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COMPARATIVE STUDY OF BONE FORMATION USING PLATELET RICH PLASMA VERSUS AUTOGENOUS BONE IN MAXILLARY SINUS AUGMENTATION WITH SIMULTANEOUS IMPLANT PLACEMENT

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ABSTRACT

Background: Sinus augmentation with various types of materials had become a standard procedure to increase bone height in the posterior maxilla ,allowing placement of an implant. **Aim of the study**: To evaluate and compare clinically and radiographically the bone formation around simultaneous implant placed in the maxillary sinus with plasma rich protein (PRP) loading versus autogenous chin corticocancellous particulate. Patients and methods: This study was conducted on twelve patients with intermediate vertical posterior maxillary bone height (4-6 mm) who were randomly divided into two groups of six patients each. PRP gel was applied around and above the implant in group I. Whille ,The chin corticocancellous bone was applied to group II. In both groups, a collagen membrane was used to cover the lateral bone window. Three and six months after surgery, Cone Beam Computed Tomography (CBCT) was used to assess the degree of mineralization and height of the bone around the implant. **Results:** Radiographically, densitometric values of the bone surrounding implant via CBCT measurements were higher in autogenous bone group than PRP group at both three and six months postoperatively with statistically significant difference. As regard to bone height, measurements were higher in autogenous bone group than PRP group at both three and six months postoperatively with statistically significant difference between both groups at three months while non significance at six months postoperatively. **Conclusion:** Positive effects of both PRP and autogenous bone graft on bone density and height for sinus floor augmentation with immediate implantation has been documented.

KEYWORDS: Sinus lifting, sinus augmentation materials, platelet-rich plasma, autogenous bone.

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INTRODUCTION

Due to enhanced pneumatization of the maxillary sinus and a near contact of the sinus to crestal bone, anatomic restrictions are frequently linked with the posterior maxilla, an inadequate posterior alveolus, and a close approximation of the sinus to crestal bone. Because of sinus pneumatization, the maxillary sinus is of particular concern when implant treatment is contemplated for posteriorly edentulous individuals. This result is due to two phenomena: first, increased osteoclastic activity of the Schneiderian membrane's periosteum, and second, an increase in positive intra-antral pressure. Vertical bone availability for implants is commonly reduced or eliminated. Bone grafting and implantation can be done simultaneously if there is sufficient alveolar bone height and only partial sinus pneumatization. (1)

The implant is inserted successfully through the crestal bone into the graft material after ensuring there is at least 4-6 mm of alveolus present to anchor the implant during the healing phase. Various procedures, including lateral or crestal approaches, can help overcome a lack of alveolar bone height with bone grafting of the maxillary sinus to raise alveolar height and decrease the size of the sinus. (2)

If the alveolar bone height is to be elevated more than 3 mm, many practioners consider that more typical sinus lift methods, such as a lateral approach employing a Caldwell-Luc osteotomy (3), should be utilized instead of sub-antral augmentation. (4) To address the issue of a lack of bone, a variety of techniques and materials for enhancing bone height have been created. In order to install lengthy dental implants, sinus augmentation has become a common surgery to raise bone height in the posterior maxilla (5, 6)

Autogenous bone grafts, both intra-oral and extra-oral, are considered the gold standard since they provide no risk of immunological rejection or disease transmission. They also have osteoinductive and osteoconductive properties, as well as being a source of osteoprogenitor cells, resulting in positive clinical outcomes. However, the limited amount of intra-oral graft available, the requirement for general anesthesia, and hospitalization when extra-oral sites are used, which can result in donor site morbidity, are all downsides. (7- 9) These disadvantages of autogenous bone harvesting point to the necessity for other sources. Several authors have conducted considerable research on various bone replacements(10-12). They can be employed as an osteoconductive scaffold on their own. (13, 14)

Allogenic grafts are transmitted between members of the same species that are genetically distinct. Demineralized freeze-dried bone (DFDB) is a common substance. The antigenicity of the substance is reduced during the freeze-drying process. Because of the potential of disease transfer and significant resorption, the sinus conference in 1996 determined that DFDB is not an acceptable bone substitute. (15, 16)

