

A minimally invasive technique for transcrestal sinus floor elevation

Abstract

Background

Transcrestal maxillary sinus floor elevation represents an effective surgical option to vertically enhance the available bone in the edentulous posterior maxilla.

Purpose

The purpose of the present study is to describe a minimally invasive technique for transcrestal sinus floor elevation, the Smart Lift technique, through a paradigmatic clinical case.

Conclusion

The Smart Lift technique is based on specially designed drills and osteotomes used with a stop device that restricts the working action to the residual bone, thus preventing the accidental penetration of instruments into the sinus cavity. Also, the use of a standardized sequence of instruments has been shown to limit the impact of the clinician's judgement and skill, thus allowing for rapid learning for inexperienced clinicians. The technique is effective to achieve endo-sinusal bone formation with limited post-surgical morbidity.

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Introduction

In the posterior maxillary sextants, the insertion of implants of desired length and diameter may be limited by the dimensional alterations of the bone crest that occur after tooth loss,¹ partly due to the pneumatization of the maxillary sinus.² Transcrestal maxillary sinus floor elevation (tSFE) represents an effective surgical option to vertically enhance the available bone in the edentulous posterior maxilla.^{3,4}

Technique description

The Smart Lift technique was developed by the Research Center for the Study of Periodontal and Periimplant Diseases, University of Ferrara, Ferrara, Italy, and the Department of Odonstomatology, Ospedale "Casa Sollievo della Sofferenza," San Giovanni Rotondo, Italy.^{5,6} The technique is characterized by transcrestal access to the sinus cavity by means of specially designed drills and osteotomes. The pristine bone at sites of implant placement is drilled up to the sinus floor with a trephine bur and then used to fracture the sinus floor by hydraulic pressure through osteotomes. In this respect, the procedure represents a modification of the technique proposed by Fugazzotto.⁷ One of the advantages of the technique lies in the use of all manual and rotating instruments with adjustable stop devices, which are selected in relation to the vertical amount of residual bone at sites where implants have to be placed. These stop devices have a variable length and may be adapted to all manual and rotating instruments. The use of the stop device restricts the working action of burs and osteotomes to the vertical amount of residual bone, thus preventing the accidental penetration of instruments into the sinus cavity. The determination of the working length (i.e., the distance from the bone crest to the sinus floor) where the osteotome and burs have to limit their working action is first diagnosed on 2-D and/or 3-D radiographs, and then verified intra-surgery by means of a specially designed osteotome. The second advantage relates to the standardized sequence of instruments used for the Smart Lift procedure, which has been shown to limit the impact of the clinician's judgment and skill, thus allowing for rapid learning for inexperienced clinicians.⁸

The Smart Lift technique shares its clinical indications with the other surgical procedures for tSFE:

- indications for implant-supported prosthetic rehabilitation, based on accurate diagnosis and treatment planning;
- systemic and local conditions that are compatible with implant placement and sinus floor elevation procedures;
- residual bone height (i.e., the distance from the bone crest to the sinus floor) that prevents the insertion of an implant of the desired length and residual bone height of at least 2 mm.

The Smart Lift technique must not be performed whenever systemic and local conditions contraindicate sinus floor elevation.

The Smart Lift technique: Sequence of instruments

According to the prosthetic treatment planning, the locations for implant placement are established, and the residual bone height at such locations is radiographically measured as the distance from the bone crest to the sinus floor (radiographic working length).

All instruments in the surgical set are characterized by laser marks at each millimeter to allow for precise control of the working length. In the conventional sequence (used with a residual bone height of at least 3 mm; **Fig. 1**), the first drill (locator drill) is used to perforate the cortical bone at the site where the implant is to be placed. A second drill (probe drill), with a diameter of 1.2 mm and cutting only at the top edge, is used to define the position and orientation of the implant. In order to minimize the risk of sinus floor perforation, this bur is used with an adjustable stop device that is set at least 1 mm shorter than the radiographic working length. The probe osteotome (\varnothing : 1.2 mm) is carefully inserted into the site prepared with the probe drill and gently forced in an apical direction through the cancellous bone until the cortical bone resistance of the sinus floor is met. Therefore, the probe osteotome provides the surgical working length, which is the true anatomical distance from the bone crest to the sinus floor in the exact location where the implant should be placed. Thus, the working action of all manual and rotating instruments that will be used in subsequent surgical steps must be set at the surgical working length using the proper adjustable stop device.

