Management of peri-implantitis is becoming an increasing issue for implantologists and periodontists. The need for bone augmentation is more and more frequent, especially in the posterior maxilla requiring sinus augmentation. Peri-implantitis represents a real danger for implants, but to this day, the available literature concerning the impact of this disease on regenerated bone and on maxillary sinus pathology is very limited. This report presents two cases showing bone alterations due to peri-implantitis and its possible impact on maxillary sinus health. In both cases, the causal implant was removed regardless of prior functional endoscopic surgery to restore sinus health, and it was not necessary to implement any reconstruction procedure because bone regeneration occurred naturally. Further research will be necessary to confirm these initial findings.


Radiographic and Histologic Evaluations of Peri-implantitis on the Grafted Maxillary Sinus: A Report of Two Cases

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Maxillary sinus augmentation using the lateral approach is a very predictable technique for implant placement in the atrophic posterior maxilla. One of the main causes of late implant failure is peri-implantitis leading to implant loss. To date, there are very few publications describing this complication and its management, which mostly consists of removing the infected material and considering new implant placement.

The aim of this article is to report on the radiologic and histologic follow-ups of peri-implantitis cases for two patients who received implants in a maxillary sinus augmented with deproteinized bovine bone graft using the lateral approach.

Case Reports

This report was conducted in strict accordance with the recommendations of the Declaration of Helsinki for investigations with human subjects.

The maxillary sinus augmentation was performed using a one- or two-stage lateral approach, determined by the residual bone height. Antibiotherapy was performed for 1 week after augmentation. A collagen membrane (Bio-Gide, Geistlich) was used on top of the graft (Bio-Oss, Geistlich). When using the
two-stage approach, the implants were placed 6 months after grafting and remained submerged for 3 months before prosthesis delivery. When using the one-stage approach, the prosthesis was delivered 6 to 9 months after implant placement. All of the implants had a rough surface. During the annual follow-up visit for each patient, the prosthesis was removed when possible, and periodontal probing was performed. When bleeding or suppuration was observed and/or when the pocket depth exceeded 5 mm, a radiograph was taken to detect any bone defect and to diagnose peri-implantitis. In such cases, CBCT was performed to check for the presence of associated sinusitis with or without sinus ostium blockage.

Case 1

In March 2019, a 42-year-old non-smoking man consulted for pain at implant site 25 (FDI tooth-numbering system). Clinical examination showed a 10-mm probing depth with suppuration. The CBCT scan revealed a bone defect within the graft extending 2 to 3 mm from the implant apex, with significant inflammation of the sinus membrane without ostium blockage (Fig 1a). The diagnosis was peri-implantitis within an augmented sinus without associated acute sinusitis.

This had a history of treated periodontitis (the teeth at sites 25, 26, and 27 were missing): In early May 2009, the patient underwent a maxillary sinus augmentation with simultaneous placement of two implants (Astra Tech, Dentsply Sirona) replacing tooth 25 (4.5-mm diameter) and tooth 27 (5-mm diameter). In December 2009, a cemented partial restoration was placed. The patient was monitored twice during the first year, and then on a very irregular basis by his attending dentist.
Immediately after the peri-implant diagnosis in 2019, a combination of amoxicillin and metronidazole was prescribed, and the implant at site 25 was removed (Fig 1b). Curettage of the defect was performed until bone bleeding was observed. CBCT scans were performed on a regular basis to monitor the healing process. After 6 months, there was complete regeneration of the defect (Fig 1c), and the sinus membrane showed no more thickening. Figure 3 shows the radiopaque residual graft and the radiolucent area below corresponds to the regenerated zone. Another implant was placed in position 25 and was in function 2 years later (Fig 1d).

