The Window Bone Chisel Sinus Augmentation Technique for Placing Short Implants in Patients with ≤ 3 mm of Residual Alveolar Bone. A Three-year Prospective Study

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The Window Bone Chisel Sinus Augmentation Technique for Placing Short Implants in Patients with ≤ 3 mm of Residual Alveolar Bone. A Three-year Prospective Study

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Abstract

The objective of this study was to display a window bone sinus augmentation technique using a chisel combined with simultaneous short implant placement in the minimal edentulous posterior maxilla with 1-3 mm of residual bone height (RHB), as well as to evaluate the clinical effect in a prospective study. 167 short implants were installed in 107 patients in the severely atrophic posterior maxilla immediately after sinus floor elevation between January 2011 and November 2013. A window bone sinus augmentation technique using a chisel was applied in the surgical procedure. The mean residual bone height (mRHB) adjacent to or beneath the sinus was 2,99 ± 1,10 mm, ranging from 1,02 mm to 4,96 mm. A healing period of 6 months was observed for all implants. The final prostheses were restored 1 month later. At baseline and the follow-up appointments the stability and osseointegration of the implants were clinically evaluated, also the bone height gain around the implants was measured using SimPlant Planner 14.0° and Schick 33 Digital Sensor System CDR DICOM° softwares. The cumulative survival rate of the implants was 98,8% after a period of 6 to 36 months (22,33 months ± 10,20). The radiographic results demonstrated that mRBH gain after the restoration was 5,15 ± 1,55 mm. Based on the results and within the limits of the study, it can be suggested that short implant placement in conjunction with window bone sinus augmentation technique could yield predictable clinical results for edentulous posterior maxillary region with RBH less than 3 mm.

Introduction

The posterior maxilla remains a challenge for implant placement because of the limited availability and the poor quality of bone present in fully and partially edentulous patients. The limited bone height is the result of maxillary sinus pneumatization and bone resorption following tooth loss; the quality of the residual bone is usually D3 or D4 [1,2].

To overcome these anatomical limits, therapeutic solutions as lateral sinus floor elevation (LSFE) and osteotome sinus floor elevation (OSFE) procedures are being used to regenerate and increase bone volume in the atrophic maxilla before implant placement and are considered to be safe and predictable procedures [2,3]. These techniques have been reviewed and discussed broadly over years.

LSFE with clinical success was first reported by

Tatum, in 19974 and first published by Boyne in 1980 [5]. Since then, numerous authors using different modified techniques and bone-graft materials have reported good clinical success [6-10]. The lateral technique involves the elevation of the schneiderian membrane through preparation of a window in the lateral wall of the maxillary sinus creating an empty hole in the floor of the antral cavity. This area is then filled with different grafting materials [1]. Even though LSFE procedures are highly predictable and successful in the regeneration of bone for implant placement in the atrophic maxilla, there are complications or medical risks commonly associated with this approach that may deter patient acceptance. Severe facial swelling, hematoma, and associated pain are not uncommon after the LSFE procedure [11]. These are often the result of the large extensive flap design from the tuberosity to the distal surface of the canine or premolar. Another common complication is sinus membrane perforation. The rate of occurrence ranges from 10% to 44% even when competent clinicians performed the procedure12-16. Reports from the Sinus Consensus Conference of 1996 indicated that there is a direct relationship between sinus-membrane perforation and complications, and studies have found that the greater the membrane perforation, the greater the incidence of postoperative infection [12,17].
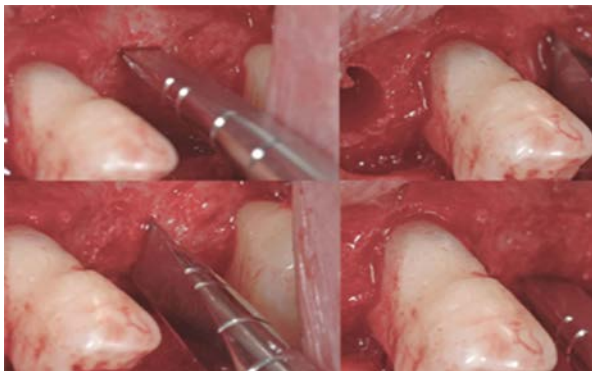

Figure1. A,B,C,D. Surgical Procedure. Square bony window preparation was progressively performed by using an appropriate calibrated bone chisel.

