A Step-by-Step Management of Extraction Sites in Areas of Maxillary Sinus Pneumatization: A Literature Review and a Case Presentation of a New Surgical Technique

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Abstract

Introduction: The rehabilitation of the posterior maxilla with implant-supported prosthesis is often complicated by pneumatization of the maxillary sinus. Bone grafting is commonly required in these cases. Over the years, a number of techniques have been developed for this type of reconstruction.

Aim: Present and discuss the possibility of alveolar bone regeneration for subsequent placement of oral implants using Fugazzotto's technique in combination with particulate autograft harvested from the mandibular ramus and a connective tissue pedicle flap to cover the graft.

Methods: A case of a 37-year-old woman with a molar perforated during endodontic treatment and indicated for extraction and implant placement is reported.

Result and conclusion: The clinical case showed the possibility of grafting of extraction sites combined with atraumatic elevation of the maxillary sinus floor can be achieved using non-conventional techniques such as Fugazzotto's technique associated with alveolar bone regeneration.

Key words: Bone regeneration, sinus floor augmentation, dental implants

Introduction

The rehabilitation of the posterior maxilla with osseointegrated implants often presents challenges, the most common being the proximity of the maxillary sinus and low bone density. Maxillary sinus pneumatization, which follows tooth extraction, commonly makes bone grafting necessary for rehabilitation of this area (Barone *et al.*, 2008). Thus, proper extraction procedures have become increasingly important in complex oral rehabilitation treatments, whereby a minimally traumatic extraction can minimize resorption while preventing changes in the gingival architecture (Kubilius *et al.*, 2012).

The procedure of choice to correct this anatomic defect is elevation of the maxillary sinus membrane. The decision on which technique to use depends on the volume of bone remaining and the degree of pneumatization of the maxillary sinus (Sharan and Madjar, 2008). Two classical techniques are described in the literature: the lateral window technique (Tatum, 1986) – a traumatic technique – and the crestal approach (Summers, 1994) - an atraumatic technique. Fugazzotto (1999) described a variation of the atraumatic technique, using bone from the interradicular septum and trephine burs.

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Another factor to be considered is the type of material to be used to fill the maxillary sinus cavity and extraction site when immediate implant placement is contraindicated (Jensen *et al.*, 1998). Although a number of alternative materials have been used with varying results, autologous bone is still considered the gold standard for this type of bone repair (Rickert *et al.*, 2012). Autologous bone is the grafting material with better biocompatibility, although its use is associated with increased postoperative morbidity. For this reason, the use of bone substitutes has quickly gained popularity (Jensen *et al.*, 2012).

Bone grafts placed into extraction sites need to be covered for protection and stabilization. In order to achieve greater predictability, various authors (Nemcovsky *et al.*, 1999; Novaes and Novaes, 1997; Rosenquist, 1997) have suggested several surgical procedures, including coronally positioned flaps, pedicle flaps, free gingival grafts and tissue expansion in an effort to achieve and maintain primary closure of the soft tissue after bone regeneration therapy.

The aim of this paper is to present and discuss, based on a case report, the possibility of alveolar bone regeneration for subsequent implant placement when using Fugazzotto's technique (Fugazzotto, 1999) in combination with particulate autograft harvested from the mandibular ramus and a flap closure technique, as described by Nemcovsky *et al.* (1999).

Case report

This case report was conducted in accordance with the provisions of the World Medical Association Declaration of Helsinki (June, 1964) and its subsequent amendments. The patient signed the informed consent for the procedure and for the use of clinical data for scientific purposes and publication. Patient anonymity was ensured.

A 37-year-old woman, with no systemic disease, sought treatment in the dental clinic of the school of dentistry in the Federal University of Santa Catarina. The first right maxillary molar, which had been perforated during endodontic treatment, was indicated for extraction and implant placement. Clinical examination (*Figure 1A*) revealed a healthy periodontium. However, radiographic evaluation (*Figure 1B*) showed root resorption without any sign of apical infection and close contact of the roots with the maxillary sinus resulting from grade 3 pneumatization (Sharan and Madjar, 2008).