The xenogeneic grafts come from a donor of different species. A bovine bone mineral is commonly used as it has a mineral structure and surface that resembles autogenous bone. It works well as an osteoconductive substance. Alloplastic materials, such as hydroxyapatite, beta-tricalcium phosphate, polymers, and bioactive glasses, are inorganic, synthetic biocompatible bone graft alternatives. The use of platelet rich plasma (PRP), platelet-derived growth factors, and transforming growth factor in the sinus graft is frequently used in clinical practice to speed up healing and improve bone production. Platelet gel provides access to autologous growth factors, which are nontoxic and immunogenic by definition and can speed up the regular processes of bone regeneration. PRP has been suggested as a way to improve the quality and quantity of regenerated bone in the oral and maxillofacial regions. However, the literature on the use of PRP as an adjuvant in sinus augmentation

is inconsistent, the theory behind the usage of PRP is that by concentrating platelets, the benefits of released growth factors will be amplified. A bone morphogenetic protein (BMP-7) is another well-known growth factor that is osteoinductive and has the potential to induce mesenchymal cells to develop into bone-forming cells. [17-18] In the 1990s, PRP and platelet concentrate were also regarded key growth factors in the area of dentistry (Marx et al., 1998). [19]

Therefore, we aimed in this study to evaluate and compare clinically and radiographically the bone formation around simultaneous implant placed in the maxillary sinus with PRP loading versus autogenous chin corticocancellous particulate.

PATIENTS AND METHODS

The current study included twelve patients (8 females and 4 males) ranging in age from 39 to 54 years old who were seeking implantation of their missing posterior maxillary teeth and had restricted bone height below the floor of the maxillary sinus due to sinus pneumatization. They were chosen from the outpatient clinic at Cairo University, Faculty of Dentistry, Oral and Maxillofacial Surgery Department. The patients were chosen based on their medical history, clinical examination, and radiographic evaluation utilizing panoramic and CBCT radiography to ensure that they met the following criteria: no recent sinus surgery, significant sinus floor convolutions, or distinct sinus septa. For the future prosthesis, the inter-arch spacing is acceptable. The height of the ridge at the implantation site should be (4-6 mm). With written consent, all patients agreed to participate in this study (Figure 1).

Patients were categorized into two groups, each with six patients. The first group received maxillary sinus lifting and implant insertion with autogenous PRP loading, while the second group had the identical operations but with autogenous chin corticocancellous bone grafting.

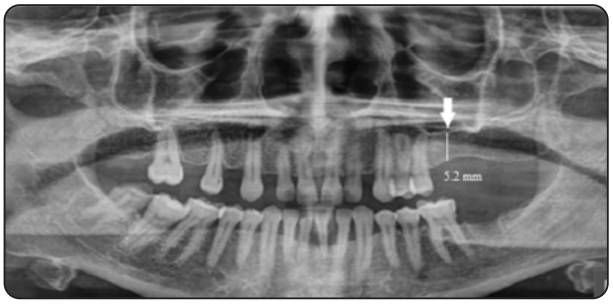

Fig. (1): A photoradiograph showing sinus pneumatization (white arrow)

Shortly before surgery, platelet-rich plasma was taken from the patient's own blood. A total of forty milliliters of venous blood were extracted and evenly distributed among eight five-milliliter tubes that had been pre-loaded with the anticoagulant citrate dextrose-A. These tubes were centrifuged at 1300 rounds per minute for 10 minutes. The total blood was split into three layers after the first spin: a bottom red-colored blood cell layer, an upper straw-colored layer containing platelet-poor plasma (PPP), and a platelet-rich plasma (PRP) layer in the border layer between these two layers. PPP and 2 mm of the top section of PRP were extracted, transferred to a new tube, and centrifuged at 3500 rpm for additional 15 minutes. This resulted in a clear yellow serum layer on top and a dark yellow layer of highly concentrated PRP on the bottom. The lowest layer of PRP was sucked into another syringe (about 0.6ml from each tube). One milliliter of 10% calcium chloride solution was combined with 80 units of USA bovine thrombin (activator). To complete the activation and gel state change of the PRP, 0.5 ml of the produced activator was added to freshly prepared platelet-rich plasma and left for 2 minutes (Each 1ml PRP requires 0.1ml of the activator to be activated). [19] (Figure 2)

Surgical procedure

The alveolar ridge and lateral wall of the maxillary sinus were uncovered using a trapezoid

flap. A pilot drill was used to make the initial hole through the surgical stent, and then the lateral window and Schneiderian membrane lifting were performed, followed by implant insertion extending into the sinus chamber. The PRP gel was used to fill the area between the sinus membrane and the sinus floor around the fixture in group I. The area over and surrounding the implant in group II was filled with autogenous bone taken from the chin. In both groups, collagen membrane was used to completely cover the lateral surgical area, and then the flap was sutured (Figures 3, 4&5).

