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CASE REPORT

Fluid Dynamic Transcrestal Sinus Floor Elevation Using a New Surgical Instrument, Flusilift and Hyaluronic Acid as Only Biomaterial: A Case Report

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ABSTRACT

Despite validated surgical techniques and the development of biomaterials, the procedures aimed at increasing the maxillary bone volume by sinus floor elevation have complications with various degrees of relevance.

The perforation of the Schneiderian membrane is one of the most frequent events while performing the detachment of the membrane and it can increase the risk of iatrogenic sinusitis, impairment of functional homeostasis, dispersion of the graft material in the antral cavity as well as its bacterial colonization with a subsequential failure of the procedure.

This report presents a case where transcrestal sinus lift was performed using Flusilift (Sweden & Martina, Due Carrare PD), a new instrument that allows fluid dynamic elevation of the sinus floor using saline solution to detach the Schneider's membrane in an atraumatic way without using a sinus elevator and obtain an adequate alveolar ridge regeneration using hyaluronic acid in gel formulation to support an implant placement.

Hyaluronic acid seems to play a key role in wound healing and contributes to a faster bone neoformation in bone regeneration procedures.

INTRODUCTION

The Sinus Floor Elevation technique, first described by Boyne and James in 1980 [1], aims to obtain an adequate bone regeneration in order to perform implant surgery and place implants within maxillary sinus in atrophic maxillary alveolar ridge.

The procedure is performed by osteotomy of the lateral wall of the maxillary sinus, followed by Schneiderian membrane elevation and placement of autogenous particulate bone graft between the membrane and the alveolar ridge. Bone augmentation is generally provided by grafting the sinus cavity with autogenous bone, bone substitutes, or a combination of these biomaterials [2].

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Transcrestal Sinus Floor Elevation (tSFE) was first described by Tatum [3] and subsequently modified by Summers [4,5].

In 1994, Summers introduced the osteotome technique, a minimally invasive modification to sinus lift that can be used to place implants in the same sinus surgery or to prepare a future implant placement site.

Osteotome-root analog instruments are used to prepare the crestal osteotomy site. The osteotome is inserted through the edentulous alveolar crest at the lower border of the maxillary sinus floor and produces a fracture at the cortical bone of the sinus floor, leaving the Schneiderian membrane intact. Then, the condensing of the bone graft material applies lateral and apical pressure, resulting in separation of the Schneiderian membrane from the floor of the sinus, creating new space for the graft between the membrane and the sinus floor and allowing the placement of an implant of adequate length.

The crestal approach is highly effective, with an eccellent implant and prosthetic survival rate, low intraoperatory complications and low morbidity compared to the lateral approach. However, tSFE proved to be safe only when an elevation threshold of 5 mm without bone graft and implant placement was estimated [6-8].

A further development of the technique proposed the preparation of the implant site through drills with depth stops which avoid sinus floor perforation during the penetration phase and allows a subsequently biomaterial graft placement in the site.

In 2002, Fugazzotto [9] suggested that the pristine bone at sites of implant placement could be drilled up to the sinus floor with a trephine bur and used to fracture the sinus floor by hydraulic pressure through osteotomes. Since then, many surgical techniques with specially designed instruments for the transcrestal approach have been reported in the literature.

In literature there are surgical techniques which suggest the elevation of the Schneiderian's membrane by using hydraulic pressure, following the Pascal principle [10].

The introduction of a pressured fluid tends to detach the membrane in a controlled and homogeneous way, avoiding perforations even in alveolar ridge with reduced height. The procedure is followed by the insertion of a bone substitute biomaterial graft within the sinus and by the placement of an implant in the same appointment.

Autogenous bone grafts are considered the gold standard in bone regeneration techniques. Boyne, James and Tatum first reported the use of autogenous grafts in sinus floor elevation. To reduce the volume of autogenous bone to harvest and the morbidity of the donor area, bone substitutes are used in sinus augmentation procedures. Many biomaterials have been developed and suggested as a valid option to the autogenous bone, such as xenogenic and allogenic grafting materials, other natural and synthetic biomaterials. Autogenic, allogenic, xenogenic, and synthetic biomaterials are currently on-the-board options for a dental bone grafting process. Absence of immunological responses and a high-volume augmented bone should be listed as the main advantages of autogenic grafts, on the other side they showed a higher infection rate. Other natural biomaterials such as xenogenic grafts can also be employed due to their feeble induction of inflammatory reactions and high durability. Synthetic biomaterials such as bioactive glasses are also another promising way to perform bone augmentation considering their notable neosynthesized bone and low amount of residual graft.

