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Case report

ROLE OF MAGNETIC MALLET AND PHOTO-BIO-MODULATION ON MESENCHYMAL STEM CELLS IN SINUS GRAFT SURGERY: A CASE REPORT

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ABSTRACT

Sinus membrane elevation is a common surgical technique to increase bone height in the posterior maxilla before dental implant placement. However, the biological mechanism of bone regeneration in the sinus membrane remains largely unknown. A case report of sinus lift elevation and implant insertion with a Magnetic Mallet is described, as well as pre and post-surgical use of laser for decontaminating the implant site. In addition, Schneider's membrane formation is reported, and the efficacy of laser-associated therapy in the sinus lift procedure is discussed.

KEYWORDS: *mesenchymal stem cells, maxillary sinus membrane, sinus lift, osteotomy, magnetic mallet, photobiomodulation*

INTRODUCTION

In many implant-prosthetic rehabilitations, bone augmentation in the posterior maxillary is very important. Since 1965 the elevation of the sinus floor through the lateral wall of the maxilla has been mostly successful, and for 30 years, this method has been recognized as a gold standard for internal ridge elevation. The starting point of this technique is a donor site: the autologous bone, mixed with biocompatible materials, is then used for floor elevation (1).

The invasiveness of the lateral approach is obvious: a donor site requires additional time and volume and determines the risk of morbidity in either the donor or recipient site.

A different approach was first investigated in 1986 by Tatum OH (2): he accessed the sinus floor through the ridge crest. The technique uses a series of osteotomes after reaching the sinus floor. The osteotome was used to crack the sinus floor bone and elevate the Schneiderian membrane, which was then pushed with antral curettes to create the space into which the graft material was packed.

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Another variation of this method was described by Summers RB (3), who created a more practical and efficient crestal approach. Two different ways were suggested:

A) osteotomy sinus floor elevation (OSFE) through the only use of the implant (tent effect);

B) bone-added osteotomy sinus floor elevation (BA-OSFE) through the positioning of an implant and the packing of graft bone particles.

Clinical observations of bone formation in sinus-lifting procedures without grafting bone substitutes were observed, but the biological nature of bone regeneration in sinus-lifting procedures is unclear. Therefore, comprehending the biological basis of the healing process is necessary to improve surgical techniques and reduce the risk of complications and failures.

MATERIALS, METHODS AND RESULTS

Case report

A 28-year-old male with no significant medical history presented for the replacement of missing second premolars extracted 3 years earlier. The results of blood tests, including a complete blood count, chemistry, and clotting profile, were all within normal limits.

The initial X-ray (Fig. 1) revealed a height of alveolar bone resorption edentulous area in the upper region of the left posterior maxilla (area of second premolar) with pneumatization of the maxillary sinus. The residual bone height was 3 mm, the alveolar ridge was about 7 mm wide, and there was the absence of significant vertical resorption of the alveolar ridge.

The punch incision was preferred initially, but a full-thickness flap was raised because of the risk of miscalculating the exact alveolar bone height in the critical area under local anaesthesia. The bone was accessible and marked with an Er:YAG laser (Pluser-Lambda SPA, Vicenza, Italy, parameter 200 mj, 20 Hz, 600-micron tip). The implant site was prepared using the magnetic-dynamic mallet device (Meta Ergonomica, Turbigo, Milan, Italy). For the mallet technique, the following inserts were used for the required depth of 0.5 mm below the sinus roof: P.F. 10–160, F–200, F–230. Program power 2 to 4 was used. For the drilling technique were used lanceolate drill Ø –2.2 mm, Ø–3.0 mm, Ø–3.2 mm, Ø–3.4 mm, Ø–3.6 mm and a countersink Ø-4 mm.