Postoperative radiographic evaluation:

An immediate postoperative panoramic radiograph was performed to ensure the proper implant positioning. (Figure 6).

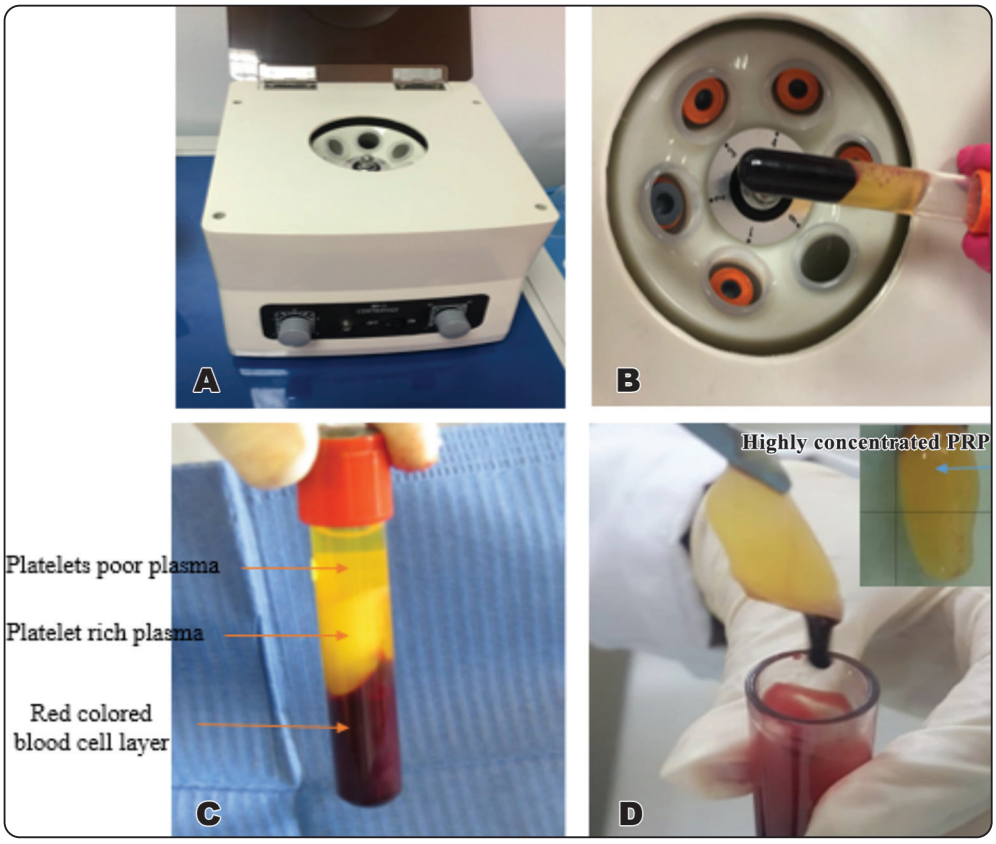

Fig. (2): Photograph showing ;(A&B): Centrifuging equipment. (C): Appearance of three layers after the first spin of centrifuging of the blood specimen. (D): Highly concentrated PRP after the second spin of centrifuging.

