INTRODUÇÃO

The maxillary sinuses impose an important influence on partially or fully edentulous maxillary rehabilitations with dental implants. In a rehabilitation process with implants the space to place a dental prosthesis over an implant may be jeopardized by the remaining space between the dental arches. Because of this small space, an alveolar crest onlay bone graft is unlikely to be made. However if a bone graft is placed between the sinus membrane and the sinus floor, it is possible to improve the osseous thickness of the alveolar crest without compromising the space to place a prosthetic tooth (Sendyk & Sendyk, 2002).

The presence of a bone crest with a reduced bone height demands an intervention on the maxillary sinus with the purpose to increase the bone amount available to implant insertion (Gulherme et al, 2009). The surgical procedure can be executed in one or two surgical stages when related to the implant insertion. Since the first publication about this kind of surgery by Boyne & James (1980) various materials and techniques has been used for sinus lift procedures (Wallace, 2006; Van der Bergh et al, 2000).

There are some techniques to access the maxillary sinus, the lateral window technique, the osteotome technique, and the placement of dental implants in one or two surgical stages. The objective of this study was to review the literature about the sinus augmentation techniques, lateral window or osteotomes, and the placement of dental implants in one or two surgical stages. There were obtained clinical studies and literature review studies by internet search, MEDLINE and text books. These studies were analyzed and placed in an analytical review. Aspects relative to anatomy, access the maxillary sinus, placement of the implants in one or two surgical stages, implant survival in grafted sinus, residual bone amount, graft materials and surgical complications were analyzed.

UNITERMOS: bone transplantation; bone substitutes; dental implantation, endosseous; maxillary sinus; osseous substitutes.

RESUMO

The sinus floor elevation technique has been used in an important way on partially or fully edentulous maxillas. This procedure permits the placement of dental implants whereas the residual bone height is insufficient. The presence of a reabsorbed bone crest with the impossibility of a dental implant placement requires an intervention on the maxillary sinus, with the proposal to increase the bone quantity for the implant placement. It is possible to do these procedures in one or two surgical stages according to the technique and implant placement. The objective of this study was to review the literature about the sinus augmentation techniques, lateral window or osteotomes, and the placement of dental implants in one or two surgical stages. There were obtained clinical studies and literature review studies by internet search, MEDLINE and text books. These studies were analyzed and placed in an analytical review. Aspects relative to anatomy, access the maxillary sinus, placement of the implants in one or two surgical stages, implant survival in grafted sinus, residual bone amount, graft materials and surgical complications were analyzed.

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Different materials are described on the literature to improve the bone volume on this region. Autogenous bone, bovine bone, human tissue bank bone, synthetics bone substitutes as calcium sulfate, bioactive glass, hydroxyapatite and an association of these materials are used for (De Leonardis & Pecora, 2000; Cordioli et al, 2001; Xu et al, 2003; Chen & Cha, 2005; Wallace et al, 2005; Chiapasco et al, 2006; Marin et al, 2007).

The objective of this study was to review the literature about the sinus augmentation techniques, lateral window or osteotomes, and the placement of dental implants in one or two surgical stages. There were obtained clinical studies and literature review studies by internet search, MEDLINE and text books. These studies were analyzed and placed in an analytical review. Aspects relative to anatomy, access the maxillary sinus, placement of the implants in one or two surgical stages, implant survival in grafted sinus, residual bone amount, graft materials and surgical complications were analyzed.

LITERATURE REVIEW

Anatomy

The maxillary sinuses are pneumatic compartments of the paranasal sinuses group, which includes the etmoidal, frontal and esphenoidal sinuses. Some plausible functions might be warm and humidify air, reduction of the skull weight, act like a resonance space and retain mucus (Figún & Garrino, 1994).

The maxillary sinus in the adult can be compared to a quadrangular triangle with its base at the lateral nasal wall and its apex extending to the zygomatic process. The volume of the maxillary sinus range from 2 and 25 cm$^3$ with a mean size range from 8 to 12 cm$^3$ (Figún & Garrino, 1994).

