Experimental study on histological changes in the sinus membrane following sinus lift

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Abstract
The aim of this study is to assess the histological changes in the sinus mucosa adjacent to the alloplastic material used for subantral augmentation. Materials and Methods: The study included ten sheep and a dog. The first group of five sheep underwent a sinus lift procedure, using PerioGlas as an augmentation material; the second similar group of sheep was the control group. The dog underwent a sinus lift procedure, with PerioGlas augmentation, after the sinus membrane was intentionally perforated and two implants were placed in the same operative step. Results: Scanning electron microscopy (SEM) of the sinus mucosa in the control group revealed cells without cilia between goblet cells. The cilia were uniformly arranged in sections in the same direction. Changes occurred in the sinus mucosa after grafting, such as drastic reduction of ciliated cells, which seemed to be replaced by goblet cells. In all sheep undergoing grafting, generalized fibrosis was found in the mucosal area that came into contact with PerioGlas. In two of the sheep in which grafting was performed, mucoid cysts with pseudostratified ciliated epithelium were present. Even when the sinus mucosa was perforated (in the dog), the inflammatory process developed in the mucosa did not prevent the integration of the graft and implants. In conclusion, following the sinus lift procedure, changes occur in the sinus membrane to adapt to the new situation, without the appearance of chronic or acute suppurative processes.

Keywords: sinus lift, sinus mucosa, electron microscopy, sinus grafting.

Introduction
The edentulous posterior maxillary region is probably the most difficult clinical situation for reconstruction in dental implantology. The loss of upper molars often causes a progressive reduction in the alveolar bone volume, both in a vertical and transversal diameter. A well represented maxillary sinus, in conjunction with reduced subantral bone are often a great challenge for the placement of an implant [1–4]. With the development of implantology, the need for surgical techniques to increase the volume of the atrophic alveolar process, particularly in the posterior region of the maxilla, has become imperative. Thus, the elevation of the sinus floor was developed and widely used [5–7]. Several studies performed by various authors have assessed the degree of integration of sinus grafts or implants after the elevation of the sinus mucosa and subantral augmentation [8–10]. The histological changes occurring in the sinus mucosa after sinus lift have been less studied. Only experimental studies are possible, probably because harvesting of a mucosal sample and histological evaluation of that sample are required [11–13].

Aim of the study
The aim of this study is to assess the histological changes in the sinus mucosa adjacent to the alloplastic material used for subantral augmentation.

Materials and Methods
The study included ten sheep and a dog. The sheep were matched for age (one year) and weight (30–32 kg), benefiting from the same rearing and treatment conditions, assigned for the study into two groups. The groups of animals were as follows:
- Group 1: sheep 1–5;
- Group 2: sheep 6–10;
- Group 3: dog 1.

Group 1 underwent sinus lift, using PerioGlas as an augmentation material. Group 2 was the control group, in which the elevation of the sinus floor was not performed. In the dog, a sinus lift procedure with PerioGlas augmentation was performed, after the sinus membrane was intentionally perforated intraoperatively, then two implants were placed during the same surgical approach.
Results

Clinical results

Postoperative evolution of the animals included in the study was very good, except for one sheep of Group 1, marked with the plate number 03, where the presence of a local infection required drainage, with the subsequent removal of the augmentation material and the collagen membrane (Figure 1).

Electron microscopic results

Examination by TEM (transmission electron microscopy) of the sheep control group (II), without sinus lift, evidenced intact covering epithelium in the maxillary sinus mucosa, with the presence of goblet cells, ciliated cells and basal cells. Connective tissue included sero-mucous cells, which secrete mucus on the surface of the sinus membrane (Figure 2).

In the grafted sinuses, an increase in goblet cells and seromucous cells was seen, without important structural changes in the sinus membrane (Figure 3).

The examination by scanning electron microscopy (SEM) of the sheep control group revealed the presence of cells without cilia in the spaces left at mucosal level, which were goblet cells (Figure 4).