Case 2

In January 2008, a 65-year-old non-smoking woman was diagnosed with peri-implantitis on the implant at site 17 in a grafted sinus, almost 12 years after the prosthesis was placed, with a 10-mm pocket depth and suppuration. No association with sinusitis was detected. An
antibiotic therapy (amoxicillin and metronidazole) was prescribed to sedate the symptoms. Despite the clinicians’ recommendation, the patient refused to remove the implant. Monthly irrigations with chlorhexidine were performed for a period of 10 years, until acute sinusitis due to peri-implantitis was diagnosed in March 2018 (Fig 3a).

This patient had previously consulted with the present authors in July 1996 to replace three missing teeth (15, 16, and 17) due to chronic periodontitis. Sinus augmentation was performed on the right side in September 1996; the residual bone height was 2 mm, and three implants (IMZ TPS coated, Dentsply Sirona) were inserted 6 months later. At implant uncovering, the implants at sites 15 and 16 were not osseointegrated and were replaced by two implants (Brånemark, Nobel Biocare) with a machined surface. Two crowns were splinted and screwed directly on the implants at sites 16 and 17, and a screw-retained single crown was placed on the implant at site 15. The patient was regularly monitored by her attending practitioner, but acute sinusitis was diagnosed in March 2018. The patient was referred to an ENT (otorhinolaryngology specialist) who performed an antrostomy10 to prevent an oroantral fistula after implant removal. The surgery consisted of restoring the ostium patency (when the sinus drainage is blocked) by removing first the middle turbinate (turbinectomy) in order to reach the sinus ostium to be widened (meatotomy). One month later, the implant at site 17 was removed with thorough curettage of the residual bone defect until bleeding was observed at the bottom of the defect. The sinus then no longer showed any pathologic image, and residual grafting material was seen at the bottom of the bone defect (Fig 3b). The CBCT scan performed 1 year later showed complete regeneration at the defect site (Fig 3c) and a healthy sinus membrane. At that time, the patient presented with mucositis at implant sites 15

<table>
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<th>Table 1 Case 1 Histomorphometry Results</th>
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<td>Vital bone</td>
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<td>Residual graft</td>
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<td>Healed area</td>
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Fig 3 Case 2 CBCT scans. (a) The initial scan shows peri-implantitis with ostium blockage and acute sinusitis. (b) After antrostomy and implant removal, the sinus membrane is healthy, and a residual graft is visible. (c) Bone at the defect site showed complete regeneration after 1 year.
and 16, which required a free gingival graft. During this procedure, with the patient’s written informed consent, a bone biopsy sample was harvested from the regenerated area. The histologic examination (Table 2) showed Type 3 bone free of any residual grafting material in the healed zone.

**Histologic Processing**

Both biopsy samples were performed perpendicular to the crest, including the bone defect and the residual bone graft. All biopsy samples were fixed in 4% formalin for 5 to 7 days, then dehydrated in serial steps of ethanol (70%, 80%, 90%, 100%) for 1 day per concentration. The biopsy sample was then embedded and polymerized in Technovit 9100 (Kulzer) according to the manufacturer’s instructions. After polymerization, each sample was cut into two sections using a precision cutting machine (Secotom-50, Struers). The sections were mounted onto opacified acrylic-slides and grinded to a final thickness of approximately 80 µm on a rotating grinding plate (Labo-Pol-30, Struers). Specimens were subsequently stained with azure II (Merck) and pararosaniline (Sigma-Aldrich, Merck).

**Histologic and Histomorphometric Evaluations**

Imaging was performed using an Axio Imager M1 microscope (Zeiss) equipped with a digital software AxioCam HRc (Carl Zeiss). Histomorphometric analysis was achieved using analySIS FIVE software (Olympus Soft Imaging System).