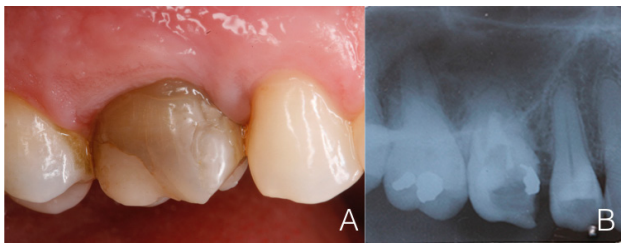

Figure 1. A) Clinical and B) radiographic appearance at baseline.

One hour prior to surgery, 2 grams of amoxicillin were given prophylactically. The surgical and prosthetic planning for rehabilitation of the posterior maxilla consisted of repairing alveolar bone, atraumatic elevation of the maxillary sinus floor and subsequent placement of a dental implant. The decision w made based on the classification of sinus pneumatization, which was grade 3, and also on the amount of remaining bone. Also, we evaluated the characteristics of the septum and root shape. Considering these factors, we decided to perform the socket filling and the sinus elevation using Fugazzotto's technique.

Atraumatic extraction of the compromised tooth was performed using periotomes (Maximus Hospital MaterialsÒ, Belo Horizonte, Minas Gerais, Brazil) – to preserve the interradicular septum – without flap elevation, thus preventing buccal wall resorption caused by periosteal elevation. (*Figure 2A and B*)

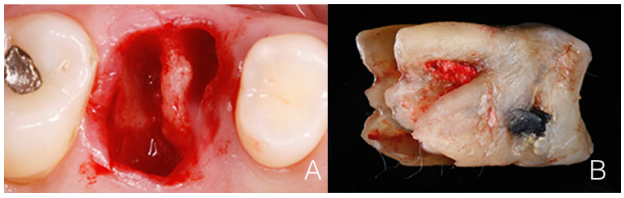

Figure 2. A) Extraction site. Observe the preservation of bone septum after atraumatic extraction. B) Perforation and root resorption process.

Following extraction, the socket was curetted to prevent the development of apical lesions and the formation of granulation tissue resulting from the unsuccessful endodontic treatment. In accordance with the preoperative planning, the maxillary sinus floor was elevated using Fugazzotto's atraumatic technique and the extraction site was filled with particulate autologous bone graft.

The implant site was prepared using a trephine bur (NeodentÒ, Curitiba, Paraná, Brazil) to drill a hole with a diameter large enough to cover the area defined by the interradicular septum and approximately 50% of the extraction site, with a depth of approximately 2 mm from the maxillary sinus floor (*Figure 3*). Next, an osteotome (NeodentÒ) with a diameter compatible with the hole drilled was used to elevate the sinus floor and septum. The particulate autograft used to fill the extraction site (*Figure 4A*) was harvested from the retromolar area of the mandible with a disposable bone curette (NeodentÒ).

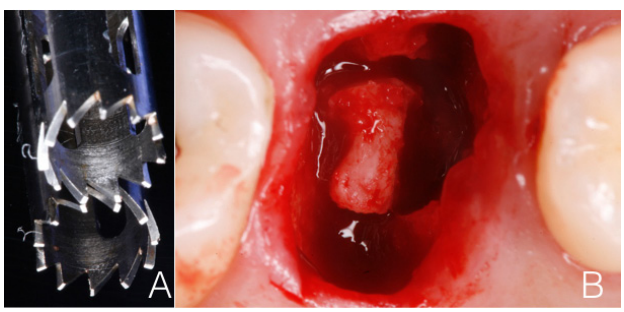

Figure 3. Trephine burr (A) and surgical socket after drilling (B). Observe the rupture of the lateral walls of the septum.