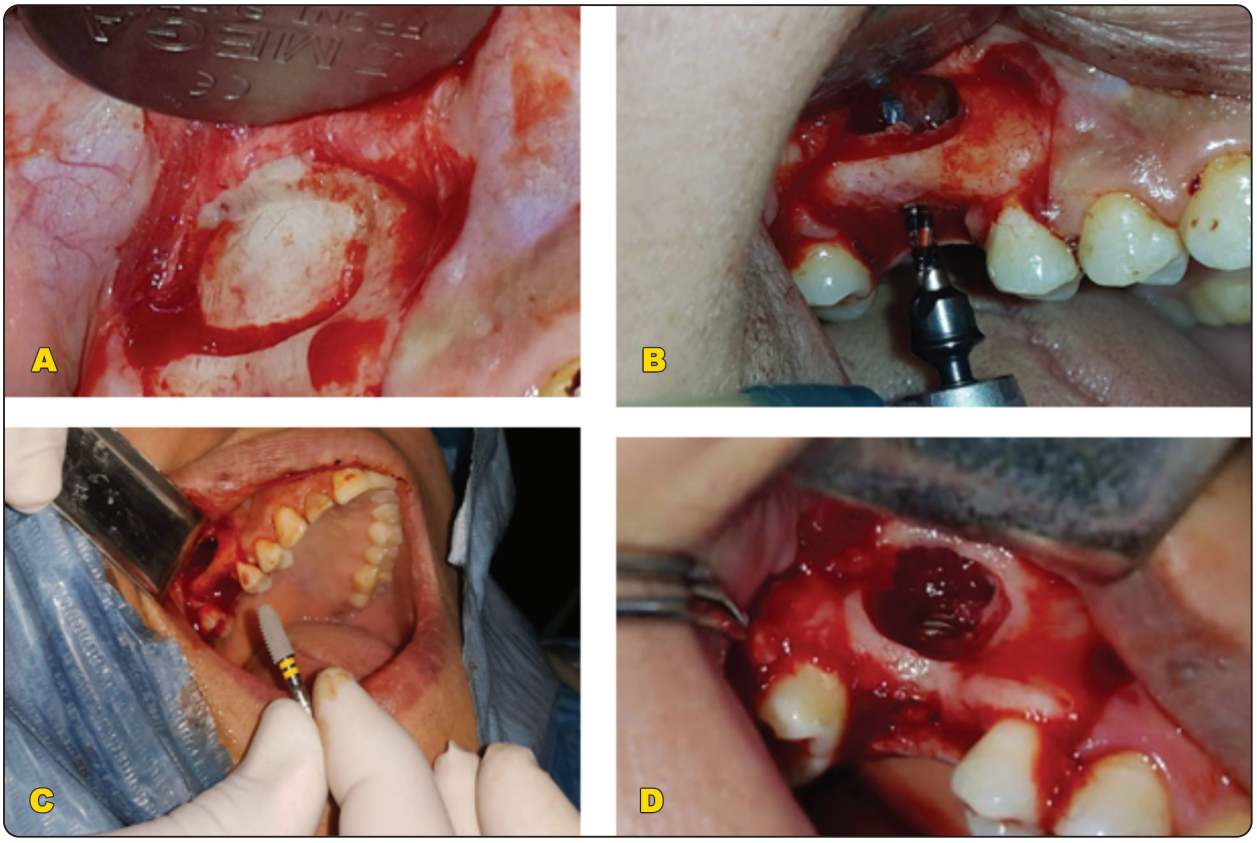

Fig. (3): A photograph showing; (A): The flap reflection. (B): Implant drilling. (C): Implant insertion. (D): The sinus membrane tented over the implant.

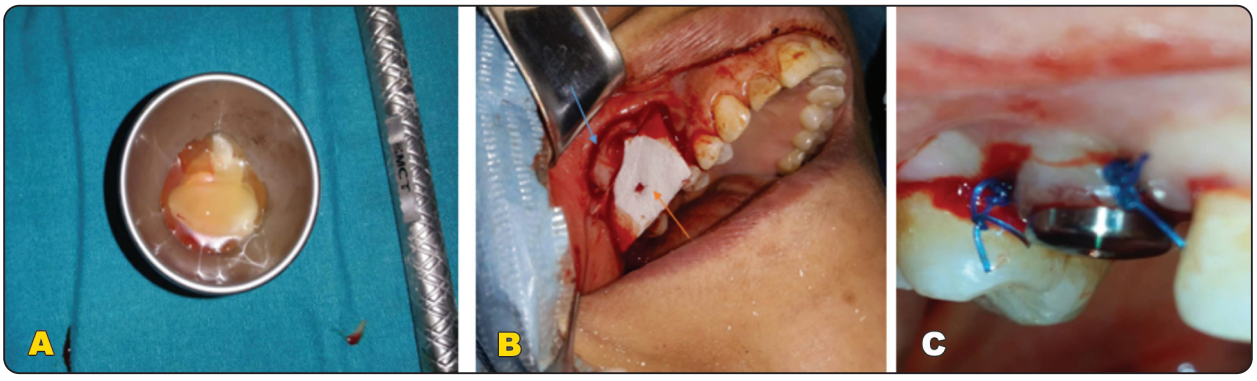

Fig. (4): A photograph showing; (A): Highly concentrated PRP after the second spin of centrifuging. (B): PRP application into the sinus (blue arrow) & collagen membrane placement (red arrow) (C): Suturing of the flap surrounding the implant. (Case No.2, group I)