Over the years, allografts, alloplasts, and xenografts of various types have been used alone, or in combination with autografts. These grafting materials were reported as osteogenetic, osteoconductive or osteoinductive [11,12].

However, these biomaterials are not exempt from complications linked to their placement or their nature.

For example, during bone like biomaterial graft packing, in cases where a perforation with rents or tears > 10 mm has been produced, there is a risk of partial or complete loss of the graft material into sinus cavity, that can lead to ostium obliteration, postoperative sinusitis or sinus infection.

Another complication concerns the surgical site infection, which can spread to the graft. Scarano, et al. [13] examined bacterial proliferation into the grafted biomaterial in sinus cavities. The sample was sent for a histopathologic examination that detect the spread of infection from an implant surface to the entirety of the graft in the maxillary antrum. Complete removal of all infected bone graft material is the treatment to choose in such cases.

Unlike particulate biomaterials, hyaluronic acid in gel formulation can avoid these complications due to the severely reduced risks of perforation during the membrane elevation procedure and, moreover, due to its fluidity and solubility that makes ostium obliteration very unlikely in case of gel graft displacement [14-17].

MATERIALS AND METHODS

Kit mise

The M.I.S.E. EVO Kit (Sweden & Martina, Due Carrare PD) is a system that allows the maxillary sinus to be atraumatically and gradually augmented to a height of 5-10 mm above its initial level. The bending of the cortical bone and the overcoming of the phase of elastic deformation until the bone breaks to allow the insertion of a reconstruction biomaterial and an implant are guaranteed by gradual and

atraumatic series of steps of 1 mm each, using depth stops. The significant advantage of this system with respect to conventional osteotomy techniques is the use of drills that, when used with depth stops, make it possible to gradually and predictably raise the Schneiderian membrane in steps of 1 mm at a time, conserving its integrity. This technique also avoids the need to open a lateral window [18-24].

Flusilift

Flusilift is a device that allows a fluid dynamic transcrestal sinus lift elevation, using a constant pressure created by Flusilift handpiece by the extrusion of a low viscosity fluid (reticulated hyaluronic acid) that gently detach the way from the membrane and, at the same time, fill the newly formed space between the alveolar ridge and the membrane.

The kit is composed by a handpiece, a ferrule and three tips of different diameters.

Following the Pascal Law, the extruded fluid applies a homogeneous pressure on the Schneiderian's membrane which permits a gentle elevation in every clinical situation without perforation risks linked to sinus elevators.

The instrument has the shape of an osteotome with a rounded tip, hollow inside on which a syringe is inserted through a plastic junction. Once injected, the biomaterial gel or the saline solution flows within the Flusilift and extrudes from two holes placed 1 mm below the rounded tip, on the lateral side and opposite to each other. In this way, the injected biomaterial uplifts the membrane and remains within the sinus, promoting bone neoformation.

Hyaluronic acid

To our knowledge, there are not any articles that evaluate the effectiveness of hyaluronic acid as a surrogate for bone derived biomaterials on humans, but there are many papers that assess the association between hyaluronic acid and biomaterials. These studies highlight how hyaluronic acid could boost bone regeneration through a faster mesenchymal cells' differentiation along with a facilitated mineralization of the cellular matrix.

This paper shows how a minimally invasive approach, in association with an osteoinductive biomaterial, could minimize the patient morbidity, risks, intra or postoperative complications and costs while speeding up the surgical timing.

CASE PRESENTATION

Chief complaint

A 37-year-old female, non-smoker, who was medically fit and had no bruxism, consulted our practice with a complaint of a missing upper molar (Figure 1). The tooth was extracted several years earlier due to a periodontal problem.

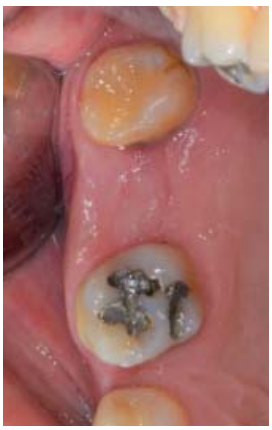

Figure 1 Preoperative view.

History of present illness

Missing upper molar with adequate dimensions and keratinized gingiva in #17 area were found for further prosthetic restoration.