Radiographs were taken with a depth gauge to determine the length of the preparation. To improve primary stability in cancellous bone, condensing the bone through radial reinforcement has been achieved by a series of bone condensing devices of magnetic mallets with a tapered tip. The magnetic mallet device fractured the sinus cavity floor with a 3.6 mm Ø drill and a countersink 4 mm Ø. A change in the resonance during malleting indicated a complete osteotomy. The Valsalva test to assess the patency of the membrane of Schneider was negative during all procedures. Before inserting the fixture, the surgical site was irrigated with SiOxyl+ solution, and a diode laser irradiated the cavity for 60 sec (2.5 W Peak Power, 0.5 W Average Power, T-on 20

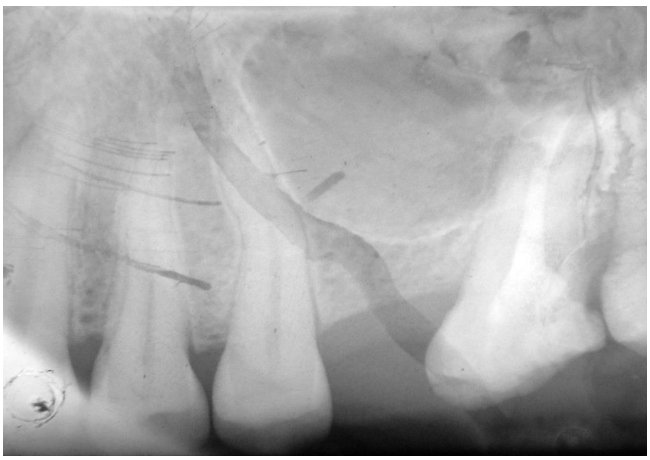

Fig. 1. *The initial X-ray. The residual bone height was 3 mm.*

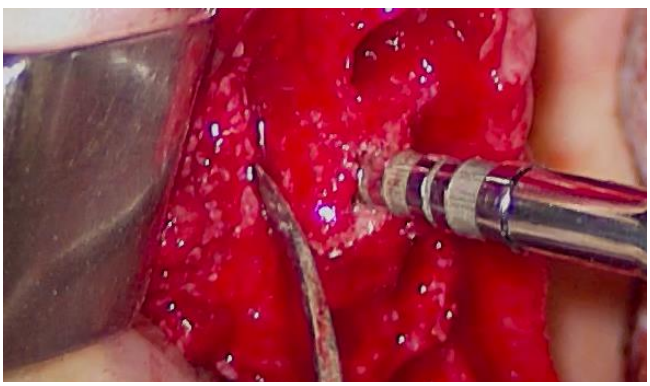

Fig. 2. *Magnetic Mallet: drills in action.*

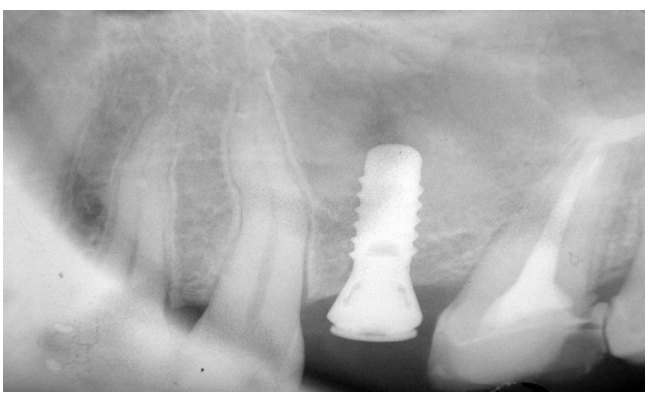

Fig. 3. *X-ray immediately after surgery.*

micron, T-off 80 micron, Frequency 10.000 Hz, tip 400 microns), in order to decontaminate the area and to improve the bone regeneration. A 10 mm long, 4.1 mm diameter and not submerged SLA implant screw ITI (Straumann, Basel, Switzerland) was used.

Manual screwing facilitated lifting the sinus membranes to the desired system height, and the initial stability was achieved. Finally, the surgical site was closed with a 4-0 resorbable suture. The implant position and the amount of sinus floor lifting were visible on radiographs (Fig. 2). Photobiomodulation (PBM) sessions were made for the first 4 months every 2 weeks, including day 0.

The patient received PBM every 14 days for 4 months using a multi-panel system consisting of eight cold lights, with a combination of penetrating wavelengths, from visible to infrared, simultaneously or singly activated on considering the effects needed, such as reduction of pain, inflammation, and oedema. PBM session releases 6 min of irradiation with 48 J/cm of fluency, calculated as the sum of the fluency produced by each cold light, 16 J/cm, multiplied for the three different light groups, 16 J/cm^2 x 3 = 48 J/cm^2. The fluency was calculated by considering 40mm as the distance from the three light groups to the patient's cheeks (delivered by lateral light groups) and lips (delivered by frontal light group) (Fig. 3).