In 1994, Summers introduced the less-invasive OSFE procedure that utilizes a crestal approach as an alternate method to regenerate bone for implant placement in the atrophic posterior maxilla [18,19]. The crestal approach involves utilizing tapered osteotomes with increasing diameters for creating an osteotomy for the selected implant. By gently tapping the osteotome in a vertical direction, the floor of the maxillary sinus is fractured and the membrane is simultaneosuly lifted [19]. To enhance this method, Summers also described the bone–added osteotome sinus floor elevation technique (BAOSFE), which considered of adding a bone mixture to the prepared osteotomy reducing the

rate of sinus membrane perforation by a hydraulic pluf effect [18].

The success rate of this technique was comparable to the LSFE procedure, but the more conservative crestal approach has several advantages over the lateral antrostomy, which include reduction of operation time, trauma, and postoperative morbidity [20]. In light of the numerous benefits bestowed to the patient with the use of the crestal approach, there is a great interest in expanding its applicability.

Figure 2. Surgical procedure. Intraoperative periapical radiograph: the bone chisel cuts the bone up to the inner cortical of the maxillary sinus.

Sinus lifting grafting and implant placement can be accomplished as a one or two-steps procedures. Implants are placed 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.

Figure 3 A,B. Surgical Procedure. A. The square bony window is mobilized by using a concave calibrated hand osteotome; B. Square bony window is displaced apically towards the schneiderian membrane elevating the maxillary sinus floor.

Historically, the use of this technique was limited to patients with at least 5 mm of residual bone height (RBH) to ensure adequate implant stabilization and parallelism [21,22].
When the RHB is less than 4 mm, a delayed placement is traditionally advocated as described by Smiler DG et

al. [23] 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. 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 [24].

Figure 4. Surgical Procedure. The sinus lift abutment is engaged in the well of the implant.

In this study the authors attempt to describe and evaluate the feasibility of a one-step approach sinus augmentation technique in which short implants are inserted simultaneosuly. The technique uses a bone chisel instead of traditional burs or a piezosurgery device to perform the osteotome sinus augmentation with a minimally invasive procedure [25].

The objectives of this three-year cinical prospective study were:
1. To investigate a window technique of OSFE using a bone chisel.
2. To evaluate the short-term performance of this technique combined with simultaneous short implant placement in the minimal edentulous posterior maxilla with 1-3 mm of RHB.

Materials and methods

The study was conducted in accordance with the World Medical Association Declaration of Helsinki. All partecipants gave their informed consent. Implantoprosthetic treatments were carried out by all the operators who were involved in the study both at their private dental offices and at the Oral Surgery Unit of the Department of Oral and Maxillofacial Sciences, "Sapienza" University of Rome.

Patient Selection

Between January 2011 and November 2013, a total of 107 patients were consecutively enrolled in this prospective study. The study group comprised 42 men and 65 women, mean age 50, 21 ± 8,89 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.
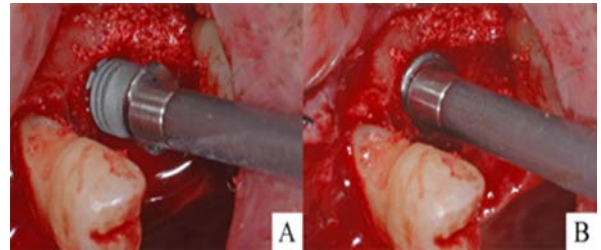

Figure 5. A,B. Surgical Procedure. Insertion of the implant-abutment unit. Before implant insertion the bony window's margins were gently finished with a hand reamer having the same diameter of the implant.

