M, male; F, female; RBH, residual bone height before the surgery; ASBH, bone height after the surgery; BRBH, bone height before the restoration; VI, vertical increase of the bone.
Eight patients had not restored the final prosthesis till the date collection finished.

reduces surgical time and invasiveness. However, many literature reviews and meta analyses[23,24] have lent support to the view of poorer outcomes for short implants compared with implants with traditional length in the atrophic maxilla. Short implants are still perceived to have a greater risk of failure compared with longer ones because of increased loading of the limited supporting bone, an unfavorable crown-to-implant ratio,[25] and reduced resistance to lateral forces over functional time.[26] In contrast, recently, the use of short rough implants was proposed as a successful treatment in the atrophic posterior maxilla with survival rates of around 95%.[27–29] No significant difference was found, suggesting that implant length had no consistent relation with implant survival.[30]

CONCLUSION

The inlay osteotome sinus augmentation technique using a trephine allows the relatively atraumatic implosion of an autogenous alveolar bone core and the apical displacement of the floor of the sinus. The results of this study indicate that the procedure and implant design recommended in the present paper should allow simultaneous sinus augmentation and implant placement in areas with minimal crestal bone height less than 5 mm, extending the indication for implant supported restorations. Utilizing the available anatomic variations in sinus morphology may also allow better primary stability for this particular protocol.

Only short-term data were presented here. Further follow-ups and analysis are planned for the evaluation of the clinical and radiographic performance of this therapy.

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