Localized Management of Sinus Floor Technique for Implant Placement in Fresh Molar Sockets

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ABSTRACT

Background: The use of osteotome for vertical bone augmentation and localized sinus elevation with minimal surgical trauma represents a suitable procedure to increase the vertical dimension of available bone for implant placement.

Purpose: The aim of this study was to report clinical and radiographic results of localized management of sinus floor (LMSF) in fresh molar sockets at 13-year follow-up.

Materials and Methods: Fifty-three patients, needing one or two maxillary molar extraction, were enrolled in this study. LMFS procedure was performed and 68 implants were positioned. A presurgical distance from the alveolar crest to the floor of the maxillary sinus and the amount of new radiopacity between the sinus floor and alveolar crest were measured from the mesial and distal surfaces of each dental implant surface.

Results: After a mean follow-up period of 9.76 ± 5.27 years (ranged from 4 to 17 years) a survival rate of 100% was reported. Mean bone height at temporary prosthesis placement was 7.99 ± 1.16 mm. They were stable over time, reporting a mean value of 8.01 ± 1.46 mm at 13-year follow-up.

Conclusions: The results of this study demonstrated that LMSF procedure in fresh molar sockets allowed to expand the dimensions of resorbed posterior maxillary alveolar bone both vertically and horizontally with a success rate of 100% of implant osseointegration over time.

KEY WORDS: bone expansion, LMSF, natural bone regeneration, sinus augmentation, sinus elevation

INTRODUCTION

Posterior maxillary tooth extraction induces an inferior expansion of the maxillary sinus in relation to fixed anatomic structures, consequently proving the pneumatization phenomenon after tooth loss. The expansion of the sinus is larger after extraction of teeth enveloped by a superiorly curving sinus floor, extraction of several adjacent posterior teeth, and extraction of second molars in comparison with first molars.[1] Additionally, roots that protrude into the sinus have a thin cortical bone lining, and during extraction procedure, this thin bone may break and dislocate, allowing the sinus to expand toward the empty socket.[2]

Molar extraction induces greater pneumatization than premolar extraction probably because of larger defect left in the alveolar cavity, allowing the sinus to pneumatize.

Loss of alveolar height and width following tooth removal is significant, often accounting for up 50% of the alveolar mass in the area. Such resorption often precludes implant placement or placement of narrower, shorter implants than desired, often in less than ideal position.

In fact, it is also important to consider the amount of the occlusal forces in the posterior segments of the dentition in relation to the implant support. Molars are teeth with large occlusal surfaces and a multi-rooted anatomy that is specifically designed for this function. If these teeth have to be replaced in a well-designed treatment plan, the clinician would consider that these teeth should be possibly replaced with large implants.

Consequently, to prevent expansion of sinus floor and preserving the bone volume of fresh sockets after

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DOI 10.1111/j.1708-8208.2011.00348.x

tooth extraction, immediate dental implant placement[3] is recommended. The use of osteotome for vertical bone augmentation and localized sinus elevation with minimal surgical trauma represents a suitable procedure to increase the vertical dimension of available bone for implant placement. The crestal bone is displaced toward the sinus floor, and the apical portion of the implant is placed in the augmented space. In a clinical study,[4] at the time of maxillary molar extraction, a modified trephine and an osteotome procedure were performed to implode the interradicular bone following maxillary molar extraction. Particulate material and a membrane were then placed to increase regeneration of alveolar bone.

In other studies, implants were placed in fresh extraction sockets with simultaneous maxillary sinus floor elevation using the osteotome technique.[5–7]

The localized management of sinus floor (LMSF) procedure[8] provides implant placement and sinus lifting simultaneously. LMSF is a further application of the principles of the edentulous ridge expansion technique. It is composed of a partial thickness flap, the buccal expansion of the residual alveolar bone, and the fracture and elevation of the sinus floor with simultaneous implant placement.

In the present clinical study, LMSF is performed after molar extraction. It combines tooth extraction, buccal expansion of the residual intra-septum bone, elevation of the maxillary sinus floor, and implant insertion in a single surgery procedure. The aim of this study is to report clinical and radiographic results of LMSF in fresh molar sockets with a long-term 13-year follow-up.

MATERIALS AND METHODS

Patient Selection

Between November 1992 and December 2005, 53 patients from a private practice setting were restrospectively enrolled in the study.