Their mean residual bone height (mRBH) adjacent to or beneath the sinus was 2,99 ± 1,10 mm, ranging from 1,02 mm to 4,96 mm. The most frequent missing teeth were first molars (44,3%), second premolars (31,1%) and second molars (24,6%). Patients were treated with 167 short implants with one-stage crestal sinus floor elevation approach.

Preoperative Work-Up and Radiographic Analysis

Preoperation work-ups included an assessment of the edentulous alveolar ridges using casts and a diagnostic wax-up.
At baseline and the follow-up appointments, independent, calibrated examiners measured radiographic interproximal bone level using standardized digital periapical radiographs and Computed Tomography (CT) scans.
CT scans provided quantitative information on maxillary sinus anatomy. Preoperatively, the bone height that could be achieved was estimated. Periapical radiographs were obtained with a X-ray machine operating at 60 kVp, perpendicular to the long axis of the implants with a long-cone parallel technique. On the basis of information obtained from the preoperation work-up, surgical plans were draw up. Surgical templates were manufactured for edentulous spaces involving more than one tooth.
Radiographic evaluation was performed both before

implant placement and after prosthetic restoration using respectively CT scans and periapical radiographs. Mesial and distal marginal radiographic bone level changes were recorded using SimPlant Pro 2011 for Intel X 86 Platform V14.0.1.2 Materialize Dental Software ® for CT scan radiographs and Schick 33 Digital Sensor System CDR DICOM Software ® for periapical radiographs which calculates area and pixel value statistics for user-defined selections. Spatial calibration was set to express dimensional units in millimeters. The platform of the implant served as a reference to the radiographic bone level. The fixture threads served as an internal reference. Bone level was measured as the distance from the platform of the implant to the crest of the bone. The radiographic change in interproximal bone level was numerically calculated by comparing the previous level with the current level emerging from periapical radiographs.

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 square window 0,5 mm smaller than the implant to be installed was progressively performed by using an appropriate calibrated bone chisel (Fig. 1A,B,C,D, 2). The bony window is then mobilized starting from the corner to its center by using a concave calibrated hand osteotome selected to correspond to the diameter of the bone chisel preparation (Fig. 3A,B).
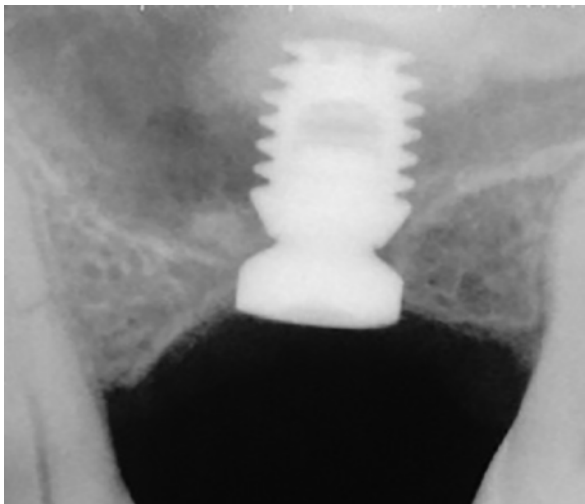

Figure 6. Figure 6 Surgical Procedure. Periapical radiograph shows the inserted implant in Fig. 5.

The sinus floor was then elevated displacing the square bony window apically towards the schneiderian membrane. It was necessary to add allograft material (β-tricalciumphosphate, SynthoGraft™, Bicon, LLC 501 Arboway Boston, MA, USA).