The extraction site was closed using the technique described by Nemcovsky *et al.* (1999). First, an intrasulcular incision was performed anteriorly to the mesial area of the right maxillary lateral incisor. A split-thickness palatal flap of about 1.5 mm thickness containing epithelial and connective tissues was detached to prevent necrosis. Two incisions (one vertical and one horizontal) were then made in the split-thickness flap. The vertical incision was performed in the mesial portion of the first incision with a length long enough for the extraction site to be covered in the buccal-palatal direction. The horizontal incision was performed parallel to the first incision with a length long enough for the extraction site to be covered without tension. The connective tissue within the incisions was then separated from the underlying bone and rotated to cover the extraction site. This technique allowed the primary closure with soft tissue. (*Figure 4B*)

After an 8-month period to allow tissue healing *(Figure 5A)* and bone maturation, cone-beam computed tomography (CBCT) images were obtained to assess the amount of bone formed after grafting (*Figure 5B*). An external hexagon implant (Biomet 3i, Palm Beach, California, USA) measuring 6.0 x 10.0 mm was chosen because it allows platform switching (Lazzara and Porter, 2006). Incision and detachment of the flap revealed significant bone formation, which was also clinically observed *(Figure 6A)*. The drilling sequence used was recommended by the manufacturer, and after implant installation a cover screw was placed to protect the implant during osseointegration (*Figure 6B*).

Six months later, the implant was uncovered and a healing cap was placed. After 14 days, the healing cap was replaced by a temporary abutment and gingival conditioning was performed. After another 6 months, a final implant-supported prosthesis was installed which was in harmony with peri-implant tissues at the one-year follow-up (*Figure 7A and B*).

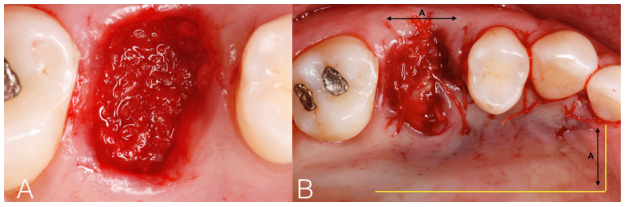

Figure 4. A) Autograft filling the extraction site. B) Connective tissue pedicle flap for primary closure of the extraction site, as described by Nemcovsky et al., 2000.

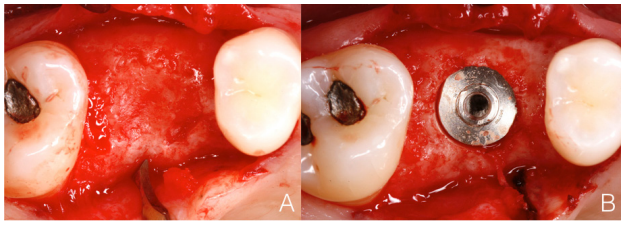

Figure 6. A) A marked bone formation can be observed after detachment of the flap. B) Dental implant in position.

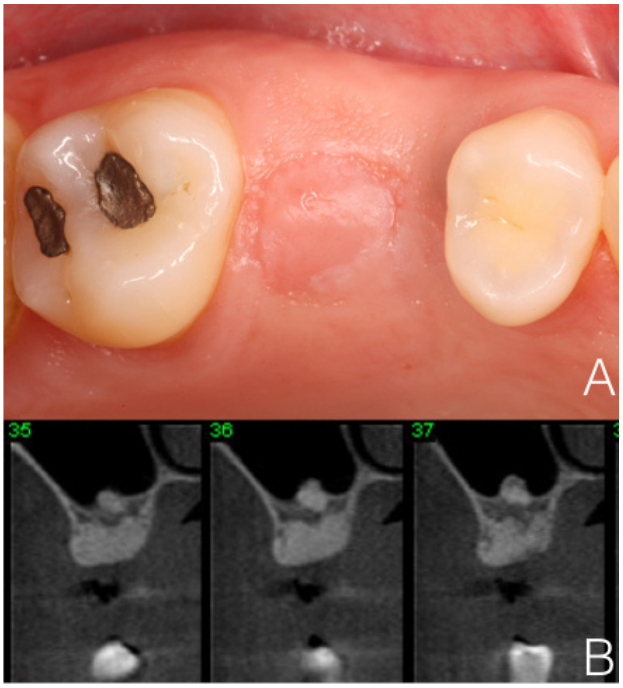

Figure 5. A) Clinical and B) tomographic appearance 8 months after treatment. Observe the bone formation resulting from grafting.