The patients were 33 females and 20 males; the mean age was 54.3 ± 19.2 years, varying from 31 to 73 years.

The following inclusion criteria were adopted: good general health, no chronic systemic diseases. All subjects included in this study needed to have one or two maxillary molar extraction for deep decay or vertical root fracture.

Teeth included as sites for immediate implant placement had to demonstrate integrity of the peripheral alveolar walls and absence of alveolar infection. Teeth with failed endodontic therapy but with no damage to the peripheral alveolar walls were included in this study.

Exclusion criteria were the presence of chronic systemic disease, smoking of more than 10 cigarettes, bruxism habits, uncontrolled diabetes, coagulation disorders, alcohol or drug abuse, and poor oral hygiene.

The patients included in this clinical study were treated by a single operator (G.B.B.) in private practice office.

All patients gave their written consent to carry out the treatment according to the described protocol.

Surgical Procedure

At first stage, local Xylocaine® anesthesia (Astra, Milan, Italy) was used on all patients.

All patients were premedicated with a nonsteroidal anti-inflammatory drug (Naprosyn®, 1.5 g; Recordati, Milan, Italy) and an antimicrobial agent (Ciproxin®, 1 g; Bayer, Milan, Italy) 1 hour before surgery. Antibacterial and anti-inflammatory medications were continued for 5 days after surgery.

All multi-rooted molars were hemisected, the roots were removed carefully to preserve the interradicular bone, and the sockets were debrided. A flapless approach was followed for preservation of the periosteum and keratinized mucosa with an atraumatic and adequate exposure of alveolar anatomy. For replacement of maxillary multi-rooted molars, the implants were inserted in the central intra-septum. A 2-mm surgical bur (Komet Italia, Milan, Italy), inserted 5–7 mm,[8] was used to prepare a stable point in which progressive bone expanders were inserted to create the bone site for the implant placement. Utilizing a post-extraction radiograph taken with the parallel technique was possible to evaluate the residual bone existing under the sinus floor (Figures 1 and 2).

A progressive in diameter bone expander was inserted in the previous hole created with the small surgical burr maintaining a palatal direction. The bone expanders were pushed deep in the bone, by mallet forces, leaving 1 to 2 mm before the estimated sinus floor level. The distance between the crest and the floor of the sinus was measured radiographically (periapical intraoperatory, radiograph with the parallel technique). The intra-septum bone was progressively expanded in the root alveolus spaces that progressively change the profile from round to oval from the center to the periphery.

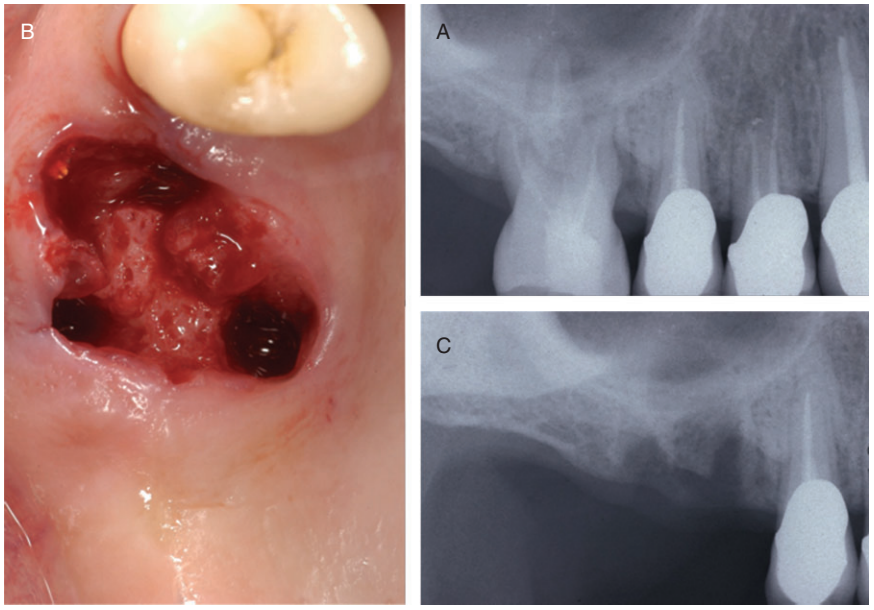

Figure 1 Preoperative radiograph of tooth 16 (A); clinical aspect of the alveolar gingival after tooth extraction (B); the distance between the ridge crest and the floor of the sinus is measured on a preoperative periapical radiograph (C).