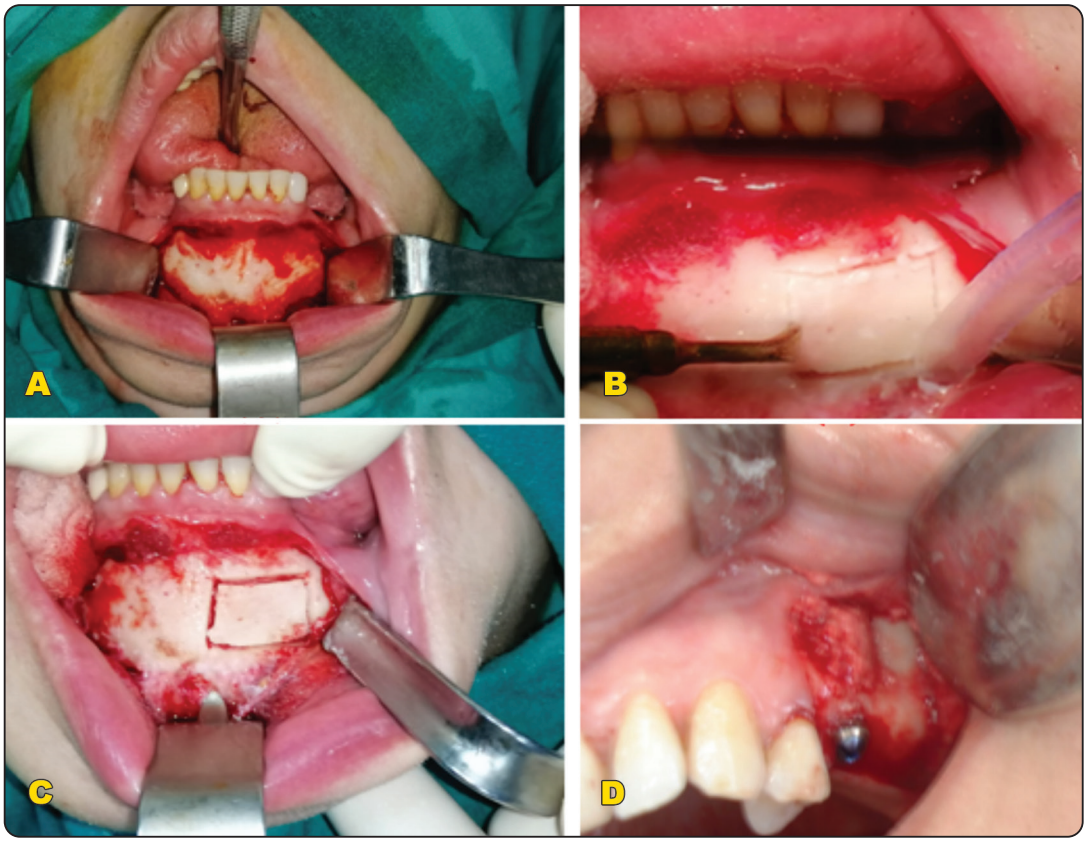

Fig. (5): A photograph showing; (A): Flap reflection. (B)&(C): Harvested autogenous bone from the chin. ((D): Autogenous bone placement over and around the implant. (Case No.2, group II)

Fig. (6): A photoradiograph showing proper implant position.

Coronal and sagittal views of CBCT were utilized to assess the amount of produced bone around the area of the implant inside the sinus cavity of all subjects using intraoral radiography (IOR) software at three and six months postoperatively.

Statistical Analysis

The distribution of numerical data was checked for normality, and normality tests were used (Kolmogorov-Smirnov and Shapiro-Wilk tests). The data of bone density and height revealed a parametric distribution. The mean and standard deviation (SD) values were used to represent the data. Measurements that are repeated ANOVA test was used to compare the groups as well as to look at how each group changed over time. When ANOVA test was significant, Bonferroni's post-hoc test was

employed for pair-wise comparisons. $P \leq 0.05$ was used as the significant level. IBM SPSS Statistics for Windows, Version 23.0, was used to conduct the statistical analysis. IBM Corporation, Armonk, New York.

RESULTS

1-Clinical results

Except for one case in each group that had a mucosal soft tissue infection that was treated with antibiotics, the whole cases healed normally using Amoxicillin 875 mg combined with clavulanic acid 125 mg antibiotic (Hibiotic, amoun pharmaceutical co. S.A.E. – Egypt). It was prescribed every 12 hours for 5 days. Chorohexitol mouth wash (Orovex mouthwash- macro group pharmaceuticals-Egypt) was used.

2-Radiographic Results

At three and six months after surgery, CBCT demonstrated bone deposition around the implants in both groups, which appeared as increased radio-opacity surrounding the implant with its protruded part inside the maxillary sinus. The density of the bone was evaluated using a grayscale value, while the height of the bone was measured in millimeters. (Figure 7).