Short implants were placed immediately after the elevation. 5.00-mm-wide X 6.00-mm-long locking taper implants were chosen in 48,5 % of the cases, 5.00-mm-wide X 5.00-mm-long ones in 25,75% and in the last 25,75% cases 6.00-mm-wide X 5.00-mm- long and 6.00-mm-wide X 5,7-mm-long were alternatively used (Implants Bicon, LLC 501 Arboway Boston, MA, USA). The implant was inserted in the antrostomy with the aid of a sinus lift abutment engaged into the implant due to locking taper connection (Figure 4). The stability of the implant relied only on the grip of the sinus lifting abutment and on the contact between the implant and the lateral slopes of the maxillary sinus. The sinus lift abutment was larger than implant diameter (6, 6,5 or 7 mm) thus sealing the antrostomy and tightening the implant in position (Fig. 5A,B). The implant gripped mesially, distally and to the buccal and palatal slopes when the residual ridge high was higher (2-3 mm); otherwise it would rely both on stabilization effect of sinus lift abutment and tension due to schneiderian membrane and grafting material inserted (Fig. 6).
A precise tension-free, interrupted suture of the margins was necessary, allowing for a primary wound closure.
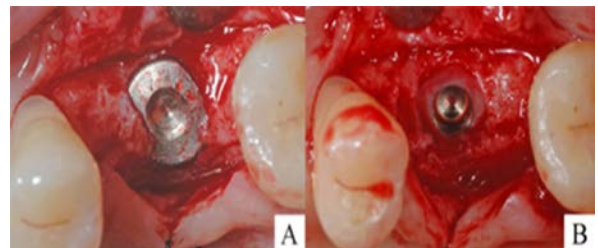
Figure 7. A,B Healing Period. Implant uncovering at second-stage surgery. A. The sinus lift abutment is still in place 6 months after surgical procedure. Note the bone overgrowth. B. The well of the implant is visible once sinus lift abutment is unscrewed.

Postsurgical Treatment

Oral and written postoperative instructions were given to all of the patients. As a prophylactic measure, all patients received 2g Amoxicillin with or without Clavulanic Acid 1 hour before treatment. Patients were instructed to take 1g capsule every 12 hours for 7 days thereafter 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 implants. A second-stage surgery to uncover the implants was needed and an additional healing period of 3-4 weeks was necessary to achieve proper soft tissue healing. Sinus lift abutment and overgrowth bone over it were removed by bone roungers

(Fig. 7A,B). The final prostheses (Integrated Abutment Crown, IAC™) were restored 1 month later (Fig. 8A,B).

Figure 8. A,B. Prosthetic phase. Periapical radiographs of another clinical case. A. IAC™ insertion 7 months after surgical procedure. B. 3 years after implants placement. Arrows show the "basket-like" bone organization.

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 periapical radiograph to check (a) periimplantsoft tissue condition, (b) mobility of implant, and (c) marginal b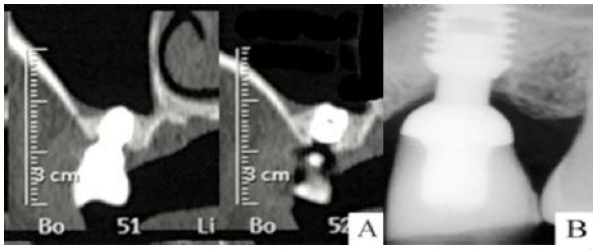one loss. At 12 months follow-up visit a TC scan was prescribed and used for better evaluate the vertical bone increasing after the restoration phase (Fig. 9A,B).

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 measures of the TC scan 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.
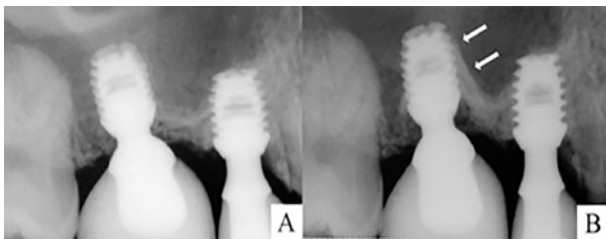

Figure 9. A,B. Follow-up Period. Post-operative periapical radiograph and TC scan of the clinic case showed in Fig. 7. A. TC scan performed one year after implant placement; B. Periapical radiograph shows the new bone organized around the 1.4 implant three years after its placement.