We made two consecutive stages of irradiation in each PBM session, for a total duration of 12 min and 96 J/cm^2 of fluency delivered. A relaxation time of 1 min was made between each session. Each PBM stage was delivered every 14 days. Finally, the fluency delivered to the patients was 192 J/cm^2 per month. Amoxicillin, 500 mg for 8 hours, analgesics, and chlorhexidine mouthwash twice daily for 7 days have been prescribed to the patient. The sutures were removed after 7 days, and the patient was followed twice a month for 3 months (Fig. 4).

Eight months after inserting the implant, X-rays showed the implant and the surrounding bone under the sinus membranes tented in the second premolar region in the upper left (Fig. 5). The system has been loaded and restored with a porcelain-metal crown. X-ray taken at 36 months (Fig. 6) showed a stable clinical situation around the plant's apex. In addition, a dome-shaped structure was observed at the site of the second premolar area.

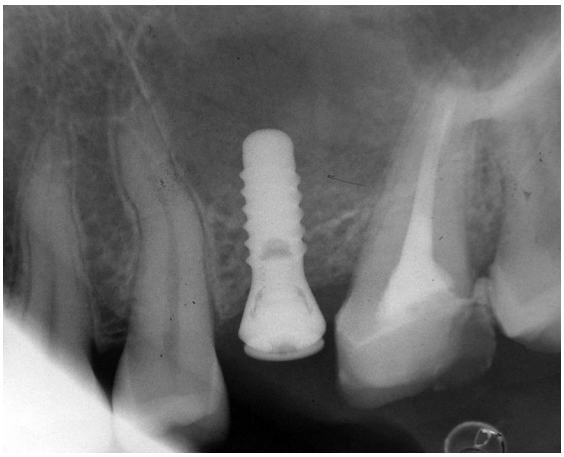

Fig. 4. *X-ray 3 months after surgery.*

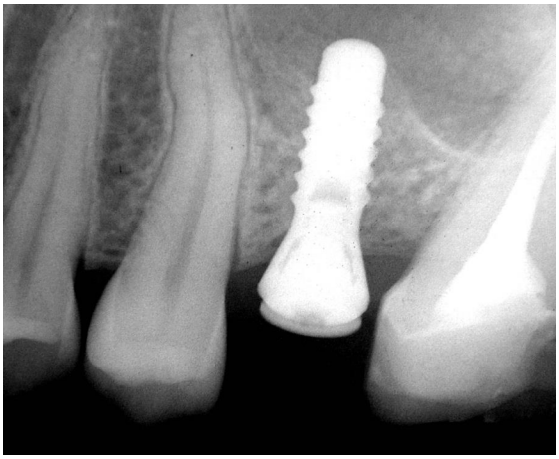

Fig. 5. *X-ray 8 months after surgery.*

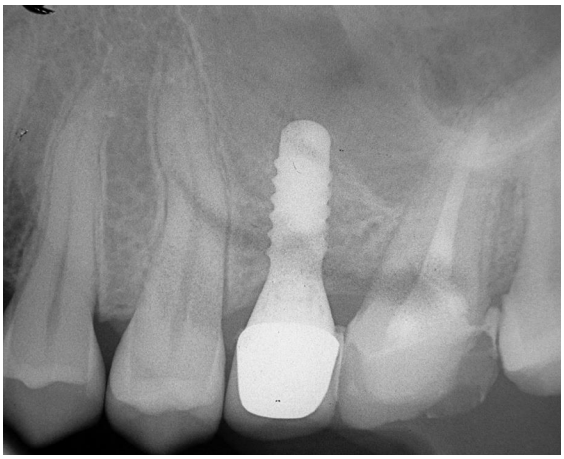

Fig. 6. *X-ray 36 months after prosthesis.*

DISCUSSION

The magnetic-dynamic technique has recently been introduced in oral bone surgery, such as dental extraction, split crest, sinus lift, and implant site preparation (4). The case reported shows the bone formation around the implant radiographically after the application of the OSFE technique realized by the magnetic mallet device.