History of past illness

She had no significant medical history.

Imaging examinations

Cone-Beam Computed Tomography (CBCT) showed a severe vertical bone loss with a mean Residual Bone Height (RBH) of 3 mm and a thickness of the Schneider's membrane of about 6 mm (Figures 2,3).

FINAL DIAGNOSIS

The final diagnosis was severe vertical bone loss with a RBH lower than 4 mm.

TREATMENT

Before the surgery, the patient signed an informed consent form. The developed treatment plan, based on the patient's condition, was discussed with the patient. The procedure began by patient rinsing her mouth with 0.12% chlorhexidine mouthwash for 1 minute. Articaine 4% with adrenaline 1:100000 (PIERREL) was administered as local anesthesia. Antibiotic therapy with Amoxicillin 1 g every 12 hours for 6 days, rinses with chlorhexidine 0.12% for 10 days starting the day prior the surgery and dexibuprofen (Seractil 400 mg) after the surgery and every 12 hours if needed.

A palatal incision with intrasulcular extension on adjacent teeth was chosen as the best design to enhance visibility and to avoid overlap between the suture and the implant site and possible exposures of the surgical site (Figure 4). After the full thickness flap elevation, the implant site was prepared with MISE kit (Sweden & Martina, Due Carrare PD) following the producer indications.

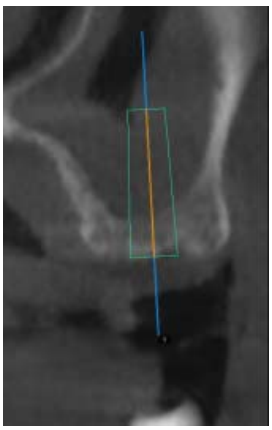

Figure 2 Cross sectional CBCT view.

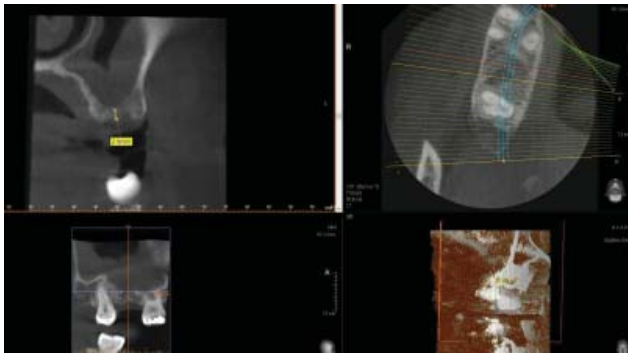

Figure 3 CBCT views.

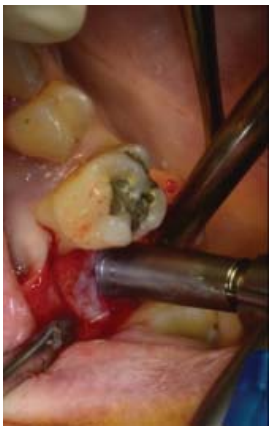

Figure 4 Handpiece with stop.

The initial drill was used with ø 2 mm stop at a speed of 800 rpm to ream the guide hole for the following drills. An adequate depth stop (2 mm) was chosen to ensure that the preliminary preparation reached 1 mm from the maxillary sinus floor (Figure 5). Then the intermediate drill with ø 2.50 mm at 800 rpm with the same depth stops was used to enlarge the site preparation. The stop guaranteed that the residual bone thickness of 1 mm beneath the sinus floor remained unaltered. Then the implant socket, prepared with the cylindrical drills, was measured using the depth gauge of the MISE kit.

Then we used the Chamfered drill with ø 3.0 mm (C3.0), fitting it with the depth stop (2 mm) corresponding to the depth measured with the depth gauge, which would bring the working length to 1 mm from the cortical floor. We used the handpiece at a speed of 800 rpm, ensuring adequate external irrigation. Then we moved on to the second depth stop (3 mm), which would increase working height by 1 mm with respect to the first stop.

Proceeding with this sequence, we were able to feel the cortical floor with the third depth stop (4 mm). Then, we fitted the fourth stop (5 mm). During these final steps, a substantial bending of the cortical bone was generated without breakage, lifting the maxillary sinus floor by about 2 mm.