The bone height after the prosthetic restoration (ARBH) was measured with the same method. The vertical increase in height of the implant site (VI) is the difference of ARBH and RBH (ARVI = ARBH-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 periapical

radiographs 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

There were no adverse events observed clinically in the oral tissues or the maxillary sinus. No sinus membrane perforation or implant displacement into it occurred. A total of 167 implants were placed in one hundred and seven patients.

With the exception of two implant failures (1,2%), all implants were clinically successful. The cumulative survival rate of the implants was 98,8% after a period of 6 to 36 months (22,33 months ± 10,20). Each of the implants was clinically stable and was loaded without pain or any subjective sensation. The radiographic results demonstrated that the mRBH gained after the restoration was 5,15 ± 1,55 mm (Table 1). Resorption of the bone core located apical to the implant could be observed by periapical radiograph images evaluation 12 months later. However, a gratifying mount of bone was reconstructed around the implants (Figure 8B, figure 9B).

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 [20,26].

Compared with the traditional OSFE, which uses twist drills or burs to prepare a channel for the osteotomes, this window technique presented offers a number of advantages. The use of a bone chisel 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. 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.

This alternative therapy includes the simultaneous placement of short implants, defined as implants with an intrabony length of 8 mm or less [27]. This strategy reduces surgical time and invasiveness. However, many literature reviews and meta analyses have lent support to the view of poorer outcomes for short implants compared with implants with traditional length in the atrophic maxilla [28,29]. Short implants are still perceived to have a greater risk of failure compared with

Table 1. Variables and Results of 167 Implants during the Study Period

No.	Sex	Age (Years)	Implant Site	Implant Lenght (mm)	Implant Diameter (mm)	RBH (mm)	ARBH (mm)	ARVI (mm)
1	M	46	1.5	5	5	1,98	8,04	6,06
			1.6	5	6	2,7	7,06	4,36
2	F	53	2.5	5	5	4,32	9,89	5,57
			2.6	5	6	4,11	6,96	2,85
3	M	41	2.7	6	5	3,34	9,89	6,55
4	M	43	1.5	5	5	1,62	8,52	6,9
5	M	44	2.7	6	5	4,58	8,59	4,01
6	M	50	2.6	6	5	2,79	6,54	3,75
7	F	50	2.5	5	5	4,29	7,83	3,54
			2.6	5	6	2,84	7,47	4,63
			2.7	5	6	1,37	8,68	7,31
8	M	35	1.5	5	5	2,62	6,74	4,12
9	M	39	2.5	5	6	1,87	9,96	8,09
			2.7	6	5	2,94	7,11	4,17
10	F	37	2.5	5	6	4,23	7,79	3,56
			2.6	6	5	3,17	7,51	4,34
11	F	60	2.5	5	5	4,45	10,11	5,66
			2.6	6	5	1,15	7,37	6,22
12	M	53	1.5	5	6	2,56	8,54	5,98
			1.6	6	5	3,51	7,83	4,32
13	M	55	1.6	6	5	3,89	9,22	5,33
14	M	60	1.7	6	5	3,77	7,48	3,71
15	F	60	1.5	5	6	3	7,76	4,76
			1.6	5	6	1,9	8,2	6,3
			1.7	5	6	4,15	7,95	3,8
16	F	54	1.7	6	5	3,25	7,15	3,9
17	M	55	1.5	5	5	2,36	9,04	6,68
			1.6	6	5	3,62	7,48	3,86
18	F	40	1.5	5	5	1,69	9,03	7,34
			1.6	6	5	3,61	8,9	5,29
19	F	48	2.5	5	5	1,38	9,61	8,23
			2.6	6	5	1,7	9,26	7,56
20	M	63	2.6	6	5	3,13	8,77	5,64
21	F	45	1.5	5	6	3,8	9	5,2
			1.6	5	6	2,32	6,58	4,26
			1.7	5	6	1,42	6,61	5,19
22	M	56	2.6	6	5	4,68	6,55	1,87
			2.7	6	5	3,51	10,21	6,7
23	F	41	1.6	6	5	2,69	7,49	4,8
			1.7	6	5	4,29	6,4	2,11
24	F	51	2.5	5	5	4,18	6,71	2,53