A radiographic pin (\varnothing : 1.2 mm) can be used to check direction and depth of the prepared site by means of a periapical radiograph. The radiographic pin handle has a diameter of 4 mm, thus

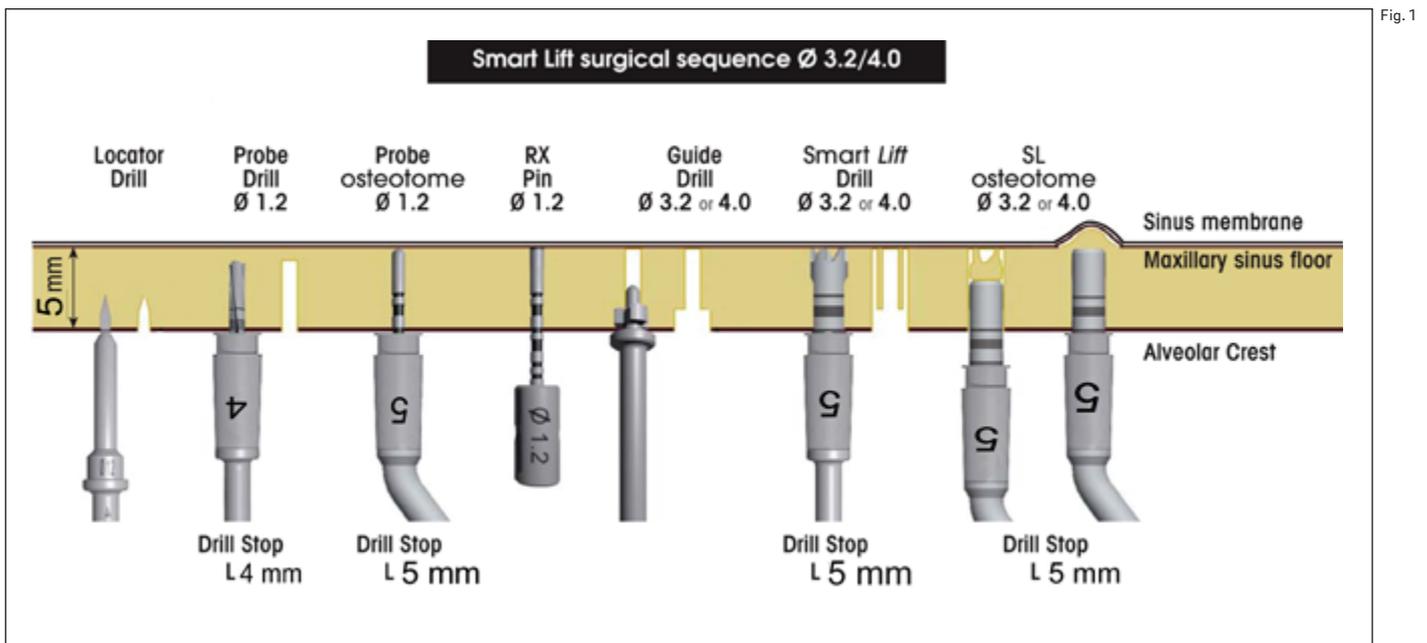


Fig. 1

Fig. 1
Conventional sequence of the Smart Lift technique (residual bone height ≥ 3 mm^{5,6}).

permitting evaluation of the spatial relationship between the prepared site and the buccolingual and mesiodistal dimensions of the alveolar ridge. This will help the clinician to determine the diameter of the implant to be placed.