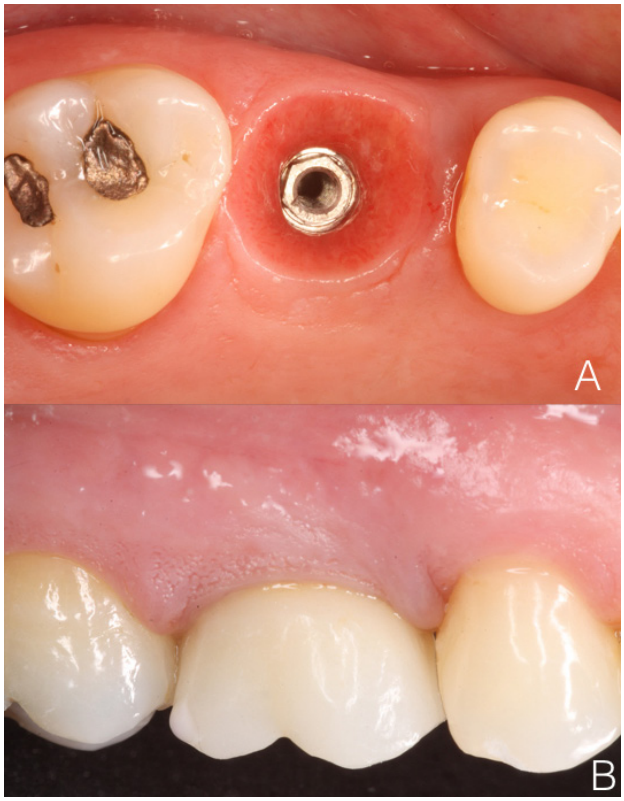

Figure 7. Occlusal (A) and buccal (B) view of clinical follow-up 1 year after the placement of the dental implant.

Discussion

Clinicians are concerned with reducing the damage to hard and soft tissues adjacent to extraction sites. Atraumatic extraction and protection of post-extraction sockets should always be taken into consideration. Moreover, the condition of important anatomical structures, such as the maxillary sinus, may complicate or be a contraindication to implant placement.

Studies on pneumatization of the maxillary sinus have shown conflicting results. Some studies have reported an increase in sinus size following extractions, while others have found no changes (Sharan and Madjar, 2008). On the other hand, it is well documented in the literature that unpredictable, and often clinically significant, morphological changes occur in the alveolar crest after tooth extraction when no regeneration therapy is used (Cardaropoli and Cardaropoli, 2008). Such changes usually affect the aesthetic appearance and compromise the bone structure to an extent that the available amount of bone does not allow the optimal positioning of the implant or even its placement in any other position (Fugazzotto, 2005).

Maxillary sinus grafting has provided predictable results in promoting bone formation due to its significant effect on increase of apico-occlusal bone volume, which allows conventional length implant placement (Sorní *et al.*, 2005; Fugazzotto, 2005). The use of the lateral window technique for sinus floor described by Tatum (Tatum, 1986) for maxillary sinus membrane elevation is indicated when the height of remaining alveolar crest is less than 5 mm and more than 2 mm. On the other hand, the atraumatic technique described by Summers (Summers, 1994) requires a minimum height of 5 to 6 mm of remaining bone. However, it is emphasized that indications of different techniques in accordance with the bone height should not be too strict. The choice lies in experience and preference from professional to professional.