Over time, the concept of bone formation associated with sinus lift has changed. At first, the hypothesis was that bone formation derived from the proliferation and differentiation of bone cells, induced by hormones (such as parathyroid hormone, sex steroids, calcitonin, D3 vitamin, glucocorticoids) growth factors (IGF-I and TGF-beta) and resorbed by the inflammatory process, with cytokines (IL-1, IL-4, IL-6, IL-11 and INF-gamma); in bone morphogenic units, the

interaction of these factors on bone surfaces was considered one of the actors of bone remodelling process (i.e. bone formation and resorption) (1-3,5).

After the mesenchymal stem cells' discovery and the role that this cell's family play in the bone formation process were uncovered, there was also a change of perspective on the biological basis of bone regeneration during osteotome sinus lift elevation. In 2009, Ginnady P. and Gintaras J. (6) noted that in many studies, new bone formation in the maxillary sinus by mucosal membrane lifting had been obtained with and without graft material. Even if the mechanism of this specific bone gain is unknown, some studies are investigating the role of the Schneiderian membrane in this process. Using both in vitro and in vivo assays, Srouji et al. (7) explore the osteogenic potential of the human maxillary sinus Schneiderian membrane. Osteogenesis requires active osteoblasts (bone-forming cells) derived from mesenchymal progenitors (mesenchymal stem cells). This cell type can be found in bone marrow stroma, periosteum, and other sites such as adipose tissue and microvascular walls. However, their presence in the human maxillary sinus Schneiderian membrane was not proven. Therefore, flow cytometry analysis was conducted on cultures by looking for specific markers expressed by osteogenic mesenchymal progenitors (such as STRO-1, CD105, CD146, CD 166, CD 71, and CD 73).

Gruber already underlined the presence of stem cells in the sinus Schneiderian membrane (8) and their potential for osteogenic differentiation in vitro culture. A histologic examination of the explanted samples shows a pseudostratified columnar ciliated epithelium facing the sinus cavity with a richly vascularized lamina propria and a deeper layer of periosteum-like connective tissue lacking any evidence of the presence of osseous mineralization. The data from Srouji's et al. investigation (7) show evidence of osteoprogenitor cells within the Schneiderian membrane.

Histological study of the explants from which osteoprogenitor cells were isolated indicated the absence of associated bone fragments, dispelling the possibility that the osteoprogenitor cells may be carried over from the maxillary bone underlying the sinus membrane. The deep portion of the human maxillary sinus Schneiderian membrane represents an interface with the underlying bone and could be equated to a periosteum. The osteogenic progenitors revealed from the study could have originated from this profound portion of the explanted tissue. It is, therefore, reasonable to assume that a periosteum-like membrane also lines the maxillary bone, forming the sinus floor at the site where this interfaces with the maxillary sinus mucosa and that lifting of the sinus mucosa results in the lifting of this periosteum-like membrane as well; this could be considered a possible demonstration of the importance of the role of the sinus Schneiderian membrane in new bone gain in association with osteotome sinus lift elevation without bone graft.

In 2015 a research conducted by Guo et al. proved the role of stem cells in bone formation in the maxillary sinus Schneiderian membrane (9). This study indicates the presence of a similar pattern of protein expression in human mesenchymal stem cells isolated from the maxillary sinus Schneiderian membrane and bone marrow. Despite this evidence, we combined our protocol lasers' techniques to improve stem cells' proliferation and differentiation in osteoblasts (10,11) and prevent bacteria contamination (12) during surgical procedures. The laser technique used, without any thermal stress, is without risk. A high-power diode laser combined with H_2O_2, OHLLT/Oxygen High-Level Laser Therapy can reduce the number of bacteria inside the periodontal pockets, around the implants, and inside the alveolar bone after extractions. Finally, laser therapy after surgery improved the healing of hard and soft tissues, reducing the risk of complications during bone regeneration therapy.

CONCLUSIONS

A case of sinus lift elevation by using a Magnetic Mallet in addition to laser therapy is reported. The role of the human maxillary sinus Schneiderian membrane, and the cell population of the deepest part of the membrane, in determining bone gain where a blood clot is formed around the implant is described. Laser applications help the potential of new bone formation without bone graft in the maxillary sinus since laser reduces bacteria in the surgical field.

Author Contributions

G.C. designed the research study. G.C. and A.L. performed the research. A.L. and P.C. wrote the manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

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Conflict of Interest

The authors declare no conflict of interest.

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