

UPPER FULL ARCH REHABILITATION WITH SINUS BY-PASS WITH TILTED IMPLANTS VIA TAPERED-THREADED EXPANDERS IN LOW DENSITY BONE: A CLINICAL TRIAL

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SUMMARY

Purpose. In the present paper the use of tapered-screw bone expanders (TSBEs) is proposed, in combination with the placement of tilted implants, in close proximity to the anterior sinus wall, solving the problem of the reduced height of the alveolar bone in the sub-antral area. The Authors present a case series of full-arch rehabilitations performed with this procedure named: Tilted Implant Expansion Osteotomy (TIEO).

Materials and methods. 12 patients (5 males and 7 females, average age 58.5 ± 8.1 years) with totally or partially edentulous maxilla were enrolled in this study. For each patient 4 implants were placed, the anterior implants in the area of lateral incisors or canines while, the posterior implants, immediately in front of the maxillary sinus, with an inclined position. Adopting the aforesaid procedure, 48 cylindrical two-piece implants were placed, 24 of which were placed in tilted position, in order to by-pass the maxillary sinus. After a healing period of 6 months, the second stage surgery was performed. The cases were finalized by means of a hybrid metal-acrylic prosthesis. The post finalization follow-up was at 12 months.

Results. Survival rate was 100% since none fixtures were lost. At the one-year follow up the clinical and radiological appearance of the soft and hard tissues was optimal and no pathological signs were recorded.

Conclusion. TIEO is a promising surgical procedure for full-arch rehabilitation of maxillary edentulous sites and represents a therapeutic alternative to sinus lift techniques.

Key words: low density bone, sinus lift, tilted implants, tapered-screw bone expanders, bone expansion.

Introduction

In patients who are partially or totally edentulous, the maxilla may present serious limitations for the realization of conventional implant treatment.

Alveolar bone resorption and pneumatization of the maxillary sinus reduce, in many cases, the

available amount of bone in both width and height for the placement of dental implants in the edentulous posterior maxilla (1, 2).

Another problem that may occur in this area is that of the quality of the bone, that is often less dense, more medullar and thinner than in the jaw (1-3).

This condition may be treated with an elevation of the maxillary sinus floor, which is usually ac-

completed via either a lateral (so-called Caldwell-Luc approach) or a transcrestal approach to the antrum.

Elevation of the maxillary sinus floor was first reported by Boyne and James as a preparation for the placement of blade implants (4). The surgical technique with grafting has since then been described by several Authors (2-18). This first technique involves a quite complex surgery, especially if an autogenous graft is desired. Ellegaard et al. and Lundgren et al. presented later techniques without grafts (5, 6).

In patients with appropriate residual bone height, augmentation of the sinus floor can also be accomplished via transalveolar approach, as was first suggested by Tatum in 1986. Later a less invasive procedure for sinus floor elevation, with immediate implant placement, was introduced by Summers in 1994 (7-9). The Schneiderian membrane and the bony floor of the sinus are elevated with osteotomes from a crestal approach, without the preparation of a lateral window. Simultaneously, some kind of graft may be placed (8, 10).

More recently, various modifications to the original transcrestal sinus floor elevation technique have been reported in the literature to overcome these issues: the use of a trephine-bur in combination with osteotomes; membrane elevation by inflation of a balloon catheter; the use of negative pressure; hydraulic pressure applied with sterile physiologic saline solution or hydraulic pressure applied with biomaterial for bone regeneration (11, 12, 14-18).

As alternative to these augmentation procedures, a more conservative treatment option to overcome the inadequate bone quantity would be to place short implants to avoid entering the sinus cavity. However, for the placement of even short implants, there is still a need for at least 6mm of residual bone height (15).

In addition the presence of oral diseases such as periodontal disease, atrophy of the oral mucosa, lesions of gastroesophageal reflux or oral lichen planus may influence success rate of these procedures (19-23).

In the present paper the use of tapered-screw ex-

panders (TSBEs) is proposed to bypass the sinus space, in combination with the placement of tilted implants (TIs), in close proximity (mesially) to the sinus walls. In the present paper, a case series of upper full-arch rehabilitations is described using this procedure.