A guide drill with a diameter of 3.2 mm (implant \varnothing : 3.75 - 4.50 mm) or 4.0 mm (implant \varnothing : 4.5 mm or larger) is then used. This drill follows the 1.2 mm diameter site preparation and creates a crestal countersink, where the trephine bur (Smart Lift drill) will be inserted. Such a countersink will force the trephine bur to follow the desired direction. The Smart Lift drill (\varnothing : 3.2 or 4.0 mm), set at the surgical working length, produces a bone core up to the sinus floor. The bone core and a variable amount of particulate bone substitute are condensed and malleted to fracture the sinus floor by means of a calibrated osteotome (Smart Lift elevator, \varnothing : 3.2 or 4.0 mm) that corresponds to the diameter of the trephine preparation. If the alveolar bone core is found to be inside the trephine, the bone core is gently removed from the trephine and replaced in the bone preparation. The osteotome is used under gently malleting forces to implode the trephined bone core over the sinus floor. In relation to the extent of vertical bone augmentation to be achieved, an autogenous cortical bone particulate or a particulate bone substitute can be further grafted and condensed into the sinus with the osteotome. Again, the Smart Lift elevator is used with the proper stop device at the surgical working length, thus preventing any unwanted

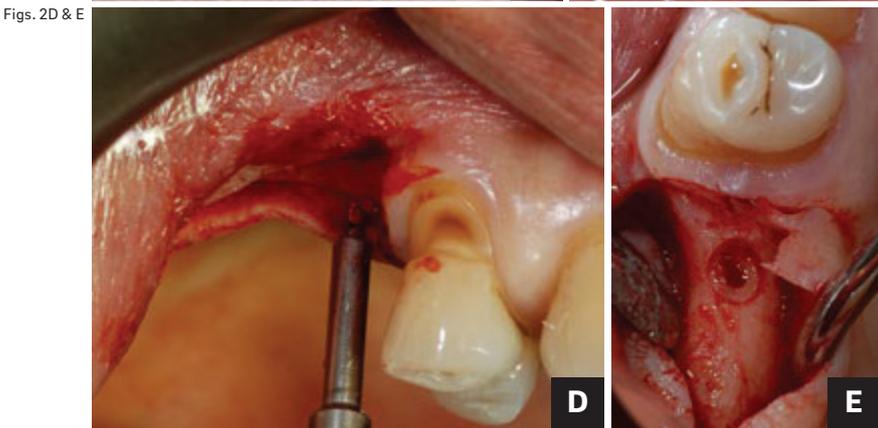
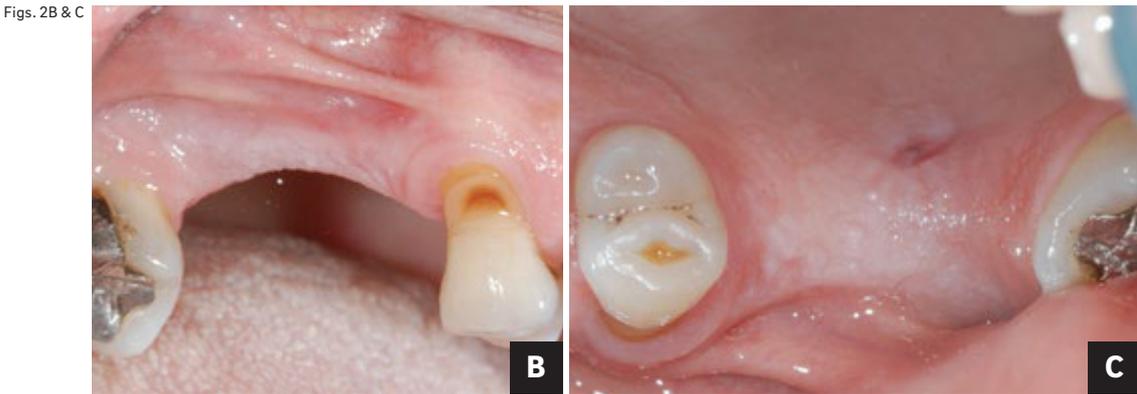
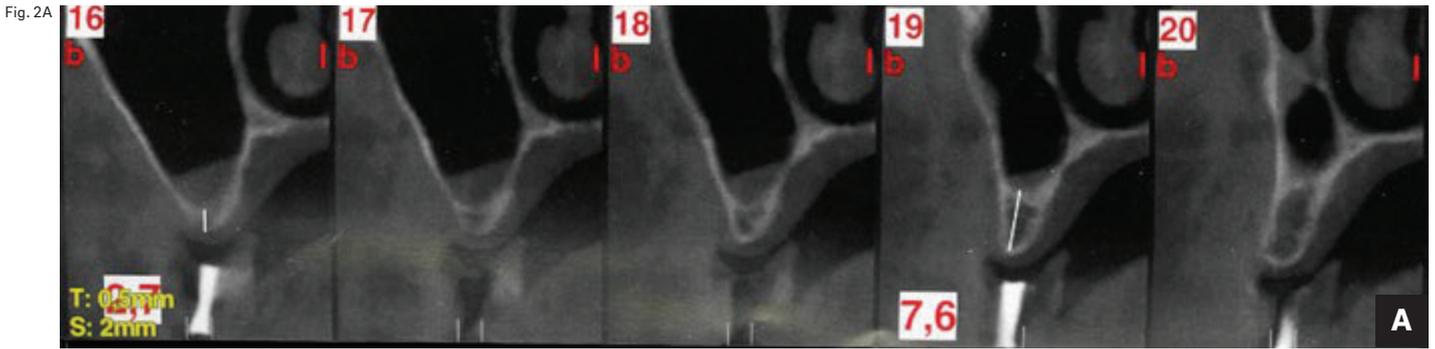
penetration of the instruments into the sinus cavity. Provided that the residual bone may ensure an adequate primary stability, an implant can be inserted during the same surgical session. Otherwise, a staged approach is recommended. If the residual bone height is 2 mm, a modified sequence must be adopted.⁹ The mean duration of the sinus floor elevation procedure (from cortical perforation to the completion of the grafting procedure), as reported in different cohort and randomized controlled trials, ranged between 19 and 32 min.^{6, 8, 10-13}