Comparison of bone density between both groups showed that; after three as well as six months, PRP group showed statistically significant lower mean bone density than autogenous bone group (P-value < 0.001, Effect size = 0.759 at three months) and (P-value = 0.025, Effect size = 0.215 at six months). Changes by time in both groups revealed that, there was a statistically significant increase in mean bone

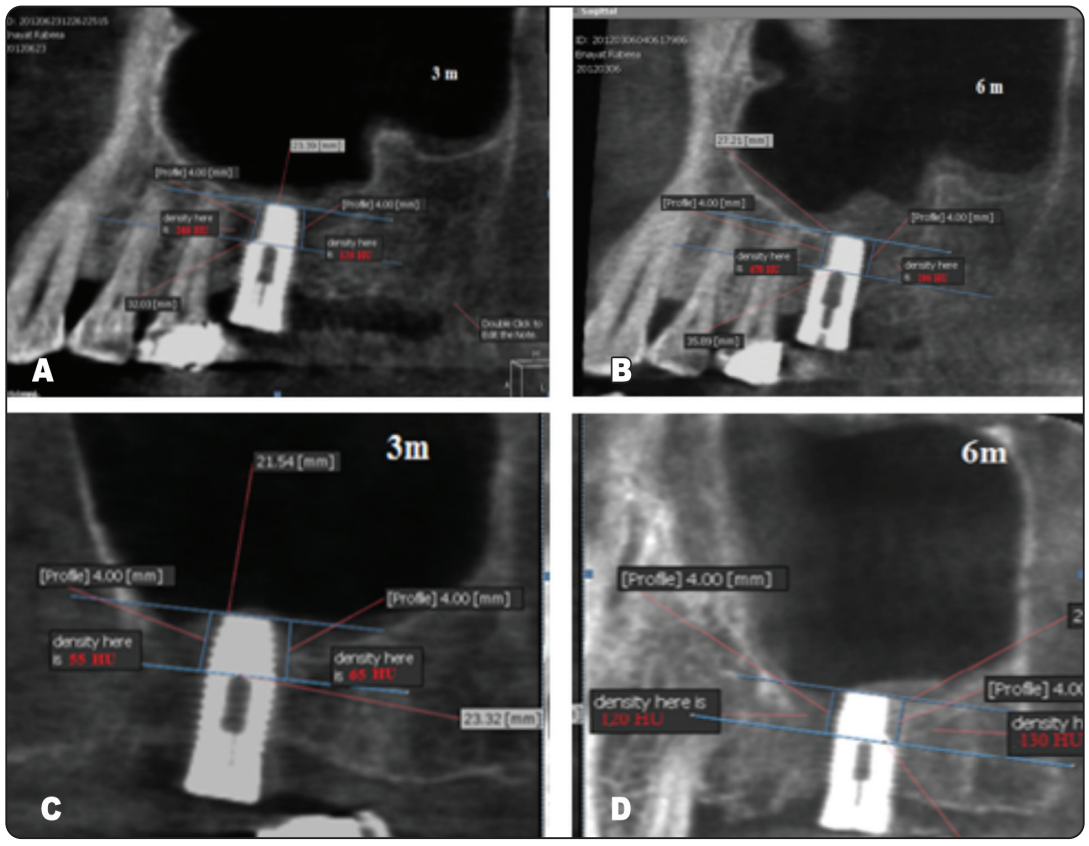

Fig. (7): A photoradiograph of post-operative CB CT (sagittal view) for bone density; (Group I): (A) 3 months, (B) 6 months. (Group II): (C) 3 months, (D) 6 months.

density after six months (P-value ≤ 0.001, Effect size = 0.882 for group I) and (P-value ≤ 0.001, Effect size = 0.735 for group II). (Table (1) & Figure (8).

Comparison of bone height between both groups revealed that; after three months; PRP group showed statistically significant lower mean bone gain than autogenous bone group. (P-value = 0.041, Effect size = 0.355). After six months; there was no statistically significant difference between bone gain in both groups (P-value = 0.066, Effect size = 0.298 at six months).

