Surgical elevation of maxillary sinus mucosa: Is it necessary to use biomaterials?

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SINUS FLOOR ELEVATION SURGERY

The bone resorption that occurs after extraction of maxillary posterior teeth may result in severe vertical and/or horizontal bone loss, compromising the planning of rehab with implants in that region. Numerous grafting techniques have been described and used aiming to restore adequate bone volume for posterior implants installation. The most used technique to restore the anatomy of this region is the procedure of maxillary sinus floor augmentation. The maxillary sinus elevation surgery was initially described by Tatum,[1] in 1986, being also reported by Boyne and James,[2] and Wood and Moore.[3] In this procedure the access to maxillary sinus is obtained through making a bone window on the lateral sinus wall, using a spherical diamond drill number 6-8, maintaining the sinus membrane integrity. The sinus membrane is then carefully lifted with the aid of specific curettes. This mobilization is performed with the bone window adhered to the membrane and displaced to the maxillary sinus roof. Created the desired space, the material chosen for grafting is then inserted.[4] In 1994, Summer[5] described an alternative surgical technique to increase the bone volume in the posterior maxilla on which the access to the maxillary sinus floor was performed through the alveolar bone crest using osteotomies of varied diameters aiming to surgically make an alveolus. The sinus mucosa was lifted and a grafting material was inserted, preceding the concomitant installation of a titanium implant. The referred technique has as main recommendation the necessity of gain of height on the maxillary sinus floor of at most 2 to 3mm. It is considered a less invasive alternative, especially for regions that did not need great sinus mucosa lifting.

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BIOMATERIALS USED

Numerous grafting materials for filling the space created after sinus mucosa lifting have been described in literature. Among them, it can be mentioned the autogenous bone,[6] allogeneic bone,[7] deproteinized bovine bone,[8] tricalcium phosphate/hydroxyapatite,[9] tricalcium phosphate ceramic,[10] Bioglass,[11] platelet rich plasma,[12] BMP-2,[13] a concentrate of autogenous bone marrow cells,[14] resorbable gelatin sponge[15] and nanocrystalline hydroxyapatite.[16] The results of the studies that used different grafting materials in this technique are similar regarding bone formation and implants survival on medium and long term. The success percentage of implants installed in grafted areas are close to the obtained with the use of autogenous bone.[17]

OSTEOGENIC POTENTIAL OF MAXILLARY SINUS MUCOSA

The similar results obtained with the use of different materials prove the predictability and success of the technique, regardless the biomaterial chosen for grafting. Such findings suggest the important role of sinus membrane on bone formation. Some studies have proved, through *in vitro* and *in vivo* models, the potential for bone formation of cells that compose the Schneider's membrane. Gruber et al[18] evaluated such properties in experimental study that gathered sinus membrane samples from adult swines. Initially, the cells were cultured and the STRO-1 expression (important enzyme expressed by osteoblastic lineage cells and adult osteoblast) was identified. Besides, cells were incubated in environment with BMP-6 and BMP-7, aiming to determine the osteoinduction potential previously proved, through alkaline phosphatase activity, osteocalcin and mineralization of extracellular matrix. After analysis of results, it was concluded that the maxillary sinus mucosa has mesenchymal progenitor cells and/or of osteogenic lineage. These findings could also be evidenced by Srouji et al[19] which in study about culture of human cells from Schneider's membrane, found its osteogenic potential which, according to the authors, contributes positively to the success on the application of maxillary sinus floor augmentation techniques. On the following year, the same group of authors evaluated the osteogenic potential of sinus membrane in experimental *in vivo* model of tissue ectopic transplantation. The samples of cells were obtained in orthognatic surgery procedures in five patients. After collection, the membrane cells were extracted, isolated and cultured in osteogenic environment which reveled presence of osteoblasts by the high alkaline phosphatase activity. Another fraction of the sample was subcutaneously implanted in immunodeficient rats for 8 weeks. Formation of new bone could be observed on sites, proving the congenital osteogenic potential of the Schneider's membrane. It is also emphasized its important role on bone repair after procedures of maxillary sinus floor augmentation.[20]

SINUS MEMBRANE LIFTING TECHNIQUE WITHOUT THE USE OF BIOMATERIAL

Lundgren et al[21] were the pioneers on the description of sinus membrane lifting technique without the use of material. In this work the authors reported a case of previous procedure of enucleation of cystic lesion in the maxillary sinus of patient referred to maxillary sinus floor augmentation. The lesion was removed and the rupture on sinus mucosa was sutured with simple stitches in resorbable wire; and the removed bone window was replaced. After three months of repair, the space between the replaced bone window and the sutured sinus mucosa was totally filled with formation of new bone. The surgical technique was, therefore, repeated in a second patient, with similar findings. After the first report, other works in animals and patients from this same group have already been published.