In a recent study,⁸ patients treated with the Smart Lift technique by 3 operators with different levels of experience in implant surgery and inexperienced with respect to the Smart Lift technique, showed a substantial extent of sinus elevation in a limited operation time, along with minimal incidence of membrane perforation and post-surgical dosage of anti-inflammatory drugs.⁸

The clinical application of the Smart Lift technique is illustrated in **Figure 2**.

The Smart Lift technique: Clinical outcomes

The Smart Lift technique was first reported in 2008.⁵ During the last 10 years, several studies have been conducted,^{5, 6, 8, 9, 11-16} reporting data on treatment outcomes and post-surgical morbidity of the procedure (**Table 1**). Only in 1 case did the Smart Lift technique not allow for the placement of implant concomitant to tSFE¹³ and



Figs. 2 A–E
 A 52-year-old male patient presented with an edentulous area in the maxillary right quadrant. Neither systemic nor local conditions contraindicating implant surgery or sinus lift procedures were identified at the screening visit. The prosthetic rehabilitation plan included the placement of 2 implant-supported crowns in the region of the maxillary right second premolar and first molar, which had been extracted 3 years prior to the visit.

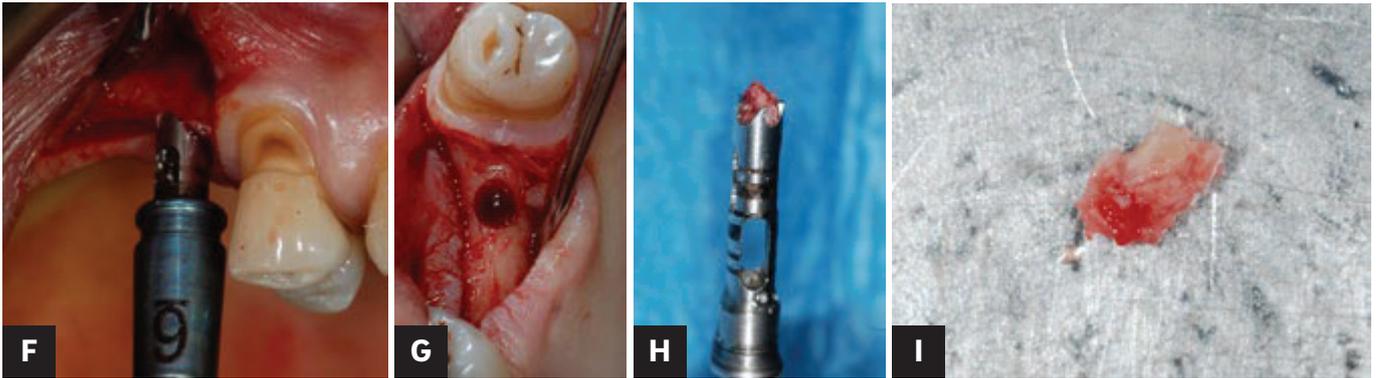
- (A)** Computed tomography scans showed a radiographic working length of 2.7 mm at the first molar site and 7.6 mm at the second premolar site.
- (B)** Lateral clinical photograph.
- (C)** Occlusal clinical photograph.
- (D)** The surgical working length assessed at the position of the second premolar was 6 mm as diagnosed with the probe osteotome. Therefore, a tSFE procedure was performed also at this site.
- (E)** A countersink was prepared with the guide drill.