Classically, the most commonly performed technique is known as lateral window sinus lift (Esposito *et al.*, 2010). It allows a greater amount of bone augmentation to the atrophic maxilla but requires a larger surgical access (Woo and Le, 2004). Another option is the osteotome sinus floor elevation technique (crestal approach), which is a less invasive, more conservative, one-stage technique for sinus floor elevation with simultaneous implant placement. While the crestal approach is less invasive and a one-stage technique, there are some disadvantages associated with it. The amount of bone that can be gained using a crestal approach is usually less than that from the lateral window technique, and a minimal amount of crestal bone height is generally recommended to stabilize the implant at placement (Esposito *et al.*, 2010). If it is not possible to place the implant at the same time as tooth extraction, Fugazzotto (1999) described a technique of sinus elevation using the interradicular septum. The procedure was found to be easy to do with very brief operating time. Intrinsic extraction socket healing capacity provided adequate bone for osseointegration that would otherwise require a sinus graft procedure. The main advantage of this technique is promoting alveolar bone regeneration by preventing changes that can negatively affect the three-dimensional architecture of the extraction site. Also, other advantages may include decreased number of surgeries, a contraction of the therapy course and a theoretical decrease of therapy costs (Fugazzotto, 2005). Still, if it is not possible to place the implant at the extraction time, comparing these three techniques in the overall treatment time, the crestal approach (Summers's technique) and Fugazzotto's technique can be considered as fast as the lateral window technique. However, Fugazzotto's technique is more predictable in maintaining the alveolar architecture. Based on these advantages, Fugazzotto's technique was elected for the management of this case. In our situation, because of the university's calendar, it was not possible to place the implant at the ideal time, which is considered 4 months for socket preservation. It is clear that the technique was able to maintain and also increase the bone height through the sinus elevation using the septum. However, we acknowledge that it is always better to respect the correct times, to prevent the loss of alveolar height, ridge and resorption of the sinus graft that can occur if implant placement is delayed.

The clinician could place the implant at the same time of tooth extraction using the crestal approach, making it faster than the others. Listl and Faggion (Listl and Faggion, 2010) state that when there are no financial restrictions on a sinus lift, the optimum treatment strategy is the lateral approach with autologous particulate bone and a resorbable membrane. When, however, monetary resources for sinus floor elevation are scarce, the decision depends on the initial bone height at the implant site. In cases where bone height is sufficiently high, the most cost-effective option is the transalveolar technique without bone grafting. In cases where bone height is comparably low, the most cost-effective is a lateral approach with no membrane application (*Table 1*).

In the present case, the amount of remaining bone was insufficient, precluding the use of Summers's technique or lateral window access and simultaneous installation of an implant with good primary stability. According to Woo and Le (2004), both techniques are efficient; nevertheless, they have advantages and disadvantages. Therefore, Fugazzotto's technique was chosen for maxillary sinus floor elevation at the same time as extraction of the maxillary molar, combining atraumatic sinus floor elevation with filling of the extraction site. Thus, this technique would maintain and regenerate both the buccal-palatal and the apico-coronal architectures. The differences between other techniques of fresh socket preservation and Fugazzotto's technique are that Fugazzotto's technique promotes maintenance of the socket structure and also increases the bone height, elevating the sinus floor using the septum.

Table 1. Comparison among three surgical techniques.

Technique	Advantages	Disadvantages
Lateral window	More common Greater amount of bone augmentation Great predictability	Larger surgical access Two- or three-stage surgery Long treatment period High cost
Osteotome	Less invasive More conservative One-stage technique Decrease in number of surgeries (one required) Decrease in cost Better post-operative course	Small amount of bone gain Minimal amount of crestal bone height required
Fugazzotto's	Less invasive More conservative More predictable in maintaining alveolar architecture Decrease in number of surgeries (two required) Decrease in cost Better post-operative course	Two-stage surgery Delicate technique (requires experience)

When compared to others atraumatic or crestal approach techniques of sinus floor elevation, Fugazzotto's technique uses more remaining autogenous bone to elevate the sinus membrane, which makes it more predictable to maintain in the desired position, providing a higher level of height gain.