Between the structures presented in the maxillary sinuses, the sinus septa and the Schneiderian membrane (sinus membrane) play an important role when surgically managing the sinus. These membrane, which is consisted by a ciliated pseudo stratified epithelium, is delicate and needs a carefully manipulation to avoid ruptures. The osseous septas influences the management of this membrane, because it is going to make harder the membrane freeing. This happens because the septa acts like a physical barrier to the curettes (Kim et al, 2006). In one study it was find an average of 26,5% septas in 200 studied maxillary sinuses. These septas were distributed in the anterior, medium and posterior regions being 25,4%, 50,8% and 23,7% respectively. The same authors identified a variation between 0 and 20,18 mm in the sizes of the septas studied (Kim et al, 2006).

Regarding the maxillary sinus anatomy there is an important phenomena that occurs after dental losses. The pneumatization is the process that explains most variable sizes of the sinus. Bone density and thickness can be explain, in part, by the chewing forces applied. The pneumatization process is likely an architectural response to the muscles and chewing forces, in agreement to the “Wolff’s Law” (“law of use and unused”) (Magini & Coura, 2006).

Disease and abnormalities of the maxillary sinuses

Beaumont et al. (2005) determined the prevalence of disease related to maxillary sinuses in patients scheduled to sinus lift procedures. This study showed that 40% of all individuals had some disease and/or abnormality in yours sinuses. The methods to identify these problems were tomographies and endoscopies. A great diversity of disease was founded. The most common conditions were chronic sinusitis and sinus cysts, presented as 77% and 72% of the patients respectively. It was concluded that after solve those conditions, a sinus floor elevation is predictable. These findings point the importance of a detailed medical history and a clinical and radiographical evaluation. The thickness of the sinus membrane is not affected by the sinus augmentation procedure and this surgery does not lead to a chronic or acute sinusitis (Peleg et al, 1999).

Techniques to access the maxillary sinus

The lateral window technique (figs. 1 and 2) begins with a mucoperiosteal flap to access the lateral wall of the sinus. A lateral window is performed with diamond burs (with
surgical drill or high speed hand piece) or piezoelectric burs. The residual bone of the lateral window can be elevated towards the sinus or completely removed. The sinus membrane is elevated superiorly to the medial sinus wall. Therefore the membrane became the superior and distal wall of the compartment that will receive the osseous graft. After positioning the graft, the lateral window is covered with a biological membrane and the flap is sutured in position (Wallace, 2006). The literature review developed by Fugazzotto (2003) shows that the lateral window technique is highly predictable.

Summers proposed a simpler and less invasive way to increase the bone quantity at the sinus floor where, with the use osteotomes (figs. 3 and 4), the inferior wall is elevated into the maxillary sinus and an osseous graft it is or it is not placed inside the space created (Fugazzotto, 2003). Two studies, a retrospective and a prospective respectively, report that the osteotome technique for sinus augmentation is predictable, less invasive and without statistically significant differences in relation to the lateral window technique (Wallace, 2006; Ozyuvaci et al, 2003). In a systematic review and meta-analysys the authors concluded that implants placed in a previously elevated maxillary sinus with osteotomes had similar success rates to implants inserted conventionally in a period of 3 years (Emmerich et al, 2005).

Sendyk & Sendyk (2002) indicates that the osteotome technique has to be use when the sinus elevation does not exceed 5 mm. When this amount is not sufficient, the lateral window technique should be the professional selection.

**Graft materials**

The graft materials are fundamental important for the prognosis since different materials have different grades of osteogenesis. For this reason most surgeons prefer to use autogenous grafts as theirs fist choice for osseous grafting or a mixture of autogenous and biomaterial bone grafts for sinus surgeries (Sendyk et al, 2004).