implant insertion had to be delayed owing to the lack of primary stability. Implant survival shifted from 100% at 6 months in 8 studies^{5, 6, 8, 10–12, 15, 16} to 94% at 12 months in 1 study.¹³ The length of the inserted implants varied between 9.0⁶ and 10.3 mm,¹⁰ and the height of the residual bone ranged from 4.5¹³ to 6.6 mm.⁵ The extent of sinus lift ranged from 5.3⁸ to 7.7 mm.¹¹

**The Smart Lift technique:
 Post-surgical morbidity**

The mean scores for post-surgical pain and discomfort, as reported on a 100 mm visual analog scale,¹⁷ ranged from 0 to 62 mm and from 0 to 17 mm, respectively.^{8, 11} The level of pain significantly decreases, starting from the first day

post-surgery,¹³ and reaches very low levels (ranging from 1.0 to 2.1 mm) at the seventh day.^{6, 8, 10–13} Six studies have reported data on intra- and post-surgical complications.^{10–13} Membrane perforation was the most frequent complication, with the incidence ranging from 0¹¹ to 13%.¹² In all cases, the perforation was managed with the insertion of a surgical hemostatic dressing (Gingostat, GABA Vebas) or a collagen matrix (Mucograft Seal, Geistlich Pharma). In all cases, the grafting procedure was completed and the implant was inserted. Rarely, other types of complications, such as transitory paresthesia in the suborbital area (1 case),¹⁵ tinnitus (1 case)¹⁵ and benign paroxysmal positional vertigo (1 case)¹² occurred. All these complications spontaneously subsided within the first week post-surgery.



Figs. 2F-I

Figs. 2F-P

(F-I) A trephined bone core was created with the Smart Lift drill with a diameter of 3.2 mm.

(J-L) The bone core, along with a bone substitute (Bio-Oss spongiosa granules, particle size of 0.25–1.00 mm, 500 mg package; Geistlich Pharma), was gently malleted using the 3.2 mm diameter Smart Lift elevator with the 6 mm stop device until the sinus floor was fractured.

(M) At the distal implant site, the surgical working length was 2 mm as assessed using the probe osteotome.