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			2.6	6	5	4,03	9,32	5,29
25	F	62	2.5	5	5	2,91	7,29	4,38
			2.7	6	5	1,51	6,59	5,08
26	M	64	1.6	6	5	4,62	8,18	3,56
27	M	57	1.7	6	5	2,66	7,9	5,24
28	M	45	1.5	5	5	4,72	9,58	4,86
			1.6	6	5	4,46	7,33	2,87
			1.7	6	5	3,91	9,66	5,75
29	M	46	1.6	6	5	1,55	*********	*********
30	M	57	1.5	5	5	3,25	10,16	6,91
			1.7	6	5	1,43	6,51	5,08
31	F	50	2.5	5	5	1,92	8,04	6,12
			2.7	6	5	4,92	9,73	4,81
32	F	55	1.5	5	6	1,96	6,96	5
			1.6	5	6	2,56	7,01	4,45
33	F	64	1.6	6	5	2,51	8,78	6,27
			1.7	6	5	1,71	6,63	4,92
34	F	36	2.5	5	6	2,56	9,23	6,67
			2.6	5	6	4,77	9,6	4,83
35	F	42	1.6	6	5	3	8,95	5,95
36	M	39	1.7	6	5	3,43	7,34	3,91
37	F	65	2.5	5	5	2,95	8,39	5,44
			2.6	6	5	2,03	6,9	4,87
38	M	63	2.6	6	5	4,73	7,94	3,21
39	M	57	1.5	5	5	2,71	7,36	4,65
			1.6	6	5	3,55	7,35	3,8
40	F	63	1.6	5,7	6	3,1	6,54	3,44
			1.7	5,7	6	4,67	6,59	1,92
41	F	65	1.5	5	5	3,71	7,11	3,4
			1.6	6	5	1,16	8,04	6,88
42	F	52	2.5	5	5	1,37	7,58	6,21
			2.6	6	5	4,55	7,27	2,72
43	M	54	2.6	5,7	6	4,16	7,63	3,47
			2.7	5,7	6	3,6	7,9	4,3
44	M	47	1.5	5	5	2,2	7,77	5,57
			1.6	6	5	1,96	7,42	5,46
45	M	40	2.5	5	5	3,22	6,98	3,76
			2.6	6	5	2,59	8,98	6,39
46	M	53	2.5	5	5	3,32	7,24	3,92
			2.6	6	5	4,01	9,15	5,14
47	M	61	1.6	6	5	1,96	8,47	6,51
48	M	48	1.7	6	5	4,18	6,7	2,52
49	F	51	1.5	5	5	3,34	9,01	5,67
			1.6	5	6	1,54	6,41	4,87
			1.7	5	6	4,86	6,71	1,85

(continued)