Steps used on technique performance:[4]

1) Making of bone window by oblique osteotomy with micro reciprocating saw.
2) Careful dissection of osteotomized bone window and sinus mucosa.
3) Storage of bone window in sterile saline solution.
4) Careful detachment of sinus mucosa.
5) Milling and installation of bone integrable implants.
6) When the immediate installation of implants is not possible because of the remnant alveolar bone crest size, the membrane is kept suspended by suture or a space maintenance device.
7) Repositioning of bone window and adhesive fixation with n-Butyl cyanoacrylate.
8) Suture.

On the technique indication, it is important an alveolar bone remnant of at least 3 to 4 mm, for posterior milling and good locking of implants.

SPACE MAINTENANCE DEVICE

Aiming to apply the principle of space maintenance after sinus mucosa elevation, some studies have tested the use of devices to perform such role (Fig 1), especially in cases in which the installation of implants cannot be performed right after the lifting procedure. Up until now, it has not yet been developed an ideal space maintenance device. Cricchio et al[22] in study in primates evaluated the hypothesis described using a synthetic resorbable appliance (polyglactin 910) of 6 x 6mm. Eight animals were submitted to bilateral maxillary sinus elevation surgery. On one side, the resorbable appliance was installed with bone integrable implants. On the opposite side it was performed only the installation of the appliance, without implants. After six months, four animals were sacrificed while the others were submitted to installation of implants on the sinuses that received only the devices. It was concluded that the use of devices on the present experimental model was not successful, results assigned to lack of stability on the implanted site. Later, in 2011, the same group of authors tested synthetic resorbable appliances with new conformation, in similar experimental model. In this study, both maxillary sinuses were lifted and a device was inserted in each side, however without insertion of bone integrable implants. Six months later, the primates were sacrificed and it was found that most of the devices were displaced, which damaged the bone formation process, once the sinus membrane was not kept in position after lifted up.[23] Schweikert et al[24] evaluated the effect of titanium mini plate fixed with screw on the upper margin of the open bone window, keeping the osteotomized bone fragment of the window positioned to the interior of the maxillary sinus of primates. On the same surgical act, bone integrable implants were installed and after 3 and 6 months the animals were sacrificed. It was concluded that despite the new formed bone have been visualized under the device, volume reduction on formed bone tissue was observed in both experimental periods. It is also emphasized the need of new studies for development of a device with adequate characteristics (Fig 1).

RESULTS OF EXPERIMENTAL AND CLINICAL STUDIES

Experimental and clinical studies have been published in literature with the application of this technique. Palma et al[25] performed an experimental study comparing the histological results of sinus membrane lifting with simultaneous installation of implants with and without the use of autogenous graft in primates. The procedures of maxillary sinus lifting were bilaterally performed where one side was treated with mucosa lifting + implants + autogenous bone graft; and the other side only mucosa lifting and concomitant installation of implants. After data analysis, it can be concluded that the amounts of obtained increase on bone tissue with or without autogenous bone were similar after