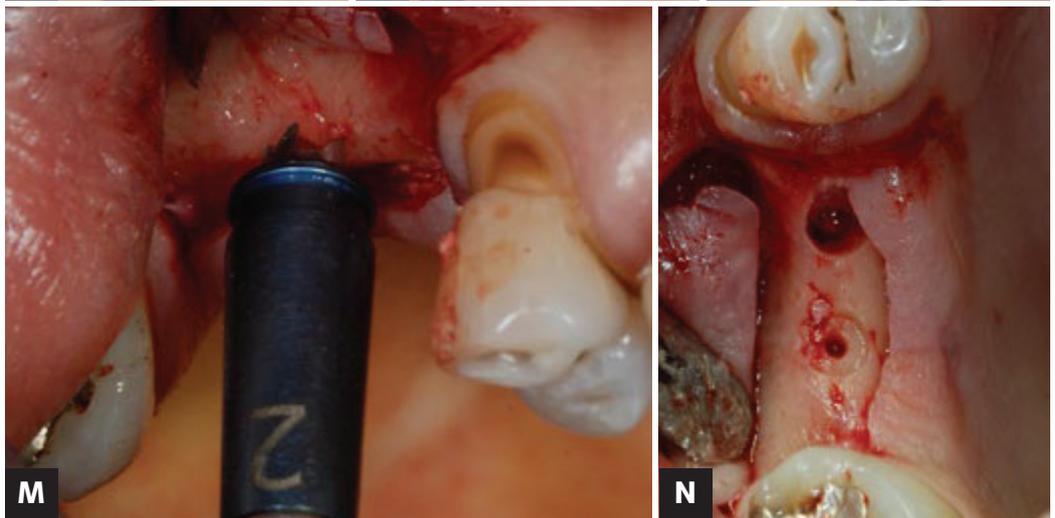
(N) A countersink created with the guide drill superficially marked the area for the Smart Lift elevator.

(O) The residual bone was gently malleted into the sinus with the Smart Lift elevator.

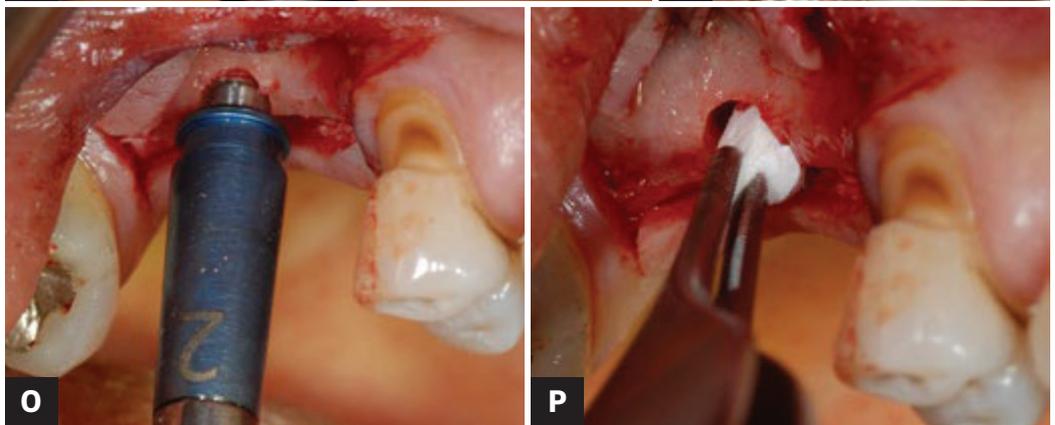
(P) A 3-D collagen matrix (Mucograft Seal) was trimmed and inserted into the crestal access.