The osteoconductive capability of different particle sizes from deproteinized bone was analyzed in an animal model with rabbits. It was concluded that small particles with size varying between 300 and 500 μm showed a better osteocondution than bigger particles with sizes ranging between 850 and 1000 μm (Xu et al, 2003). The evaluation with computed tomography scanning performed by Murakami et al. (1999) showed that implants placed in maxillary sinus augmented with autogenous bone remained stable after 12 months.

In an 8 years retrospective study, a combination of osseous grafts were studied, which includes a demineralized freeze-dried bone matrix, a small-particle spherically shaped peptide-coated product (Pep-Gen P-15, Dentsply Friadent Ceramed) and bovine-derided mineralized bone materials. The success rate reached with the placement of implants after 8 years was 99.27% (Chen & Cha, 2005). A histological evaluation in a case report study, where a bovine graft was performed, observed the presence of newly formed bone, particles of the graft material, connective fibrous tissue and giant multinucleated cells (promoting a graft particles reabsorption) in the augmented maxillary sinus. These findings did not influence the success of the implant maintenance after 6 month of the graft procedure and after 2 years of implant maintained in function (Marin et al, 2007).

Cordioli et al. (2001) used bioactive glass and autogenous bone in surgeries for maxillary sinus augmentation with simultaneous implant insertion. These authors concluded that the use of these materials is safe and predictable in relation to a simultaneous implant insertion. The using of calcium sulfate as grafting material was evaluated in a
prospective study, which had a success rate of 98.5\% in the implant maintenance after 1 year. The histological examination of the specimens analyzed showed 100\% of living bone without graft remnants after a period of 6 or 9 months (De Leonardis & Pecora, 2000).

In a study evolving 101 implants placed in 36 augmented maxillary sinuses, with an association of PRP [platelet-rich plasma] and bovine inorganic bone, Gonçalves et al. (2008) obtained an implant success rate of 90.09\%. The authors suggest that implants placed in maxillary sinuses, augmented with an association of PRP and bovine inorganic bone, show a great success rate.

A literature review demonstrated that any kind of graft material used does not influence in a significantly matter the survival rates of placed implants in augmented maxillary sinus. The survival rates of implants inserted in augmented sinuses with autogenous bone, allografts, xenografts, alloplastic materials and a mixtures of these materials were 89\%, 93.4\%, 95.5\%, 98.4\% and 93.8\% respectively (Chiapasco et al, 2006). Tepper et al. (2002) indicate the graft packing to reduce implant displacement, independently of the technique or graft material used.

The difference in osseous formation within the grafted sinuses with mineralized bovine bone associated or not to absorbable or non absorbable membranes placed over the lateral window was studied by Wallace et al. (2005) It were found differences in the histomorphometric analyses revealing that the groups with membranes showed a greater newly bone formation of 30\% and in the group without membrane 14\%. In according to these results the authors suggest the placement of membranes (absorbable or non absorbable) at the lateral window, although the success rates of the implants were 97.8\% for the membrane group (n = 129) and 100\% for the group without membrane (n = 6).

The dimensional stability of different graft materials after sinus floor augmentation was studied with computed tomography scans. After 6 months changes occur with a dimensional mean loss of 26\% for the grafted material (Kirmeier et al, 2008).

**Implant placement in 1 or 2 surgical stages**

The immediate placement of implants after a graft procedure is not indicated when the residual bone height is less than 4 to 5 mm and in case of a poor quality of bone (Chiapasco et al, 2006). Fugazzotto (2003) proposed a hierarchy of treatment selection for sinus augmentations after a critical analysis of the literature. This author concluded that if the sinus augmentation procedure is going to be performed by a lateral window approach associated with an implant insertion, it is necessary at minimum 4 mm of residual bone height to support the implant. If the residual bone height is less than 4 mm the placement of implant should be done in a second surgical approach 6 to 8 month after the grafting procedure. Some formulas were addressed to facilitate the clinician’s decisions. In the case of a residual bone height of 2x-2 (x represent the residual bone height coronal to the sinus floor at the time of therapy) it is sufficient to support implant, the sinus floor elevation with osteotomes and immediate implant placement can be done. If 2x-2 is insufficient to support implant but 4x-6 is adequate, the sinus floor elevation with osteotomes can be performed and allowed to heal. After 12 months the area can be reentered with a new osteotome approach and simultaneous implant placement. If 2x-2 and 4x-6 are both insufficient to retain the implant, a lateral window surgery is carried out and the area is reentered after 6 to 8 months for implant insertion.