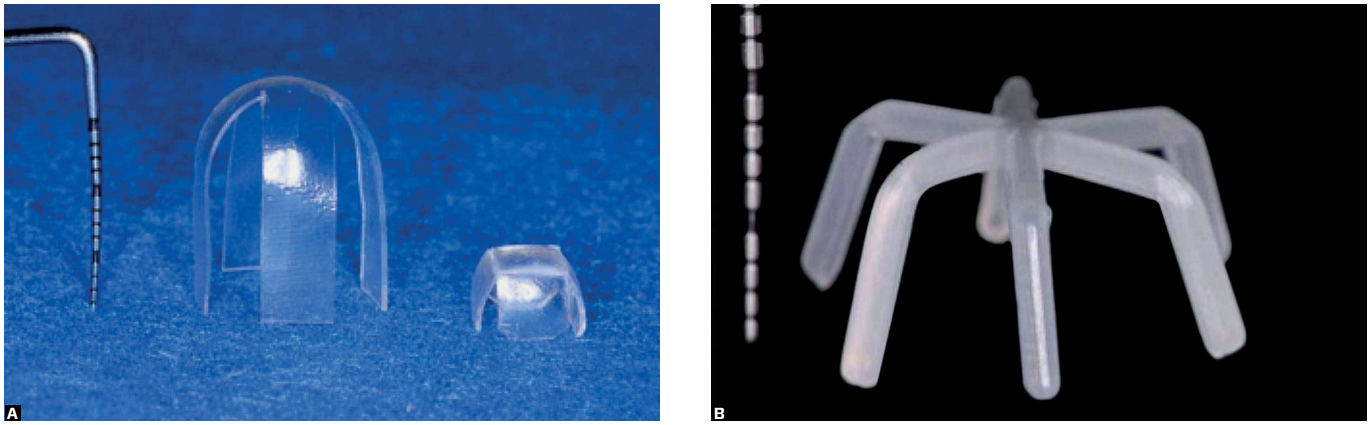

Figure 1 - Synthetic resorbable appliances (polyglactin 910) for space maintenance after maxillary sinus mucosa elevation without implant: **A**) non-permeable appliance; **B**) appliance that favors the contact between coagulum and sinus membrane.

6 months. Lundgren et al[4] presented preliminary results of the technique performance in 10 patients. A total of 19 implants were installed and the formation of new bone was observed in all patients, being stable after 12 months of prosthetic load. These results were also found in the study by Hatano et al[26] and Thor et al.[27] In both clinical studies, the formation of new bone was radiographically proved, with all installed implants successful. Recently Borges et al[28] applied the technique in 15 patients in need of bilateral maxillary sinus floor lifting procedure. In a prospective, controlled, randomized and split-mouth study, it was compared a side treated with sinus mucosa lifting, autogenous bone and bone integrable implants, to another with only implants and mucosa lifting, without grafting (Fig 2, 3, 4). It was concluded that both techniques presented similar occurrence of complications. The formation of new bone was observed in the same way on the two types of treatment.

CONCLUSIONS

1) Evidences of experimental and clinical studies prove efficient bone formation in maxillary sinus lifting procedures without the use of grafting materials.
2) The most efficient application of this technique is when the alveolar crest remnant bone has minimum size for installation of implants concomitantly to membrane lifting.
3) It is necessary more studies with large case series and evaluation of success and survival rates of implants installed on long term, also new experimental models of development of space maintenance devices.
4) In 2012, nearly 355 patients were operated by maxillary sinus floor lifting technique without the use of biomaterial (200 patients in Italy, 120 in Sweden and 35 in Brazil).

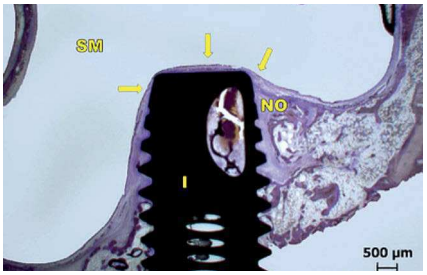

Figure 2 - Histological section of implant (I) installed on maxillary sinus floor (SM) of primate, on a period of 10 days. View of maxillary sinus and implant supporting sinus membrane (arrows). New bone formation process (NO) from Schneider's membrane. Staining: toluidine blue/pyronin Y. Magnification: 2,5x.

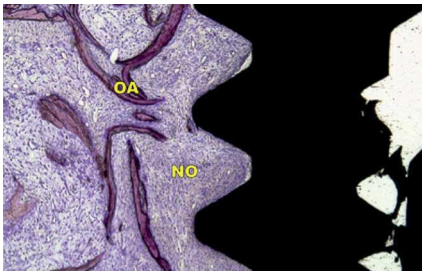

Figure 3 - Histological section of implant installed on maxillary sinus floor of primate on a period of 10 days. In this case, the maxillary sinus was grafted with autogenous bone (OA). It is noticed the formation of new bone (NO) around the implant. Staining: toluidine blue/ pyronin y. Magnification: 6x.

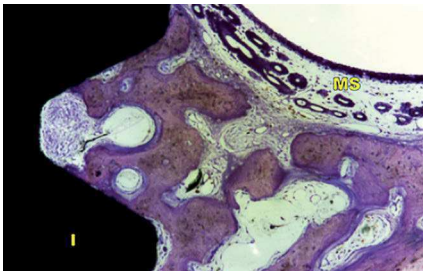

Figure 4 - Histological section of implant installed on maxillary sinus floor of primate on a period of 45 days. It is noticed that the bone formation process begins from the membrane (MS) towards the implant (I). Staining: toluidine blue/pyronin y. Magnification: 10x.

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