50	M	58	2.6	6	5	2,79	9,56	6,77
51	M	56	2.7	6	5	4,68	7,59	2,91
52	M	38	2.6	6	5	3,22	9,26	6,04
53	F	41	2.5	5	5	2,57	9,78	7,21
			2.6	6	5	3,29	9,88	6,59
54	F	44	1.6	6	5	1,42	8,22	6,8
			1.7	6	5	4,16	9,04	4,88
55	F	43	1.5	5	5	1,93	9,09	7,16
			1.6	6	5	1,37	8,11	6,74
56	F	62	1.6	6	5	2,23	7,86	5,63
			1.7	6	5	4,89	8,22	3,33
57	F	53	1.5	5	5	2,59	9,69	7,1
58	F	50	1.6	6	5	2,09	7,15	5,06
59	F	44	1.6	6	5	1,91	10,15	8,24
60	F	60	2.5	5	5	2,64	8,83	6,19
			2.6	6	5	4,35	6,45	2,1
61	F	58	1.7	5,7	6	2,6	10,08	7,48
62	F	38	1.5	5	6	2,52	9,24	6,72
63	F	53	1.6	6	5	3,19	8,39	5,2
64	M	56	2.5	5	5	1,03	9,91	8,88
65	M	65	1.5	5	5	1,02	9,3	8,28
			1.6	6	5	3,76	8,34	4,58
			1.7	6	5	4,16	8,3	4,14
66	F	35	1.6	5,7	6	4	7,51	3,51
			1.7	5,7	6	1,85	7,95	6,1
67	F	37	1.5	5	5	2,09	9,19	7,1
			1.6	6	5	2,65	8,99	6,34
68	F	40	1.6	6	5	1,27	7,6	6,33
			1.7	6	5	4,16	8,01	3,85
69	F	48	1.5	5	5	1,67	7,99	6,32
			1.6	6	5	2,31	8,64	6,33
70	M	63	1.5	5	5	4,75	6,46	1,71
71	M	45	1.6	6	5	1,43	9,53	8,1
72	M	61	1.6	6	5	4,2	9,45	5,25
			1.7	6	5	1,1	9,32	8,22
73	M	65	2.6	6	5	4,33	6,99	2,66
			2.7	6	5	3,19	6,41	3,22
74	M	50	1.5	5	5	2,81	6,51	3,7
			1.6	6	5	1,81	9,49	7,68
75	F	35	2.6	6	5	4,63	7,71	3,08
			2.7	6	5	2,71	7,71	5
76	F	46	2.5	5	5	4,73	7,46	2,73
			2.6	6	5	3,09	8,44	5,35
77	F	46	2.5	5	5	4,59	9,46	4,87
			2.7	6	5	1,84	7,73	5,89

(continued on the next page)

(continued)								
	78	F	41	1.7	5,7	6	3,87	8,98	5,11
				1.6	5,7	6	4,15	7,02	2,87
	79	F	49	2.5	5	5	1,12	7,77	6,65
				2.6	6	5	1,32	6,41	5,09
	80	F	49	1.6	6	5	2,91	6,62	3,71
	81	F	38	1.5	5	5	3,23	7,12	3,89
	82	F	62	1.7	5,7	6	2,09	6,56	4,47
	83	F	56	2.6	6	5	2,55	9,1	6,55
	84	F	45	1.5	5	5	4,29	9,4	5,11
	85	F	37	2.6	6	5	3,7	8,42	4,72
				2.7	6	5	2,65	9,94	7,29
	86	F	50	1.7	5,7	6	4,68	6,66	1,98
	87	F	35	2.6	6	5	3,37	9,52	6,15
	88	F	47	1.7	5,7	6	2,43	7,13	4,7
	89	M	50	2.6	6	5	1,1	8,66	7,56
	90	M	41	1.5	5	5	2,1	6,56	4,46
				1.7	6	5	2,79	8,15	5,36
	91	F	55	1.6	5,7	6	2,17	8,05	5,88
	92	F	54	1.6	6	5	4,03	*********	*********
	93	F	52	1.7	6	5	3,38	8,18	4,8
	94	F	37	2.5	5	5	2,24	8,3	6,06
	95	F	42	1.6	6	5	3,06	7,68	4,62
	96	F	57	1.6	5,7	6	2,89	8,52	5,63
				1.7	5,7	6	2,26	7,39	5,13
	97	F	65	2.5	5	5	1,93	7,46	5,53
	98	F	65	1.6	5,7	6	3,79	9,21	5,42
	99	F	45	2.6	5,7	6	4,87	9,62	4,75
				2.7	5,7	6	3,7	9,69	5,99
	100	M	56	2.5	5	5	3,69	8,14	4,45
				2.6	5,7	6	1,74	8,24	6,5
	101	F	40	1.5	5	5	2,45	6,58	4,13
	102	F	46	1.7	5,7	6	1,35	8,03	6,68
	103	F	46	1.6	5,7	6	3,71	8,51	4,8
	104	M	59	1.5	5	5	2,49	7,78	5,29
	105	M	56	1.6	5,7	6	4,18	8,41	4,23
	106	F	57	1.5	5	5	1,6	9,91	8,31
	107	F	36	2.6	5,7	6	4,81	9,32	4,51
Total	107			167					
Average			50.21				2,99	8,15	5,15
Stand. Dev.			8.89				1,10	1,09	1.55

The computing methods used for the following parameters are described in the text.