In a retrospective study 1.557 implants placed in 1.100 patients were evaluated. There was no correlation between implant failure and the method used to elevate the maxillary sinus floor (osteotome or lateral window techniques). In the same study the success rate for implantation was 99.27\%, where only 8 implants failed during the osseointegration fase (Chen & Cha, 2005).

**Surgical and post-surgical complications**

Schwartz-Arad et al. (2004) verified in their study that perforation of the Schneiderian membrane was the major intra-operative complication during a sinus graft procedure. In study made by Hernández-Alfaro et al. (2008) the prevalence of membrane perforations was 25.15\% with an implant survival rate of 97.14\% in the membrane perforation
group. Fugazzotto & Vlassis (2003) describes the management of the membrane perforations using platelet-rich plasma (PRP), bioabsorbable porcine membrane or synthetic membranes. The use of bioabsorbable sutures prior to the bioabsorbable membrane placement is also described for membrane perforations management (Karabuda et al, 2006). The occurrence of different post-operative complications like acute sinus inflammation, persistent infection around the implant and the presence cyst associated to the buccal surface of the implant can be found. In the study where these problems occurred it was a strong association between the membranes perforations and post-operative complications ($P < 0.001$). However, there were no correlations between post-operative complications and implant survival (Schwartz-Arad et al, 2004).

**DISCUSSION**

The success of maxillary sinus augmentation procedures for the placement of implants is well documented in the literature. However, some anatomic and surgical conditions have to be considered. The presence of sinus septa can obstruct the Schneiderian membrane displacement (Van der Bergh et al, 2000). The membrane perforations are the major intra-operative complication and it is related to the manipulation of these membranes by techniques to access the maxillary sinus (Hernández-Alfaro et al, 2008). The sinus membrane is fragile and a delicate approach should prevail, which can be achieved with a less invasive surgical procedure.

A point to be considered in the techniques choice and in the immediate or later insertion of the implant is the quantity of native residual alveolar bone which will retain the implant. At least 4 mm of residual bone is important for implant placement (Wallace, 2006; Chiapasco et al, 2006). On the other hand, for Mardinger et al. (2007) this value was established by the literature by an arbitrary way. In a study performed in humans, the authors compared two groups. In the test group 25 patients presented 1 to 3 mm of residual bone and in the control group 30 patients presented more than 4 mm of native bone prior to the surgery. The results showed 92% of success rate for the tested group and 98.7% for the control group with statistically significant difference ($P < 0.069$). The technique used was lateral window with simultaneous implant insertion, where the residual alveolar bone range between 1 to 3 mm. For the authors this procedure can be performed, in a predictable way, if some planning and performing cares, when doing the surgical procedure, are taken (Mardinger et al, 2007). Although, it seems that a minimum 4 mm height of native bone is safer, because it can promote greater implant stability. This aspect is also relevant when choosing the operatory technique, because it has influence in the osteotome technique when augmenting the sinus (Chiapasco et al, 2006).

The osteotome technique is used when the residual bone height is equal or more than 4 mm and the lateral window technique is indicated when the residual bone height is less than 4 mm (Fugazzotto, 2003). Those factors aforementioned, technique selection and implant placement in one or two surgical stages seem to be correlated. This happens because of the direct relationship among implant insertion, osteotome technique and the need of implant stabilization. The use of osteotomes suggest a minor aggression to the maxillary sinus according to Ioannidou & Dean (2000) however the lateral window seems to be more appropriated when the residual bone is less than 4 mm according to the reports of Fugazzotto (2003) abovementioned.