The initial preparation was performed with the smallest instruments B2, apical diameter 1.5 mm, and B3, apical diameter 1.9 mm. Further bone expander 4.5 x 15 mm length, with apical diameter 2.3 mm was utilized to perform the LMSF with two movements: the first one was forced in the previous palatal direction through the spongiosa that exists in the intra-septum bone lined by the lamina dura that defines the alveolar anatomy producing the vertical bone expansion in the palatal bone. This bone expander performed the initial sinus floor displacement, maintaining 2 to 3 mm before its final position, keeping the initial palatal direction. The second movement was performed orienting the bone expander occlusally. Subsequently, a 4.5 x 13 mm in length instrument was used with a progressive larger tip; it was pouched with the same occlusally movements of the previous one.

The surgical burrs were avoided because they were too destructive for the delicate residual bone.

Very delicate, careful tapping was now sufficient to displace the complex of Schneiderian membrane, cortical, and pericortical osseous tissue into the sinus cavity.[9]

Once the space obtained with the bone expanders was sufficient for the planned fixtures, a 1 x 1 cm collagen sheet was inserted in the implant bed and pushed against the vault. The fixture was than tapped in position. Two groups of implants were used: one type (Frialit, Friadent Gmbh, Mannheim, Germany) diameter 4.5, 5.5, and 6.5 mm, length 13 and 15 mm, and the other group (PILOT, Sweden-Martina, Padova, Italy), diameter 5.7 and 6.7 mm, length 13 mm and 15 mm. Implant dimensions and positions are shown, respectively, in Tables 1 and 2. Both types of implants presented conic shape and titanium plasma-sprayed surface.

The final implant emergent profile was localized within the original anatomical alveolus and preferably above it, leaving smooth collar above the crestal level for maxillary molars to allow the tissue to adhere to the collar.[10]

A small piece of collagen that was inserted below the borders of the soft keratinized mucosa that lines the extraction socket was used to cover the surgical field. The collagen (Gingistat, Acteon Pharma, Bordeaux, France) stopped the bleeding and ensured the stability of the blood clot. The collagen was held in position by inserting the suture needle at the center of the alveolus and suturing the collagen and tissue together with a crossed suture, which was not tightened.

The implant screws were uncovered, thus avoiding tissue traction. Sutures were removed 7 days after implant placement.

After 70 days implant insertion, temporary prostheses were then fitted and worn for 2 to 3 months before the final reconstruction.

The standard of success for implant function established by Albrektsson and colleagues[10] was followed.