Changes by time of bone height in both groups revealed that, there was a statistically significant increase in mean bone height after six months (P-value = 0.002, Effect size = 0.623 for group I) and (P-value = 0.007, Effect size = 0.538 for group II). (Table (2) & Figure (9))

TABLE (1) The mean, standard deviation (SD) values, and results of repeated measures ANOVA test for comparison between bone densities in both groups and the changes by time within each group:

Time	PRP		Autogenous bone		P-value (between groups)	Effect size (partial eta squared)
	Mean	SD	Mean	SD		
3 months	247.9	31.2	312.5	53.6	< 0.001*	0.759
6 months	458.7	34.1	491.8	60.7	0.025*	0.215
P-value (between times)	< 0.001*		< 0.001*			
Effect size (Partial eta squared)	0.882		0.735			

**** P > 0.05: Non significant (NS); P < 0.05: Significant (S); P < 0.01: Highly significant (HS)***

TABLE (2) The mean, standard deviation (SD) values, and results of repeated measures ANOVA test for comparison between bone heights in both groups and the changes by time within each group:

Time	Group I (PRP) Mean + SD	Group II (Autogenous bone) Mean + SD	P-Value (between groups)	Effect size (partial eta squared)
3 months postoperative	2.5±0.7	3.4±0.6	0.041*	0.355
6 months postoperative	3.8±0.6	4.4±0.5	0.066*	0.298
P-value (between times)	0.002*	0.007*		
Effect size (Partial eta squared)	0.623	0.538		

**** P > 0.05: Non significant (NS); P < 0.05: Significant (S); P < 0.01: Highly significant (HS)***

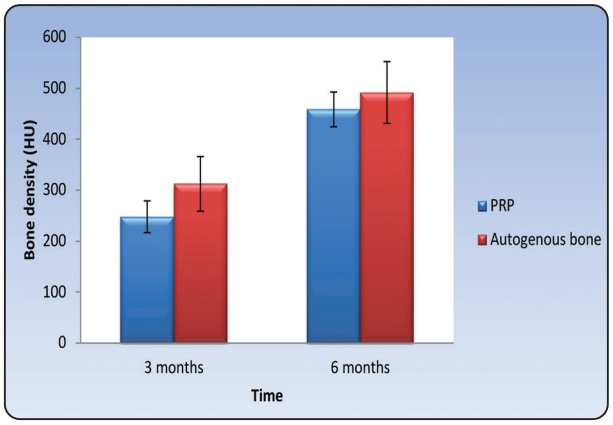

Fig. (8): Bar chart representing mean and standard deviation values for bone density in both groups.

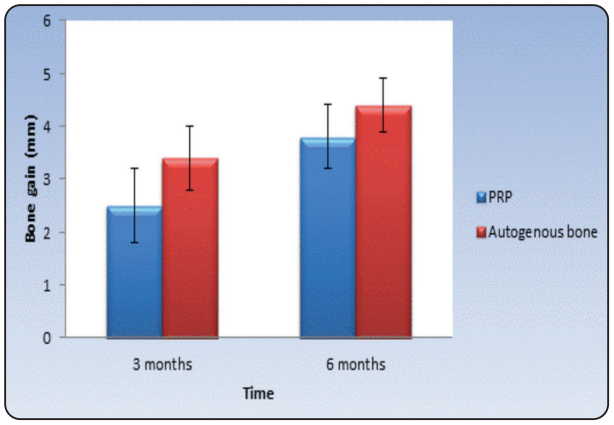

Fig. (9): Bar chart representing mean and standard deviation values for bone gain in both groups

DISCUSSION

Sinus lifting is an accepted procedure for vertical bone augmentation in the posterior maxilla, however, 17% of patients with less than 6 mm remaining bone height have implant loss. [20, 21]

Sinus lift techniques have undergone numerous changes throughout the years. Boyne - published a sinus lift with lateral access in 1960. It was first utilized to achieve the ideal intercrestal spacing required for denture fabrication. However, in 1980, Boyne and James began placing implants in the newly formed bone. Although the lateral access technique has undergone a number of changes, it remains an important concept. It is important as a sinus lift procedure, despite its significant invasiveness. [22]

In order to ensure appropriate initial implant stability, a minimum of 4mm of residual bone height was recommended in our study for simultaneous implant placement with sinus floor elevation operation, which is in agreement with Kaneko et al. [23] in patient selection criteria.

In order to improve the clinical outcome of sinus lifting treatments, bioactive substances are being investigated (Palmer et al. 2008) [24]. Platelets are a natural source of growth factors that aid tissue healing; nevertheless, the effectiveness of PRP in bone regeneration in humans remains debatable[25-28]

For bone augmentation, an autogenous bone graft is used. Maxillary sinus bone graft surgery is currently considered a safe and predictable operation. The majority of bone graft materials are known to produce good implant survival rates, however maxillary sinus bone graft materials may be absorbed over time. Because of its osteoconductive, osteoinductive, and osteogenic qualities, autogenous bone has long been regarded the "gold standard" among bone graft materials [8]. When it comes to alveolar bone deficiency, autogenous bone, according to Dragoo and Sullivan [29], is the most regenerative bone graft material.