M, male; F, female; RBH, residual bone height before the surgery; ARBH, bone height after the restoration; ARVI, vertical increase of the bone after the restoration.

limited supporting bone, an unfavorable crown-to-implant ratio [30] and reduced resistance to lateral forces over functional time [31]. 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% [32-34]. No significant difference was found, suggesting that implant length had no consistent relation with implant survival [35]. In this study short implants Bicon® were used. Compared with the other short implants, they have shown a greater number of advantages such as plateau design, locking taper and sloping shoulder properties [36]. Bicon's plateau design allows for the callus formation of mature, cortical-like, haversian bone between the fins of the implant providing a direct type of osteogenesis compared with screw-type implants [37]. In addition, its locking taper and sloping shoulder design provide respectively a proven bacterial and seal at the implant to abutment interface and more room for bone over the implant [38, 39].

There are several advantages to a one-stage approach to maxillary sinus floor elevation and implant placement, including reduced treatment time and elimination of the need for a second surgical procedure [40]. However, the ability to ensure a high primary stability in a severely atrophied ridge is of chief concern. Studies have described that the initial stability of the implants is provided by the ubiquitous presence of cortical bone at the crestal aspect of the ridge. Cardaropoli and colleagues described the presence of the cortical bone layer consistently covering the marginal portion of a healing extraction socket at 60, 90, and 180 days [41]. Ohnishi and colleagues also described the corticalization of the alveolar bone, which provided a consistent layer of cortical bone at the crestal aspect of the ridge [42]. The ability to elevate the schneiderian membrane, without perforation, utilizing the crestal approach was consistently observed throughout the study. In addition to thorough sinus anatomy evaluation, membrane detachment force, angle of instrumentation, and elasticity and deformation capacity assessment are all important factors to consider. Additionally, the number of insertion sites can increase the elastic properties of schneiderian membrane for more elevation height. Berengo and colleagues evidenced that sinus anatomy, as well as elastic properties of the schneiderian membrane, correlate with the maximum elevation height that is achievable [43]. Several authors

have reported elevation of the sinus membrane to heights of 2.5 mm to 8.6 mm, employing the crestal approach [40;44-48]. However, crestal approach cannot be performed in all cases. Perforation may lead to postoperative maxillary sinusitis or graft migration into the sinus. Crestal approach requires a thorough assessment of the anatomy, elasticity, and deformation capacity of the membrane and precise surgical approach.

The necessity for use of graft materials for maxillary sinus floor elevation is controversial [49]. When a graft material is to be used, autogenous bone remains the gold standard for augmentation of the maxillary sinus. However, autologous bone undergoes extensive resorption [50] which may be associated with contamination from intraoral pathogens [51]. The graft materials used in this study were autogenous bone and β-tricalcium phosphate-coated hydroxyapatite. β-tricalcium phosphate resorbs at a relatively slow rate and effectively maintains the sinus membrane elevated throughout the healing process. Its resorption is less than that of autogenous bone [52 and does not require a second surgical site [53].

Conclusion

The window sinus augmentation technique using a bone chisel allows the relatively atraumatic implosion of an autogenous alveolar bone core and the apical displacement of the floor of the sinus. The findings of the present study suggest that the procedure and implant design recommended in the present paper should allow simultaneous sinus augmentation and implant placement in areas with minimal RHB less than 3 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.

Further clinical investigations, follow-ups and analysis are needed to measure the mechanical properties of the schneiderian membrane, minimum force needed for its detachment from the underlying bone and its elasticity and load limits. In spite of the known limitations encountered in a prospective study, the favorable results obtained merit further studies that examine the long-term outcome of implants placed under these conditions.

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