Materials and methods

12 patients (5 males and 7 females, average age 58.5 ± 8.1 years), with totally or partially edentulous maxilla, in need of a full-arch implant supported rehabilitation, were selected for this trial (Figure 1a-b). Subjects were screened according to the following inclusion criteria: controlled oral hygiene and absence of any lesions in the oral cavity; in addition, the patients had to agree to participate in a post-operative check-up program.

The exclusion criteria were as follows: bruxism, consumption of alcohol higher than 2 glasses of wine per day, localized radiation therapy of the oral cavity, anti-tumor chemotherapy, liver, blood and kidney diseases, immunosuppressed patients, patients taking corticosteroids, pregnant women, inflammatory and autoimmune diseases of the oral cavity.

All interventions were planned by clinical intraoral examination as well as by intraoral X-ray exam (PSPIX, Sopro Acteon Imaging, France), of the edentulous sites. This latter showed a reduced thickness of the residual bone, in the sub-antral area, associated to the presence of an anterior wall of the maxillary sinus describing an inclined plane. These anatomical conditions were then confirmed by the Cone Beam Computed Tomography (CBCT) exam (NewTom 5G[®], QR, Verona, Italy) (Figure 1c). An evaluation of bone density, of each site to be treated, was evaluated by means the Hounsfield units (HU) analysis. The data assessment were performed using 3Diagnosis[®] software (v. 3.1, 3diemme, Cantù, Italy) (24). The bone density was finally confirmed by means of the intraoperative clinical assessment, performed during implant osteotomy preparation (25).