Calvarium, tibia, ribs, or iliac bone can all be used as an autogenous bone graft. Due to issues such as the inconvenience of hospitalization, general anesthesia, the use of an autogenous bone from the oral cavity such as the mental region, mandibular ramus, and zygomatic region, is frequently used. [30] This is in accordance with our present study that had used the chin as an autogenous bone graft for a sinus lift. But, in contradiction with Hwang et al [31] as regards the selection of the site of harvesting bone graft who had documented that, the cortical bone ratio of the mandibular ramus is high, however harvesting the ramus bone is challenging. Nonetheless, when compared to mental bone, it is

the preferable bone graft material for the maxillary sinus since it has a lower risk of edema and nerve injury.

Many autogenous bone graft instances showed significant bone resorption over time. Furthermore, compared to using autogenous bone in combination with bone substitutes, a study[30] found that employing 100 percent autogenous bone as a bone graft material resulted in faster absorption. Autogenous bone in combination with bone substitutes is now frequently used [30,31] which contradicts the findings of our current investigation, that show good bone densities following autogenous bone transplant at three and six months postoperatively.

The results of our clinical study, which included 12 patients divided into two groups of six patients each, appear to show that all patients had some regeneration potential. The maxillary sinuses were lifted and implants were placed with autogenous PRP loading in group I, while group II had the same procedures but with autogenous chin corticocancellous bone grafting. Densitometric values via CBCT measurements were higher in an autogenous bone group than the PRP group at both three and six months postoperatively with statistically significant differences were recorded between both groups. As regard to bone height gain, CBCT measurements showed a statistically significant higher bone gain in control group at three months postoperatively, while became non-significant between them at six months postoperatively. these results are in accordance with Geun Lee H and Deok Kim Y [32] who showed the volumetric stability (length x width x height) of bone grafts in 95 patients via CBCT evaluation 4.2 months after autogenous bone grafting and reported that the procedure was satisfactory for patients who want dental implants regardless of atrophic alveolar bone.

Lindh et al [33] discovered a strong association between bone density and trabecular bone volume, which is supported by current evidence. This is almost definitely attributable to the fact that the measurements were taken at the same time and in the same section of the skeleton.

Furthermore, our findings are consistent with those of Lindeboom et al [34] who found that PRP had a considerable stimulating effect on capillary regeneration in wound healing after sinus floor elevation.

Although some research show higher densitometric values for the PRP sites (Marx et al. [19], Consolo et al. [27] and Gruber et al. [35]), Raghoebar et al. [36] obtained similar results to our study. Another clinical study (Thor et al. [37] suggests that PRP is unsuccessful in sinus augmentation treatments. Only a few research (Thor et al. [37] and Plachokova et al. [38]) were appropriate randomized-controlled clinical trials.

The usefulness of PRP has been debated throughout the previous decade, and it is still a hot topic in current papers. [34, 39]

In the present study, preoperative, 3 and 6 month postoperative CBCT measurements were performed to analyze and compare bone densities using the grayscale value in both groups, as well as variations over time within each group. Those findings are consistent with Vandenberghe et al. [40] studies on the use of CBCT to detect bone levels, thickness, and density accurately. Following maxillary anterior single instantaneous implant placement, Barakat et al. [41] employed CBCT as a radiographic evaluation to measure horizontal and vertical dimensional changes of the labial bone plate. It was done after the implant insertion, as well as four and seven months afterwards.

PRP on the Schneiderian membrane is a basic mechanical and biological protection that may be employed in daily practice. As a result, we can clearly answer the question: Should I fill or not fill during sinus lift surgery? The filling is not required because the natural blood clot inside the subsinus chamber is sufficient for bone healing; nevertheless, filling with PRP, i.e., optimised blood clots, appears to be an adequate option for improving natural healing and securing the surgical process. [42, 43]

CONCLUSION

The present study showed positive effects of both PRP and an autogenous bone graft on bone density and height in CBCT measurements as regard to sinus floor augmentation with immediate implantation. Densitometric values and bone height were higher in autogenous bone group than PRP group at both three and six months postoperatively around the whole length of the implant.

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