Various materials, from biocompatible bone substitutes to autologous bone grafts, have been used for the reconstruction of the atrophic maxilla. Barone *et al.* (2008) found significant differences in resorption of the alveolar crest when comparing the use of pig-derived bone substitute with blood clot alone as grafting materials. A study comparing three types of bone substitutes (porcine bone, hydroxyapatite enriched with magnesium, and calcium sulfate) has reported no significant differences in the clinical outcomes of dental implants placed in extraction sites grafted with the different bone substitutes. However, the authors emphasized that further histological studies were necessary. Other studies comparing the use of bovine, porcine, and alloplastic bone substitutes, alone or in combination with autologous bone, as grafting materials have suggested that bone substitutes combined with autologous bone provide a reliable alternative for autologous bone alone in the elevation of the maxillary sinus floor for dental implants placement (Rickert *et al.*, 2012). Jensen *et al.* (2012) state that the differences reported in animal studies between the use of a bovine bone substitute alone or in combination with autologous bone in maxillary sinus floor augmentation cannot be confirmed or rejected, because bone regeneration, bone-to-implant contact (BIC), graft biodegradation, and biomechanical tests values have never been compared within the same study in animals. One year later, the same research group published a comparative study about BIC in minipigs showing an increased result using autologous bone or bovine particulate bone mixed with autologous bone in different ratios as compared to bovine particulate bone alone. Also, this study indicates that a mixture of autologous bone and bovine particulate bone should be used as graft material for maxillary sinus floor augmentation to diminish resorption of the graft and to increase BIC formation (Jensen *et al.*, 2013).

Despite autologous bone being considered the gold standard for grafting procedures because of its osteogenic, osteoinductive and osteoconductive properties (Jensen *et al.*, 1998), its uses are associated with increased morbidity because of the necessity of a donor site (Hallman and Thor, 2008). Based on the fact that maxillary sinus lift surgeries have high success rates and require a large amount of graft, it is possible to mischaracterize the autologous bone as the ideal material for these surgeries. Notwithstanding, given the lack of consensus in the literature and the small amount of filling material required in Fugazzotto's technique, particulate autograft harvested from the retromolar area of the mandible was chosen for case management, thereby reducing the risk of treatment failure.

The removal of a tooth is always followed by the loss of hard and soft tissues, once a deep and open wound (the extraction site) is created in the alveolar crest and a secondary intention healing takes place (Cardaropoli and Cardaropoli, 2008). Many regenerative procedures have been developed to restore function and aesthetic appearance (Landsberg,

2008). The primary closure of the flap is important for bone regeneration. Early exposure of the graft or its incomplete coverage can cause problems during the treatment. Covani *et al.* (2007) suggested the use of a free connective tissue graft harvested from the palate to close the extraction site. Thus, the aesthetic appearance of the area is restored and primary closure is achieved with a simple procedure. Another study has reported that the same results can be obtained using a free gingival graft and highlights the importance of maintaining the stability of the graft for a successful treatment outcome (Covani *et al.*, 2007).

In contrast to these regenerative treatments using free grafts, studies of Nemcovsky *et al.* (2000) and Fugazzotto (2006) reported the use of pedicle flaps for covering the extraction site. Only the study of Nemcovsky (1999) describes the use of a connective tissue pedicle flap. According to the author, the advantages of the technique include the uninterrupted blood supply to the flap and preservation of the aesthetic appearance by the connective tissue.

Although the results presented here are excellent, the described technique is limited to one single case and, therefore, should be interpreted as such. The findings of this case report lead us to assume that the possibility of grafting extraction sites simultaneously with atraumatic elevation of the maxillary sinus floor can be achieved using non-conventional techniques. However, these findings should be confirmed by case series and prospective studies.

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