Given the particular shape of the tip, the Chamfered drill is able to not only to deform the cortical bone of the sinus floor, but also to break it if it is particularly thin. At the moment of the breakage of the cortical bone, the stop guarantees extremely limited penetration beyond the sinus floor, of about 0.5 mm on average. This avoids significant damage to the Schneiderian membrane. In this case the breakage occurred with the fifth stop (6 mm) onto the chamfered drill.

After breaking through the cortical bone, we proceeded with the boring of the fractured cortical bone at low speed (100 rpm), using the Rounded drill with ø 3.0 mm (R3.0) and fitting the same stop used in the phase of breakage (6 mm) first, and then the 7 mm stop (Figure 6).

Then, inserting Flusilift for 8 mm (2 mm over the length at which we broke of the sinus floor), we injected 0.5 cc of saline solution beneath the sinus to evaluate, through the aspect of the suctioned saline, the integrity of the sinus membrane. Then 2.4 cc of cross linked high molecular weight Hyaluronic Acid (xHya) (Hyadent, Regedent, Zurich)

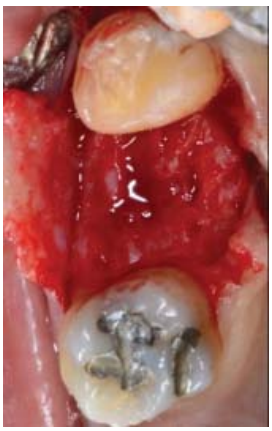

Figure 5 Occlusal view of the preparation.

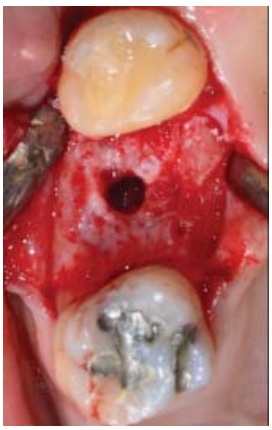

Figure 6 Occlulsal view, note the membrane.

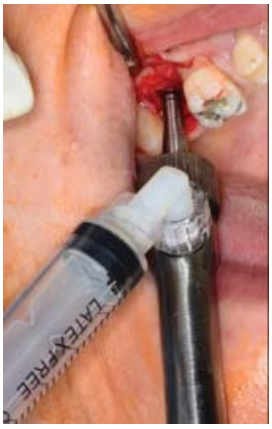

Figure 7 Flusilift in action.

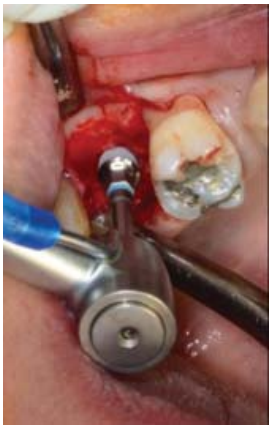

Figure 8 Impant insertion.

was injected (Figure 7). Contextually, a 3.8 x 13 mm Sweden & Martina CSR-DAT implant with a Zir-Ti surface was inserted with an implant handpiece (Figures 8,9) and the final torque was recorded with a dynamometric key (30 Ncm), an ISQ of 72 was detected, a cover screw was positioned and then the wound was sutured with a 4/0 monofilament polyamide suture (Figure 10).

Intraoral periapical x-rays were performed to evaluate the sinus elevation and filling at 7, 8 and 12 months as a radiographic follow-up (Figure 11).

After 7 months a CBCT was performed, the implant was uncovered, and the rehabilitation was finalized with a monolithic zirconium screwed crown (Figures 12,13).

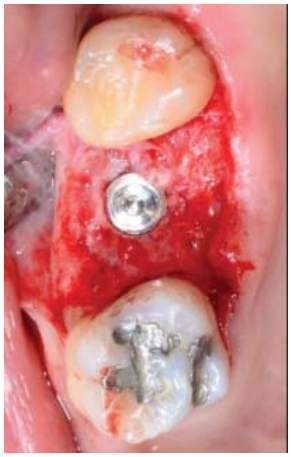

Figure 9 Occlusal view of the implant.

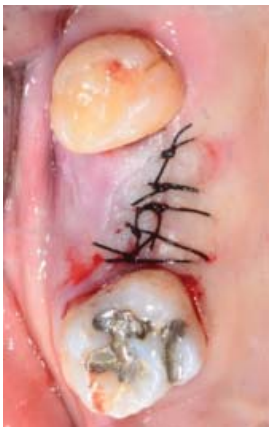

Figure 10 Suture.