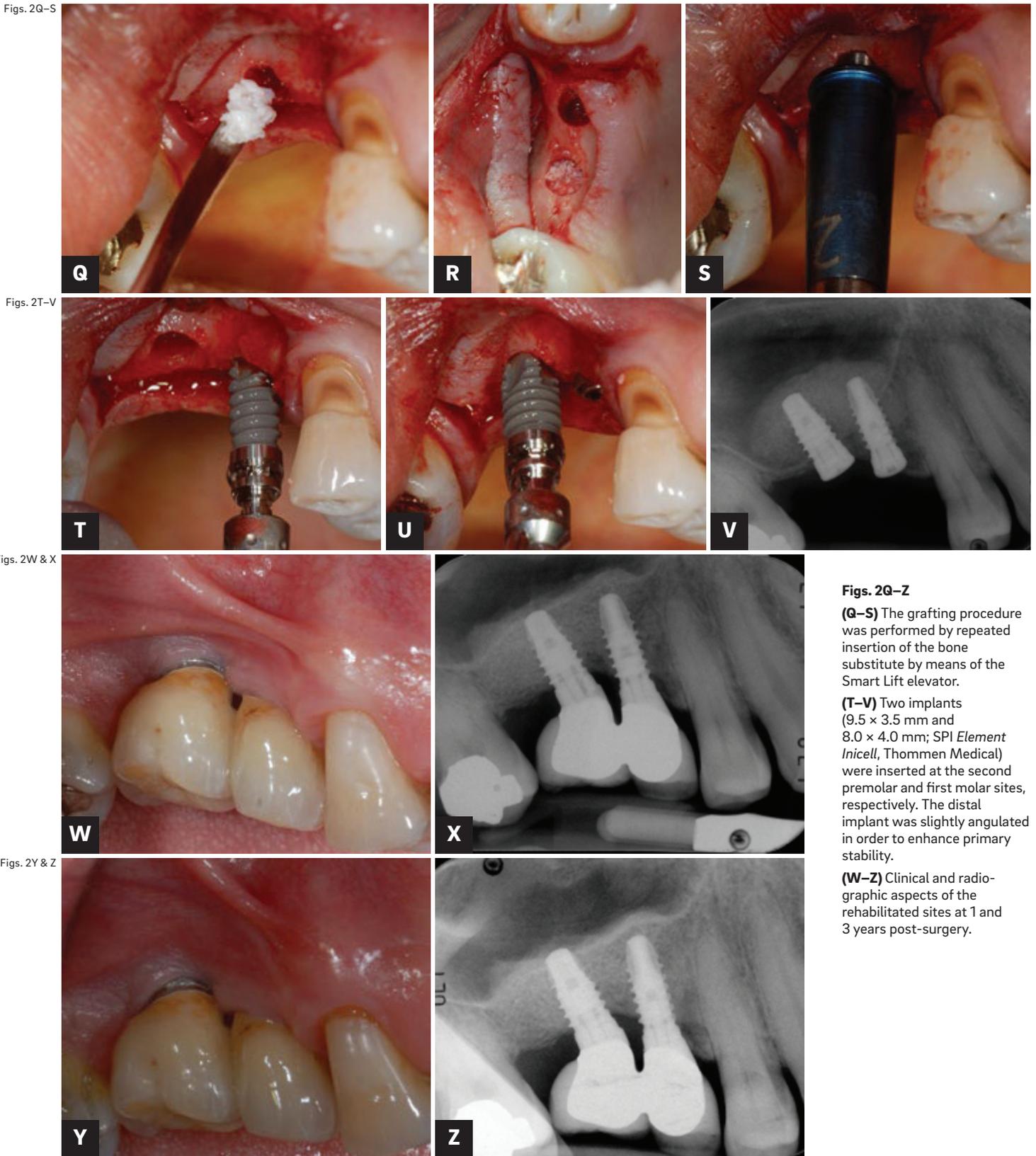
Figs. 2J-L



Figs. 2M & N



Figs. 2O & P



Figs. 2Q-Z
(Q-S) The grafting procedure was performed by repeated insertion of the bone substitute by means of the Smart Lift elevator.
(T-V) Two implants (9.5 × 3.5 mm and 8.0 × 4.0 mm; SPI *Element Inicell*, Thommen Medical) were inserted at the second premolar and first molar sites, respectively. The distal implant was slightly angulated in order to enhance primary stability.
(W-Z) Clinical and radiographic aspects of the rehabilitated sites at 1 and 3 years post-surgery.

Table 1

Authors	Type of study	No. of patients	No. of implants	Follow-up period (months)	Implant survival (%)		
Farina et al. ¹³	RCCT (tSFE group)	29	33	12	94%		
Franceschetti et al. ¹⁶	Retrospective case series	14	14	6	100%		
Franceschetti et al. ⁸	Prospective case series	Initial group	13	13	6	100%	
		Final group	13	13	6	100%	
		Expert operator group	20	20	6	100%	
		Moderately experienced operator group	20	20	6	100%	
		Low experienced operator group	20	20	6	100%	
Trombelli et al. ¹²	RCCT	DBBM group	19	19	6	100%	
		β-TCP group	19	19	6	100%	
Franceschetti et al. ¹⁵	Prospective cohort study	Smoker group	25	25	6	96%	
		Nonsmoker group	20	20	6	100%	
Trombelli et al. ¹¹	RCCT	S-HA group	15	15	6	100%	
		DBBM group	15	15	6	100%	
Trombelli et al. ¹⁰	Case series	11	14	6	100%		
Trombelli et al. ⁶	Case report	1	1	6	100%		
Trombelli et al. ⁵	Case report	1	1	6	100%		

RCCT = randomized controlled clinical trial; tSFE = transcrestal maxillary sinus floor elevation; DBBM = deproteinized bovine bone mineral; TCP = tricalcium phosphate; ND = no data; IR = interquartile range; S-HA = synthetic hydroxyapatite.