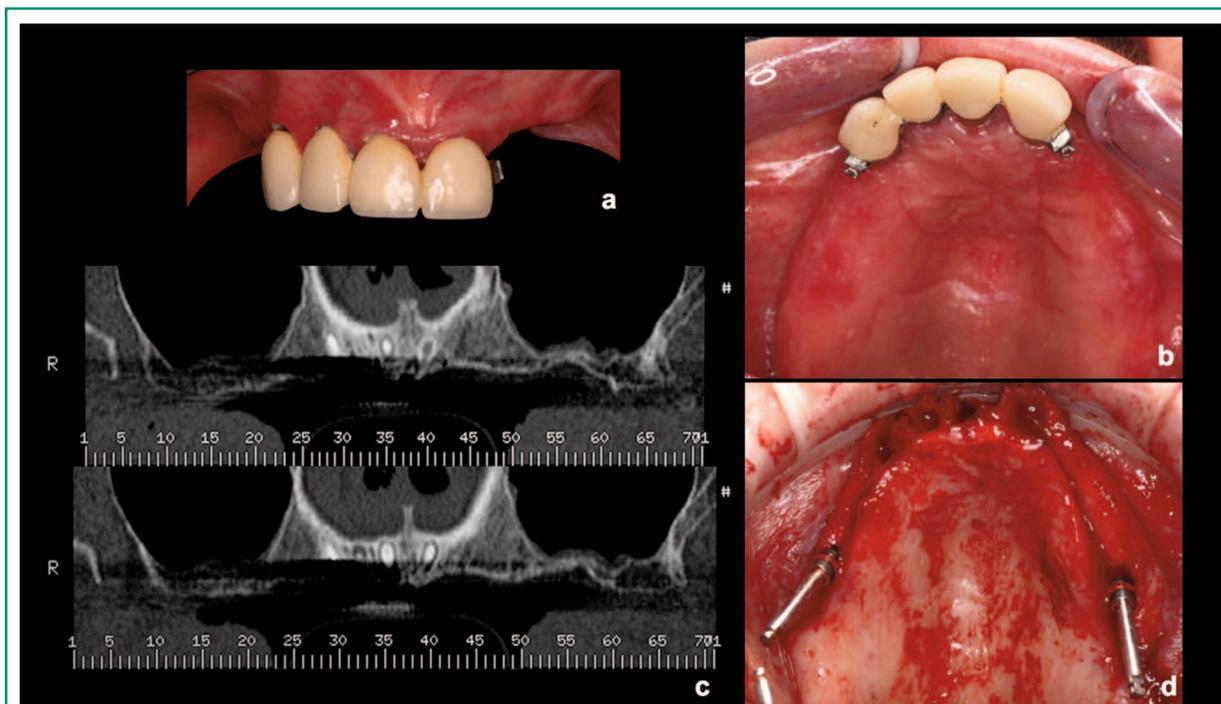


Figure 1

Clinical case describing the Tilted Implant Expansion Osteotomy (TIEO) in upper full-arch rehabilitation: a, b) intra-oral pre-operative condition; c) the CBCT exam; d) the full thickness flap is reflected and the bone burs are left *in situ* for the following radiographic evaluation of the future implant tunnel inclination.

All patients underwent the same pharmacological protocol: antimicrobial prophylaxis was administered with amoxicillin 850mg + clavulanic acid 125mg every 8h for 7 days, starting from 3 hours before the operation. After an initial rinse with chlorhexidine digluconate 0.2%, for 1 minute to disinfect the mouth, loco-regional anesthesia was performed with articaine hydrochloride 4% with epinephrine 1:100,000. Post-surgical analgesic treatment was performed with 100 mg of ketoprofene 3 times a day if necessary.

The surgeries were performed by means of a full-thickness periosteal flap elevation approach (Figure 1d). The residual teeth, if present, were extracted. Bone grafting procedure, if needed, was carried out at the same stage (Figure 2h).

For each patient 4 implants were placed, the anterior implants in the area of the lateral incisors or canines (Figure 2g) while, the posterior implants, immediately in front of the maxillary si-

nuses, in an inclined position, in order to take advantage of the thickness of the available bone. In each case the implants were placed in a prosthetically guided manner via a surgical guide. In each site the mesial implants were placed with a traditional osteotomy, performed via bone burs, preparing an implant tunnel with a diameter 0,6mm smaller than the implant chosen while, the distal implant tunnels, were prepared, first via bone burs of small diameter (up to 2,3mm), in closed proximity to the cortical bone, delimiting the anterior portion of the sinus (Figure 2a-b) and subsequently followed by the use of TSEs (Figure 2c-d). In our clinical practice the TSBES (Bone Expanding Kit Advanced, FAL-LS-002, FMD, Italy) were motor driven by a 1:20 contra-angle, at low speed (25-50rpm) and controlled torque (40-50Ncm). The TSBES in question have marks positioned at 8, 10 and 12mm of depth for a precise identification of their progression into the bone.