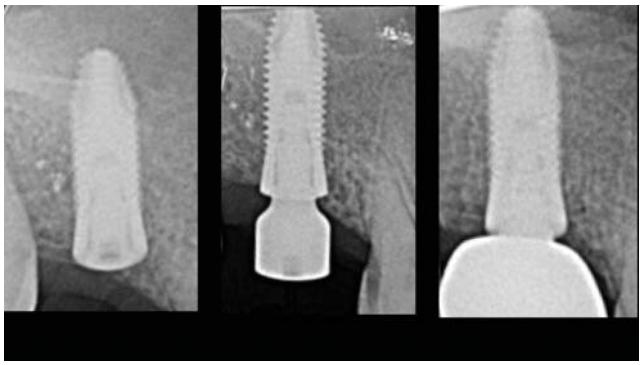

Figure 11 Periapicall x-rays postoperative (left), healing abutment (middle), follow up (right).

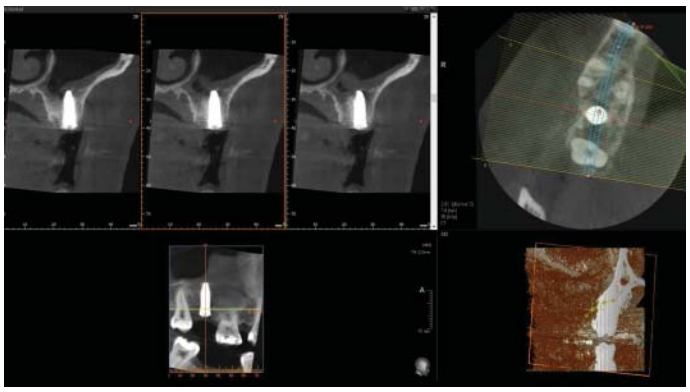

Figure 12 CBCT after healing.

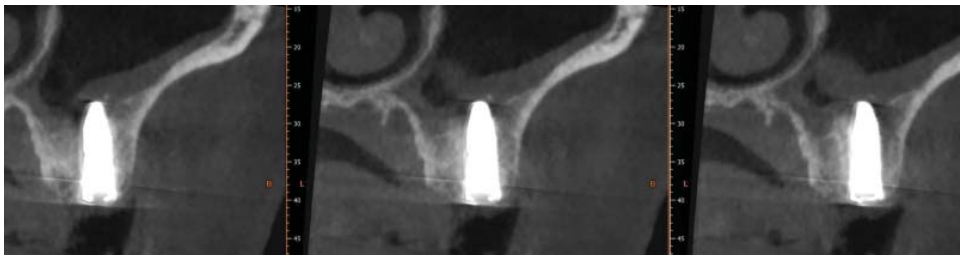

Figure 13 CBCT cross sections.

RESULTS

The follow up showed radiopacity at 0 and -1 mm from the fixture apex, so we obtained an Endo Sinus Bone Gain of 9/10 mm in comparison to the pre-operative situation. Moreover, it was possible to detect bone neoformation all around the implant and even above it. Thus, considering the fact that no other graft biomaterials apart from hyaluronic acid were used during the surgery and knowing that hyaluronic acid has a high resorbable rate and is radiolucent, we can hypothesize that the radiopaque area surrounding the implant is newly formed bone all around. The patient did not complain of pain or show signs of edema, bruising or bleeding.

DISCUSSION

The crestal and fluid dynamic approach, together with the use of Hyaluronic acid as biomaterial, could be a valid alternative to the lateral approach to obtain great new bone volumes in the maxillary sinus, in patients with low residual bone height (<4 mm). The great endo-sinus bone gain is probably correlated to the high implant length protrusion (10 mm), as already demonstrated in literature [20]. The high thickness of the Schneider's membrane did not influence the bone regeneration that occurred up to the apex of the implant. The absence of pain, edema, bruising or bleeding could be correlated to the mini-invasive nature of the surgery.

CONCLUSION

The future goal of oral surgery is to obtain the same quality and amount of bone regeneration with less invasive techniques and, therefore, fewer complications.

The fluid dynamic technique described in this case report, in association with the use of hyaluronic acid as biomaterial, aims to shorten the surgical times and to obtain great bone volume regeneration with a better bone quality compared to the bone quality obtained with granules biomaterials. Furthermore, this technique can be less invasive, with fewer intra and postoperative risks. Further studies are required to fully evaluate the features of the procedure in a variety of clinical situations.

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