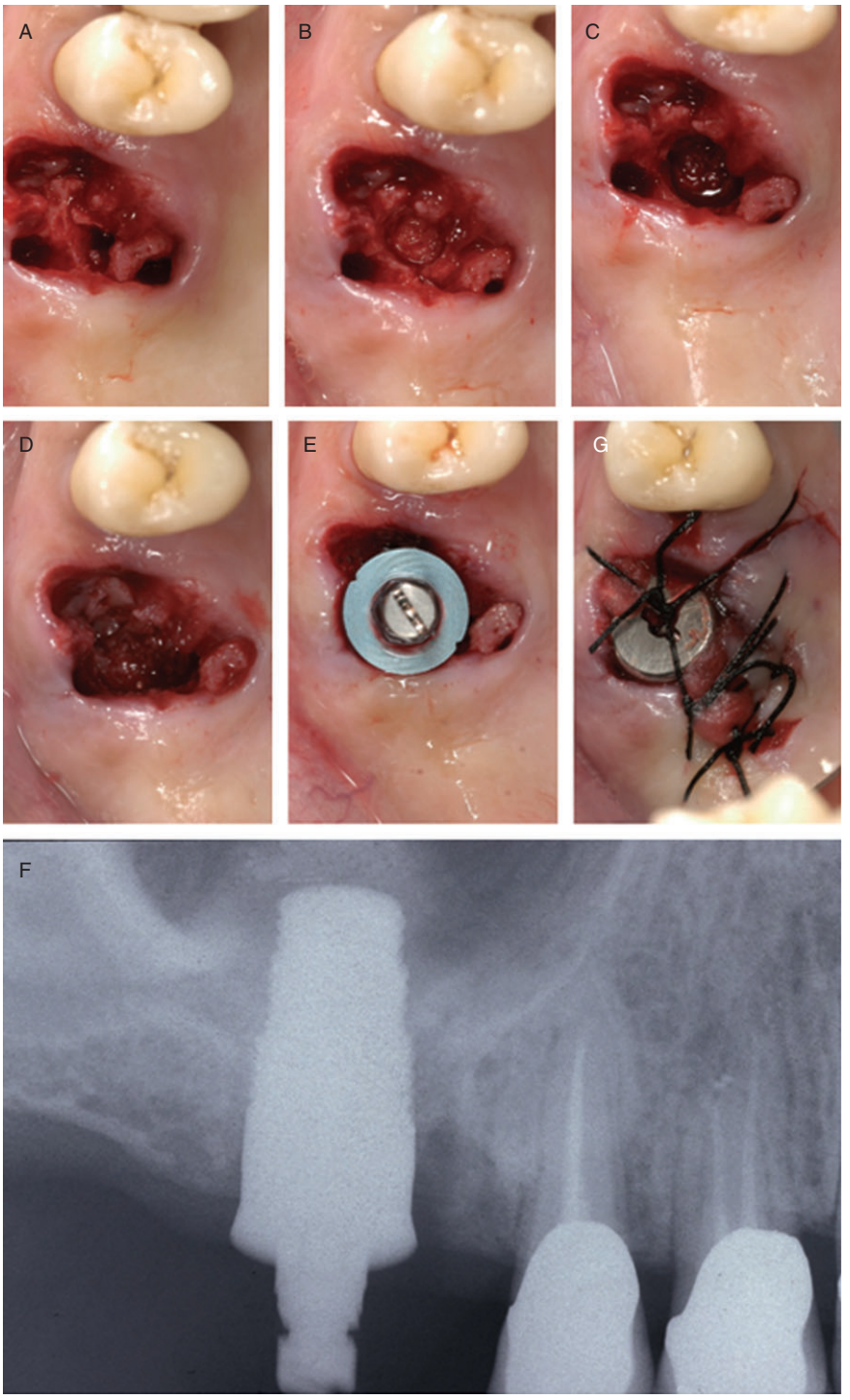

Figure 2 Preparation of implant site with a 0.10 mm surgical bur to prepare a stable point (A); a progressive in diameter bone expander starting form smallest instruments were inserted in the previous hole created with the small surgical bur maintaining a palatal direction because of more bone presence; the bone expanders are pushed deep in the bone, by mallet forces, leaving 1 to 2 mm before the estimated sinus floor level (B–D); clinical aspect of implant placement into the fresh socket (E); periapical radiograph of the implant placed into the fresh extraction socket (F); sutures in position (G).

TABLE 1 Implant Dimensions (n = 68 = Implants)

Length (mm) / Diameter (mm)	13	15
4.5	2	3
5.5	5	4
6.5	11	8
5.7	15	2
6.7	17	1
Total	50	18

In addition, implants were considered as successful only after 5 months of final prosthetic reconstruction and occlusal loading (Figure 3).

Radiographic Assessments

The periapical radiographs were taken perpendicularly to the long axis of the implant with a long-cone parallel technique using an occlusal template at baseline (presurgical), at implant placement, at 70 days (placement of temporary prosthesis), and every year of follow-up. A blinded radiologist measured bone height over time. He marked the reference points and measured lines on the screen interactively. Outcome variables were recorded on the radiographs using a digital ruler.

The following parameters were assessed from the periapical radiograph:

- A presurgical distance from the alveolar crest to the floor of the maxillary sinus.
- The amount of new radiopacity between the sinus floor and alveolar crest measured from the mesial and distal surfaces of each dental implant surface.

A mean for initial and gained alveolar bone height was obtained from the radiographic evaluations. They were measured at baseline, at temporary prosthesis placement, at 1-year, at 3-year, and at long-term follow-up of healing from implant placement.