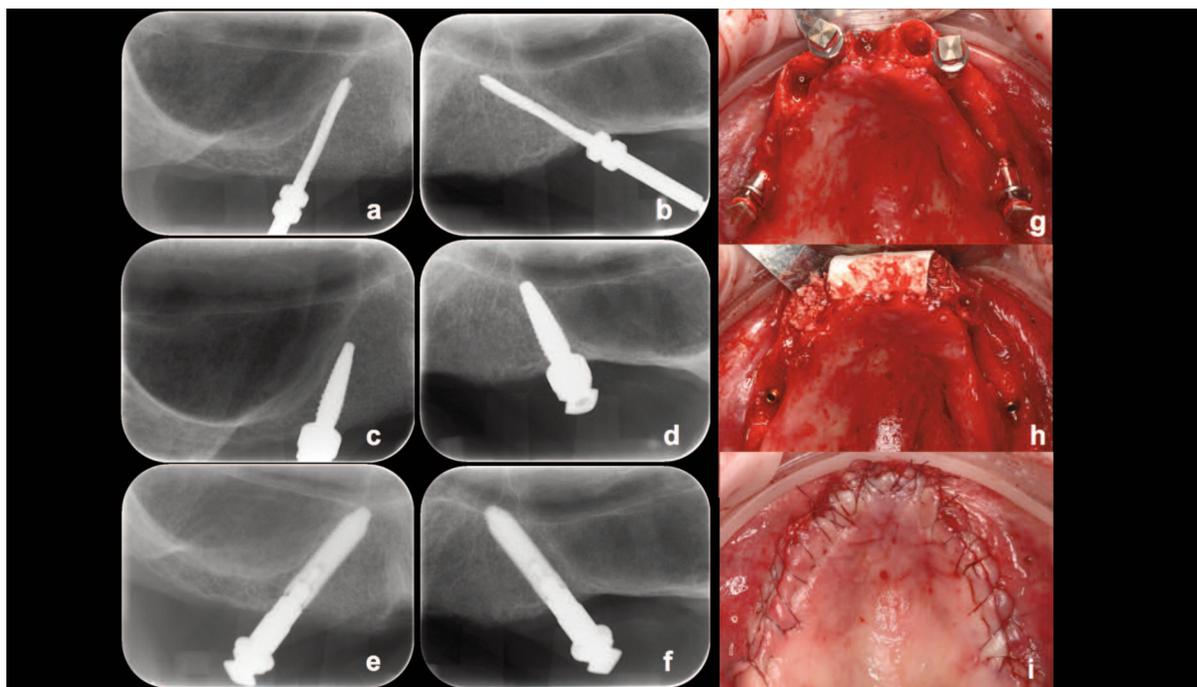


Figure 2
a, b) The bone burs are left *in situ* during radiographic evaluation of the future implant tunnel inclination; c, d) the inclination of TSBE is modified during screwing procedure in order to optimize the inclination of the implant tunnel both condensing the surrounding bone and modifying the profile of the anterior sinus wall, if necessary; e, f) the distal implants are placed; g) also the mesial implants are placed; h) the graft if needed is performed in the same stage; i) the flap is sutured.

The implant tunnel was gradually expanded by means of the TSBEs and, where needed, the operator tried to improve of the inclination of the tunnel, deforming the anterior wall of the sinus, in order to allow the use of an angled titanium abutment (at 17° or 30°) for screwable prosthesis (Figure 3a). To reduce the angulation of the implant tunnel a controlled force was applied on the head of the contra-angle handpiece, during the TSBEs screwing procedure (Figure 2c-d). This latter was performed starting from TSE n. 2. The diameter of the implant tunnel was progressively expanded until reaching a diameter from 0.8 to 1.2 mm smaller than the selected implant. Usually with TSBEs n. 3.5, n. 4 and n. 4.5, implants with diameters of 3.8mm, 4.2mm and 4.8mm were respectively positioned. Although the TSBEs have been designed to match ideally tapered implants (with similar conicity), in order to maximize the primary implant stability in the

apical portion of the implant tunnel, we preferred to place cylindrical implants through the compression of the low density bone (Figure 2e-f), determined by the discrepancy between the cylindrical shape of the implant and the conical shape of the implant tunnel. Implant lengths and diameters were selected according to the largest dimensions allowed by patient's anatomy, to reduce the risk of fracture both for the implant and the screw.

Between the first and second stages the patients wore temporary upper acrylic dentures.

After a healing period of 6 months, the second stage surgery was performed. The above provisional upper dentures were relined with a soft temporary material [Tempo, Lang, Ravelli, Settimo Milanese (MI), Italy] and kept in function for 3 months. After this span of time the final hybrid metal-acrylic prosthesis was seated within 5 weeks (Figure 3b-c-d).