Table 1
Studies reporting data on treatment outcomes of the Smart Lift technique.

	Implant length (mm) expressed as median (IR) or mean (\pm SD)	Residual bone height (mm) expressed as median (IR) or mean (\pm SD)	Immediate post-surgical extent of sinus lift (mm) expressed as median (IR) or mean (\pm SD)	Immediate post-surgical height of graft apical to implant apex (mm) expressed as median (IR) or mean (\pm SD)
	9.5 (9.5–9.5) (median) (IR)	4.5 (4.0–5.3) (median) (IR)	ND	0.9 (0.3–1.6) (median) (IR) (27 patients)
	9.8 (9.5–11.0) (median) (IR)	6.0 (5.6–6.8) (median) (IR)	6.8 (5.7–7.6) (median) (IR)	ND
	ND	6.3 (\pm 1.6) (mean) (SD)	6.6 (\pm 1.8) (mean) (SD)	2.9 (\pm 1.1) (mean) (SD)
	ND	5.8 (\pm 0.9) (mean) (SD)	7.0 (\pm 1.3) (mean) (SD)	2.5 (\pm 1.5) (mean) (SD)
	ND	5.4 (\pm 1.2) (mean) (SD)	7.2 (\pm 1.2) (mean) (SD)	2.6 (\pm 1.2) (mean) (SD)
	ND	6.4 (\pm 1.3) (mean) (SD)	6.0 (\pm 1.9) (mean) (SD)	2.3 (\pm 1.3) (mean) (SD)
	ND	5.2 (\pm 1.6) (mean) (SD)	5.3 (\pm 1.4) (mean) (SD)	2.0 (\pm 0.8) (mean) (SD)
	9.5 (9.5–11.0) (median) (IR)	5.4 (5.0–6.1) (median) (IR)	6.1 (5.6–6.9) (median) (IR)	1.5 (1.2–2.3) (median) (IR)
	9.5 (9.5–11.0) (median) (IR)	5.5 (5.2–6.8) (median) (IR)	6.8 (6.2–7.5) (median) (IR)	2.2 (1.6–3.1) (median) (IR)
	9.5 (9.5–10.3) (median) (IR)	5.3 (4.7–5.8) (median) (IR)	6.9 (6.0–7.7) (median) (IR)	2.5 (1.7–3.4) (median) (IR)
	9.5 (8.5–10.0) (median) (IR)	5.0 (4.2–6.1) (median) (IR)	6.5 (5.7–7.7) (median) (IR)	2.3 (1.3–2.8) (median) (IR)
	10.0 (8.75–10.50) (median) (IR)	5.25 (4.6–6.4) (median) (IR)	7.7 (6.70–8.55) (median) (IR)	3.0 (2.80–3.75) (median) (IR)
	9.5 (9.5–10.0) (median) (IR)	5.7 (4.33–6.35) (median) (IR)	6.5 (5.95–7.40) (median) (IR)	2.6 (2.30–3.45) (median) (IR)
	10.3 (\pm 0.9) (mean) (SD)	6.1 (\pm 1.8) (mean) (SD)	ND	ND
	9.0	5.0	ND	ND
	ND	6.6	ND	ND

Conclusion

In the edentulous maxillary posterior sextants, the vertical dimension of the residual bone crest may frequently call for bone augmentation procedures to allow for the placement of implants of adequate length and width. Among the techniques for tSFE that have been proposed in the literature, the Smart Lift technique represents

a simplified, user-friendly, standardized procedure that allows for a substantial extent of sinus lift with limited post-surgical morbidity.

Competing interests

The authors declare that they have no competing interests.

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