The type of graft placed in a grafting procedure seems not to have influence on the success of implants placed in grafted sinuses, according to the broad literature where most graft materials were used (Chiapasco et al, 2006). Therefore, is important to remember that Wallace et al. (2005) suggest the use of absorbable or non-absorbable membranes over the lateral window access to increase the vital bone formation. The implant survival rate aforementioned for this study (97.8% for the membrane group and 100.0% for the group without membrane) is similar for both groups. However, this result should be considered with precaution because of the great difference in the number of implants placed in the groups (n = 6 in the group without membrane and n = 129 in the group with membrane).

The Schneiderian membrane perforations do not influence the survival rates of implants (Schwartz-Arad et al, 2004; Hernández-Alfaro et al, 2008; Fugazzotto & Vlassis, 2003). These results should be related to the management of perforations with absorbable sutures and/or the placement of absorbable or non-absorbable membranes, by this way reestablishing the superior wall of the grafted cavity and protecting the perforated membrane.

The implant survival rate inserted in grafted maxillary sinuses is high ranging between 90 to 100% according to the paper analyzed. This success is non dependent on the surgical technique, graft material and the moment to place the implant. These findings are correlated with those found by Olson et al. (2000) which presented by a multicenter,
prospective and randomized study, a survival rate of 97.5% from 120 implants inserted by many techniques, graft materials and timing to place the implants. Gonçalves et al. (2008) also corroborate with this findings showing an implant success rate of 90.09% in implants placed in maxillary sinus grafted with a biomaterial of bovine origin and platelet-rich plasma.

As Guilherme et al. (2009) demonstrated in a studied questioning 84 patients, after sinus lifting procedures concluded that in despite of the traumatic feeling, the patients present a better quality of life.

**CONCLUSION**

The literature shows a lack of evidence-based in prospective, randomized and controlled studies, determining which is the most indicate technique for the major clinical situations presented in this paper.

Within the limits of this analytical character review, is shown that sinus augmentation procedures, which are represented by the lateral window technique and the osteotome technique, are indicate for implant insertion in one or two surgical stages. This is provided since all the anatomical and surgical aspects that involves sinus grafting procedures, with the objective of bone augmentation in the maxillary sinus, are respected.

The authors thanks to Dr. Edson and Dr. Carla, both Professors of the Professional Masters Program in Clinical Dentistry, Positivo University for English reviewing this article.

**RESUMO**

As cirurgias de elevação dos seios maxilares vêm sendo utilizadas de maneira importante na reabilitação de maxilas edêntulas parciais ou totais com implantes dentais. A presença de um rebordo alveolar reabsorvido, que impossibilite a colocação de um implante, exige uma intervenção no seio maxilar com o propósito de aumentar a quantidade de osso disponível para colocação de implantes. As cirurgias de levantamento de seio maxilar vêm sendo utilizadas com este propósito. Dentre as técnicas de elevação do assoalho de seio maxilar existem as de um e dois estágios cirúrgicos com relação à colocação de implantes. O objetivo deste estudo foi realizar uma revisão de literatura sobre a técnica de acesso lateral e a técnica com uso de osteótomos para elevação da parede inferior do seio maxilar e a colocação de implantes em um ou dois estágios cirúrgicos. Foram obtidos estudos clínicos e revisões de literatura através de ferramentas de busca na internet e base de dados MEDLINE; além de livros texto. Estes trabalhos foram analisados e dispostos em uma revisão analítica da literatura. Aspectos relativos ao acesso do seio maxilar, colocação de implantes em um e dois estágios, estabilidade dos implantes em seios maxilares enxertados, quantidade de osso remanescente, materiais de enxerto, complicações cirúrgicas, anatomia do seio maxilar e complicações decorrentes do ato cirúrgico foram analisados.

**UNITERMS:** transplante ósseo; substitutos ósseos; implante dentário endoósseo; seio maxilar; substitutos ósseos.
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