TABLE 2 Implant Positions (n = 68 = Implants)

Teeth	16	17	26	27
Implants	25	6	28	29

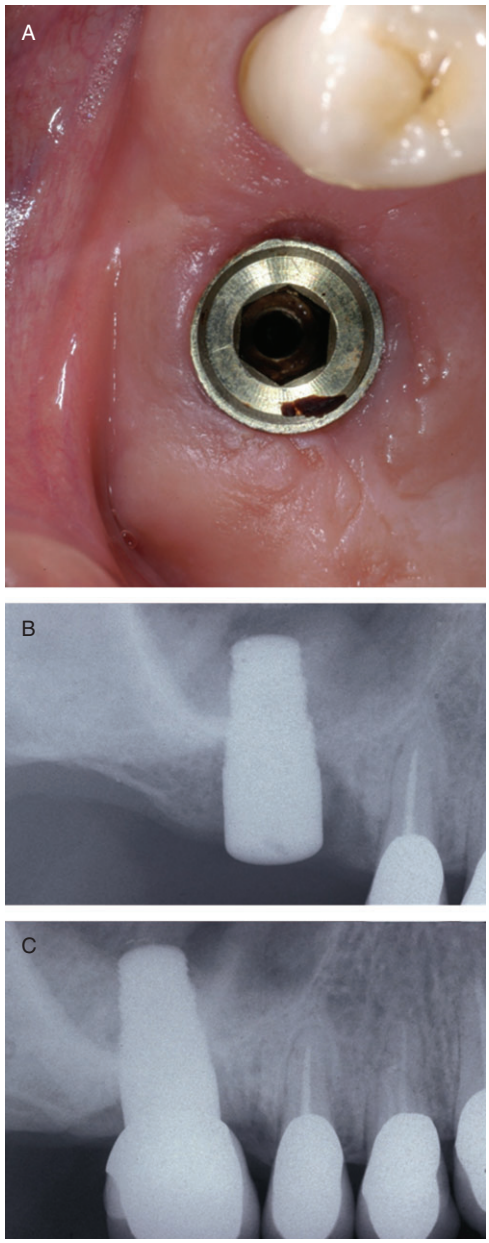

Figure 3 Healing of keratinized mucosa around abutments 70 days later (A); periapical radiograph of the implant, it was possible to observe the formation of new cortical line that lines the sinus floor (B); five-year annual check-up periapical radiograph of the implant with the new cortical lines through the apical implant fenestrations (C).

Statistics

A dedicated software was used for all statistical analyses (SPSS 11.5.0, SPSS Inc., Chicago, IL, USA). All data were reported as mean ± standard deviation. Radiographic bone heights were calculated at baseline, and for each implant at distal and mesial site, and were reported at baseline, at temporary prosthesis placement, at 1-year, at 3-year, and at long-term follow-up of healing from implant placement.

TABLE 3 Mean Bone Height at Temporary Prosthesis Placement, at 1-Year, at 3-Year, and at Long-Term Follow-Up (Mean Follow-Up 9.76 ± 5.27 Years, Ranged from 4 to 17 Years) (n = 68 = Implants)

	Prosthesis Placement	1 Year	3 Years	Long Term
Mesial bone height (mm)	8.01 ± 1.23	8.12 ± 1.71	8.05 ± 0.99	8.04 ± 1.15
Distal bone height (mm)	7.98 ± 1.10	7.99 ± 1.45	8.01 ± 1.90	7.99 ± 1.78
Mean bone height (mm)	7.99 ± 1.16	8.05 ± 1.58	8.03 ± 1.49	8.01 ± 1.46

RESULTS

Baseline mean alveolar crest bone height was 6.02 ± 0.75 mm (n = 53 = patient).

After implant placement, no final prosthesis mobility was recorded. There was a suitable wound healing around temporary abutments, with a fine adaptation to the temporary crown. Apart from expected pain and swelling, there were no other complications. After this surgical procedure, four patients experienced minor nasal bleeding, which disappeared within the first 24 to 48 hours.

The final ceramic fused to metal restorations were cemented 5 months after implant placement.

After a mean follow-up period of 9.76 ± 5.27 years (ranged from 4 to 13 years), a survival rate of 100% was reported.

Radiographic measurements at temporary prosthesis placement, at 1-year, at 3-year, and at long-term follow-up are shown in Table 3. Radiographic analysis of the successful implants shows that an increase of 7 to 9 mm of available bone was possible with this procedure.