The cilia are uniformly arranged into sections in the same direction.

In Group I, changes in the harvested sinus mucosa were noticed after grafting, consisting of the disappearance of ciliated cells, which seemed to be replaced by goblet cells (Figure 6).

The mucosal surface in Group 1 is characterized by the presence of Hunt microvilli (Figure 7).
Optical microscopy

In the sinus mucosa (intentionally perforated during surgery) harvested from the dog, an inflammatory process was present but did not influence the integration of the sinus graft and implants (Figure 8).

In frontal section, the connective tissue of the mucosa was (one third) thicker in the control Group 2 compared to Group 1, in which sinus lift was performed (Figure 9). Epithelial thickness in the proximity of the graft was smaller and the number of goblet cells was two-fold higher in the sheep in which grafting was performed. In all sheep undergoing grafting, generalized fibrosis was found in the mucosal area that came into contact with PerioGlas (Figure 10).

In two of the sheep in which grafting was performed, mucoid cysts with pseudostratified ciliated epithelium were present (Figure 11).

Figure 6 – Sinus mucosa of Group 1. SEM, ×1000.

Figure 7 – Sinus mucosa of Group 1. SEM, ×450.

Figure 8 – Ulcerated area with congestion and inflammatory infiltrates in the corium. HE stain, ×100.

Figure 9 – Non-ulcerated area with surface catarrhal reaction (mucinous goblet cell hyperplasia). HE stain, ×100.

Figure 10 – Detail of the previous figure. HE stain, ×400.

Figure 11 – Mucous retention cysts in the mucosal thickness. HE stain, ×100.
Discussion

Sinus membrane it is an important barrier for protection of the sinus cavity, in term of bone regeneration, the integrity should be preserved as much as possible. The normal physiology of the maxillary sinus depends on the normal function of the osteo-neural complex and on the maintenance of the properties of the sinus mucosa.

Reducing the volume of the sinus cavity has no physiologic disadvantages; it must be point out that may be true only if the mucosa is elevated without perforation. The correct performance of the sinus lift procedure does not affect the maxillary ostium, due to the location at a distance from the operative field [14, 15]. However, following the elevation of the sinus floor, chronic inflammatory changes might occur in the sinus mucosa, which are clinically expressed by maxillary sinusitis [16]. In the present study, no augmentation material (PerioGlas) was found in the sinus cavity of any of the subjects, even when the perforated mucosa was repaired with a collagen membrane, in the dog.

Histological evaluation did not show the presence of inflammatory processes after sinus grafting; however, some histological changes occurred in the mucosa, which consisted of a reduction in its thickness and a decrease in the number of glands and ciliated cells.

Mucosal clearance is the main factor in the maintenance of the physiology of the maxillary sinus. If epithelial atrophy is situated on the mucosal wall, it has a small influence on sinus clearance. Also, the reduction in the size of the sinus cavity does not involve physiological disadvantages [17, 18].

The goal of Lu JY et al. study (2011) was to analyze the histologic and ultrastructural changes after maxillary sinus augmentation with simultaneous implant placement using bone graft material. Calcium phosphate cement combined with goat bone marrow stromal cells were used to fill goat sinus floor space after maxillary sinus floor elevation with simultaneous implant placement comparing with those not filled any grafted materials and used as controls. The results showed that the connective tissue thickness and the epithelium thickness of mucosa were not statistically significant difference between two groups. The results are similar in our study [19].

Sul SH et al. (2008) indicate that the surgical procedure by which implants are inserted into the sinus cavity by elevating the sinus membrane without adding any graft material appears to have little influence on the histological characteristics of the sinus membrane [20].

Conclusions

The examination of the sinus mucosa by SEM, in the control group, revealed the presence of cells without cilia in spaces present at mucosal level, which were goblet cells. The cilia were uniformly arranged in sections in the same direction.

After grafting, changes in the harvested sinus mucosa were found, consisting of the disappearance of ciliated cells, which seemed to be replaced by goblet cells.
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