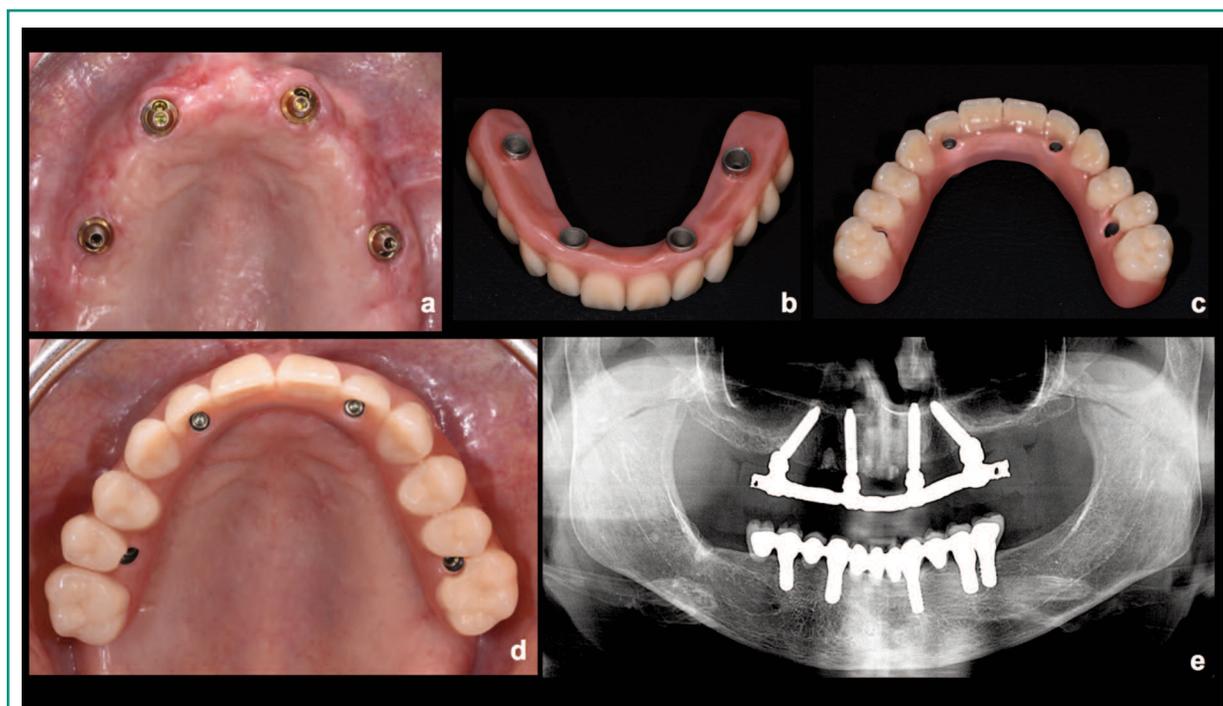


Figure 3
a) The abutments screwed on the implants; b, c) the hybrid metal-acrylic prosthesis; d) the prosthesis screwed on the abutments; e) radiographic condition at one year follow-up.

All patients were included in a strict hygiene recall and provided with oral hygiene domiciliary instructions.

The potential occurrence of complications was evaluated. The early post-operative complications were: bleeding; swelling; pain; hematoma; wound dehiscence. The late post-operative complications were: implant loss; peri-implant apical bone resorption. A year after prosthetic finalization, a clinical and radiographic follow-up of the cases was carried out in order to verify the condition of the soft and hard peri-implants tissues (Figure 3e).

Results

Between 2014 and 2015, 48 cylindrical two-piece implants (I-fix, FMD, Rome, Italy) were placed adopting the aforesaid procedure, 24 of which were placed in tilted position by means of

TSBEs, in order to by-pass the maxillary sinus. Regarding the diameter of TIs: 66.67% was 3.8mm; 29.17% was 4.2mm; 4.16% was 4.8mm. Regarding the length of TIs: 33.33% was 13mm, 33.33% was 14.5mm; 33.33% was 16mm.

On the TI sites, bone density was D4 (mean value 268.7 ± 62.7 HU). The bone density was finally confirmed by means of the intraoperative clinical assessment, performed during implant osteotomy preparation.

Using this procedure it was possible to avoid cantilever elements in 25% of cases while one element cantilevers were performed unilaterally in 41.67% cases and bilaterally in 33.33% of cases.

The occurrence of early post-operative complications was limited to swelling (33.33%), hematoma (25%) and pain (16.67%). Concerning the late post-operative complications none implants were lost during the healing period neither during the follow-up period, therefore the survival rate (SVR) was 100%. Peri-apical implant bone resorption was not observed at the

second stage surgery.

At the one-year follow up, after prosthetic finalization, the clinical appearance of the soft tissues was optimal and no pathological signs were recorded during probing exam. Radiographic examination did not show substantial changes in the peri-implant bone volume in accordance with success rate parameters (18).