DISCUSSION

The LMSF procedure in fresh molar sockets, when properly performed, is well-tolerated. This surgical procedure obtains osseointegration of implants whose length largely exceeds the preoperative bone dimensions and diameter, which can be considered adequate to substitute a multi-rooted maxillary molar. Radiographic analysis of the successful implants shows that an increase of 7 to 9 mm of available bone is possible with this procedure.

Primary stability was achieved when implants were tapped in place because the maxillary cortical bone and the cancellous bone, covered by the preserved periosseous connective tissues, are elastic.

This post-extractive surgical procedure allows wide body implant placement into a maxillary fresh molar socket obtaining primary stability in intra-septum bone spongiosa. This surgical procedure provides a horizontal expansion in the empty root spaces and a vertical expansion in the spongiosa that normally is present in the palatal bone that covers the palatal root and lines the sinus floor. The final movement produces the lateral dislocation of the bone housing surgically created for the implant with this expansion technique.

Moreover, the fixture can be large enough to replace the lost maxillary molars and is therefore perfectly capable of sustaining the heavy occlusal forces of this area.

The delicate, careful displacement of Schneiderian membrane and cortical bone tissue into the sinus cavity was performed to create a new horizontal and vertical intraosseous space with complete preservation of the original bone. The biologic basis for the healing process of the LMSF technique is similar to classic "socket" healing[11,12] in which the blood clot acts as a physical matrix that induces and enhance migration, proliferation, and differentiation of various types of cells, subsequently leading to angiogenesis.[13] Neovascularization of the blood clot and subsequently, new bone formation appears to start from released bone marrow spaces of the adjacent defect borders.

It can be argued that it may not be the size of the marginal gap per se but rather the formation of a coagulum in the defect, its retention and replacement with a bundle bone matrix that determine whether defect resolution will occur.

Furthermore, human maxillary sinus membrane tissue is considered potential sources of multipotent mesenchymal stem cells that may differentiate into osteoblasts under osteogenic induction and consequently, promote a natural healing process.[9]

Furthermore, several studies have explained the capability to obtain bone without grafting material when the Schneiderian membrane has been lifted

beyond the anatomical limits of the sinus floor, either crestally[14] or laterally.[15–17]

Nedir and colleagues[18] confirmed that the osteotome sinus floor elevation procedure without grafting material was sufficient to create bone beyond the natural limit of the sinus since implants gained endo-sinus bone despite the lack of grafting material without shrinkage of the augmented area.

Winter and colleagues,[19] utilizing the localized management of the sinus floor technique, successfully placed 58 implants without sinus grafts in atrophic posterior maxillary ridges with ≤4 mm of bone. The sinus was "raised" an average of 9.12 mm without benefit of bone grafts or membranes. The success rate after 22 months of loading was 91.4%. This preliminary study demonstrated that it is possible to place implants in an atrophic alveolar ridge with ≤4 mm of bone without the need for a traditional sinus graft. The shrinkage of the novel bone was not observed and remained stable during 3 years,[18] and in the present study, the bone height gained after sinus lift procedure did not shrink over 17 years as reported with grafted materials.[20,21] The newly elevated sinus floor was also better delimited and maintained at level with the implant apices.

The fact that all implants have functioned successfully demonstrated that the newly formed bone was able to provide adequate support to prostheses in full occlusion, even in the long term. Furthermore, it did not shrink, maintaining a stable level along implant apex. The soft tissue anatomy was maintained in its integrity during the first stage of surgery following second intention healing process, and at the time of the second surgical stage, normally, a quantity of 1 or 2 mm of soft tissue grooved up to the titanium cover screw.

The results of this study demonstrated the LMSF procedure in fresh molar sockets, allowed to expand the dimensions of resorbed posterior maxillary alveolar bone both vertically and horizontally with a success rate of 100% of implant osseointegration over time. Moreover, the implants can be large enough to replace the lost maxillary molars, sustaining the occlusal forces of this anatomic area.

CONFLICT OF INTEREST STATEMENT

We certify that we have no affiliation with or financial involvement in any organization or entity with direct financial interest in the subject matter or materials discussed in the manuscript and that the material is original, has not been published elsewhere.

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