**Discussion**

In both cases, peri-implantitis occurred around 10 years after implant placement. This is the only cause of long-term implant failure for patients who underwent sinus floor elevation. Regular follow-ups allow mucositis to be detected and treated, which is the only reversible stage of peri-implant diseases. In a recent study with a 1-year follow-up, mucositis was detected in 69% of the included patients, but no peri-implantitis case was diagnosed over the same period of time. The implementation of a strict maintenance program to detect mucositis is therefore essential. The lack of patient compliance with frequent

<table>
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<tr>
<th>Case 2 Histomorphometry Results</th>
<th>Vital bone</th>
<th>Graft material</th>
<th>Bone marrow</th>
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<tr>
<td>Residual graft</td>
<td>12.8%</td>
<td>19.4%</td>
<td>67.8%</td>
</tr>
<tr>
<td>Healed area</td>
<td>26.5%</td>
<td>0.0%</td>
<td>73.5%</td>
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**Fig 4** Case 2 histologic views. (a) A slide of the complete biopsy sample shows the residual grafted area (1) and the healed area (2), which consists of Type 3 bone (×50 magnification; azure II/pararosaniline staining). (b) Healed area (×100; azure II/pararosaniline staining).
control visits should be considered an additional risk factor.\textsuperscript{12}

Recently, Stacchi et al\textsuperscript{6} considered both the lateral window technique and one-stage sinus floor elevation to be significant risk factors for peri-implantitis. Conversely, Cho-Lee et al\textsuperscript{13} concluded that peri-implantitis is a determining factor for implant failure in a grafted sinus. Similarly, Krennmaier et al\textsuperscript{14} do not consider sinus augmentation as a risk factor for peri-implantitis, but their follow-up was only 5 years.

Generally speaking, the available literature does not provide any clear answer regarding the prevalence of peri-implantitis in native bone compared to augmented areas. For some authors,\textsuperscript{12,15} the prevalence of peri-implantitis is identical. For others,\textsuperscript{16,17} marginal bone loss is greater in grafted sites, but the term “peri-implantitis” is not mentioned as a possible etiology for the reported bone loss. However, the use of biomaterials as a potential cause of peri-implantitis is clearly mentioned in the latter studies,\textsuperscript{16,17} which could be interpreted as evidence that inner grafting material remnants could reduce the ability of the graft to defend itself against infections. To date, the literature does not allow clinicians to draw such conclusions. As shown in a recent animal study,\textsuperscript{18} peri-implantitis does not appear to be more frequent in native bone than in grafted sites, but the bone lesions are more extensive in the grafted sites. This could be explained by the fact that in that specific animal study, only bone dehiscences treated with GBR were assessed. However, other studies\textsuperscript{19,19} reporting on patients similar to the present cases confirm that peri-implantitis in a grafted sinus may lead to sinusitis.

According to Scarano et al\textsuperscript{7} it is usually recommended to remove the entire graft. In the present case report, the implants were systematically removed regardless of any association with sinusitis. In both cases, the bone at the defect sites regenerated within the following months. The healed bone presented the same characteristics as the Type 3 bone normally found in these areas. Histomorphometric analysis showed a slightly higher degree of mineralization of living bone in the healed area than in the grafted area, but this is probably due to the fact that it is younger bone\textsuperscript{20} and is free of any grafting biomaterial.

The reason for bone defect healing remains unclear, but Khouly et al\textsuperscript{13} suggested that the residual graft includes both living bone and biomaterial remnants, meaning that the upper part of the graft would be much more rigid and would withstand the pressure within the sinus, thus preventing the defect from flattening. This rigidity may be due to the presence of the hard, slowly resorbing biomaterial. The three-wall structure would then be preserved, and regeneration may start from the residual bone contained in the remaining graft. This spontaneous healing process would render any attempt for surgical reconstruction of the bone defect useless, should the bone behave well after implant loading, which remains to be confirmed. It would also be necessary to verify the process according to the nature of the specific grafting material used, as well as other factors.

Conclusions

Peri-implantitis evolving within a grafted sinus can be very destructive for regenerated bone and may lead to sinusitis. When sinus augmentation is recommended, it is therefore essential to identify the risk factors, and effective prevention measures must also be implemented in the periodontal, prosthetic, and hygienic fields. Further research with more clinical cases is necessary to codify the best treatment method for this disease, which represents a new challenge in implant dentistry.

Acknowledgments

The authors declare no conflicts of interest.

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