Discussions

The maxillary sinus is the main anatomical limitation in the upper jaw. In the last decades the problem of iper-pneumatization of the sinus combined with the reduced thickness of the residual bone in the sub-antral area was solved using both lateral and crestal sinus lift procedures (1-18). Many bone augmentation procedures were proposed in the sub-antral space, and in case of two-stage surgery procedures we must take into account that the time required for the integration of the graft still remains quite long (6-9 months) depending on the nature of the graft (1-13). Another clinical limitation is the reduced bone density in the sub-antral area that entails a greater implant failure rate, now reduced thanks to the introduction of rough implant surfaces instead of the smooth one. In 2003 Malò proposed the use of tilted implant in full arch rehabilitations, in order to by-pass the principal anatomical limitations of the jaws (i.e. maxillary sinus and mental nerve), avoiding bone grafting procedures in their distal portions (26).

In the last decade, the use of TSBEs was introduced in bone splitting techniques of edentulous ridges with mainly horizontal atrophy, in order to obtain a more progressive, predictable and safe bone expansion, rather than osteotomic splitting techniques (27). The use of TSBEs was also proposed to increase the bone density of the implant tunnel walls in cases of bone type D4, as alternative to the ridge expansion osteotomy technique. These tools revolutionized the surgical approach to expansive techniques, eliminating the percussive trauma caused by the hammering of os-

teotomes, considerably reducing the discomfort for the patient and simplifying the instrumental access in the posterior region of the jaws. In addition, it is also known that several diseases like oral lichen planus, oral dysplastic lesions, and burning mouth syndrome may favour the failure of these surgical techniques (28-31).

According to our previous clinical experience, in case of low-density bone the use of TSBEs can be advantageously extended to TIs' tunnel preparation, to by-pass the maxillary sinus (32). The TSBEs are comparable to chisels able to expand the bone thanks to their profile design, comparable to two symmetric and opposite inclined planes. This entails that the axial force applied to the expander causes a vectorial decomposition of the force: one vector is orthogonal to the axial plane and the other one is tangent to the same plane (32). The outcome will be therefore an apical progression of the expander and at the same time the compression and expansion of the walls of the bone tunnel (32). The lateral force has also a second effect: the increase of bone density, compacting and deforming the anterior wall of the maxillary sinus (32). The thread of the expander is therefore an helical inclined plane which, for the reasons just described, determines its apical progression during the screwing into the bone. TSBEs are necessary driven by geared down contra-angle (1:20 or 1:32) even though they may be operated manually by manual key or ratchet. However the manual tightening does not allow a precise control of both the torque and the insertion axis, therefore we discourage its use for this technique. Our clinical experiences show that this is a simple and predictable technique, if the procedure described for motor-driven TSBEs is strictly respected (32).

This technique, named by the Authors Tilted Implant Expansion Osteotomy (TIEO), allows to optimize the inclination of the implant tunnel by-passing the maxillary sinus, simultaneously condensing the surrounding bone and thus increasing the primary implant stability (32). The TIEO is highly accepted by patients and it certainly is a practical alternative to both sinus lift procedures and bone expanding ridge osteotomy.

In our opinion, it offers the following advantages: short surgery time is required; cheaper than other techniques; relatively atraumatic procedure that advantageously replaces the conventional osteotomy preparation with burs and/or chisels; no chiselling and malleting are required, thus improving comfort and acceptance; faster healing compared to conventional staged sinus lift procedures (32).

In our experience, the early post-operative complications rate was limited to swelling (33.33%), hematoma (25%) and pain (16.67%), while the occurrence of late post-operative complications was absent. In a previous experience these latter were represented by periapical implant bone resorption (32). This event was probably due to the over-remodelling of the sinus wall consequent to the deformation produced by TSEs or otherwise consequent to incidental occurrence of perforation of the maxillary sinus floor combined with the tearing of sinus membrane. However this complication did not compromise the final clinical outcome allowing the prosthetic finalization of the case (32). Upper full arch rehabilitation is also affected by prosthetic (33-36) and endodontic clinical outcome (36-38).

Conclusions

TIEO is a promising surgical procedure for full arch rehabilitation of maxillary edentulous sites and represents a therapeutic alternative to sinus lift techniques. In such technique TSBEs can be advantageously used, in order to optimize the inclination of the implant tunnel, condensing the surrounding bone and thus increasing the primary implant stability.

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