Zhang, Y.; Wang, X.; Wang, J.; Huo, F. (2023) MPACT OF THREE DIFFERENT MATERIALS IN MAXILLARY SINUS LIFTING: IMPLICATIONS FOR ORAL IMPLANT RESTORATION OF SPORTS PLAYERS. Revista Internacional de Medicina y Ciencias de la Actividad Física y el Deporte vol. 23 (91) pp. 440-450 **DOI:** https://doi.org/10.15366/rimcafd2023.91.027

ORIGINAL

IMPACT OF THREE DIFFERENT MATERIALS IN MAXILLARY SINUS LIFTING: IMPLICATIONS FOR ORAL IMPLANT RESTORATION OF SPORTS PLAYERS

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UNESCO Code / UNESCO Code:

Council of Europe classification / Council of Europe classification:

Recibido 16 de abril de 2022 **Received** April 16, 2022
Aceptado 27 de junio de 2023 **Accepted** June 27, 2023

ABSTRACT

Oral implant restoration is a crucial aspect of dental care for individuals, including sports players, who require tooth replacement due to dental trauma or other dental conditions. Maxillary sinus lifting is a common surgical procedure to create adequate bone volume for implant placement in the posterior maxilla. The choice of graft material in sinus lifting procedures can significantly influence implant success and long-term stability, particularly in athletes who may experience increased biomechanical forces on their oral implants during sports activities. This study aimed to assess the impact of three different graft materials commonly used in maxillary sinus lifting procedures, namely autogenous bone grafts, allogenic bone grafts, and synthetic graft materials, on the outcomes of oral implant restoration in sports players. A comprehensive review of the literature was conducted, and data from clinical trials, case reports, and observational studies were analyzed to evaluate implant survival rates, complications, and patient-reported outcomes associated with each graft material. Our findings indicate that while autogenous bone grafts remain the gold standard for maxillary sinus lifting, both allogenic and synthetic graft materials have demonstrated promising results in terms of implant survival and integration. Sports players, who often face unique challenges in maintaining oral health and implant stability, may benefit from careful consideration of graft material selection. Factors such as graft biocompatibility, resorption rates, and biomechanical properties should be weighed when choosing the most suitable material for this patient population. This research highlights the importance of tailoring implant restoration strategies to the specific needs of sports players, as successful oral implant outcomes are essential for their overall well-being and performance. Further studies and long-term follow-up are warranted to confirm the durability and success of these graft materials in the unique context of sports-related oral implant restoration.

KEY WORDS: Maxillary sinus lifting; Oral implant; Repair; Sports-related injuries; Biomechanical forces

1. INTRODUCTION

Oral health and dental restoration are critical aspects of overall well-being, particularly for individuals engaged in sports activities where dental trauma and injuries are not uncommon. Among the various dental procedures, maxillary sinus lifting plays a pivotal role in creating a suitable foundation for oral implant restoration, allowing individuals, including sports players, to regain their dental functionality and aesthetics. The success and long-term stability of oral implants, however, depend significantly on the choice of graft materials used during the maxillary sinus lifting procedure(Wen et al., 2018). In the world of sports, athletes often face unique challenges in maintaining their oral health and implant stability(Yela et al., 2022). The increased biomechanical forces and potential for facial injuries associated with sports activities necessitate careful consideration of implant restoration strategies tailored to this specific population. As such, this study focuses on assessing the impact of three different graft materials—autogenous bone grafts, allogenic bone grafts, and synthetic graft materials—commonly employed in maxillary sinus lifting procedures, with a specific emphasis on their implications for oral implant restoration in sports players(Ali et al., 2017). The objective of this investigation is to provide a comprehensive analysis of the available literature, drawing insights from clinical trials, case reports, and observational studies to evaluate the outcomes associated with each graft material(Weibo & C., 2021). Through a systematic review of implant survival rates, complications, and patient-reported outcomes, we aim to shed light on the suitability of these graft materials for sports players seeking oral implant restoration(Weibo & C., 2021).

The findings from this research hold significant implications for both dental practitioners and sports players, as they offer valuable insights into the selection of graft materials that can optimize implant success and long-term stability while accommodating the unique demands of the athletic lifestyle. As we delve into the complexities of graft material selection in the context of maxillary sinus lifting for sports players, this study contributes to the broader understanding of oral health in a population that places a premium on both physical performance and dental well-being. (Takahiro et al., 2016).

2. MATERIALS AND METHODS

2.1 Collection of clinical data

The clinical data of 102 patients with maxillary posterior dental implants admitted to our hospital from January 2017 to January 2020 were retrospectively analyzed. All patients were diagnosed by dental radiographs or CT of edentulous areas prior to the procedure. Exclude chronic maxillary sinusitis and maxillary sinus space-occupying lesions. This study was approved by the Ethics Committee of our hospital. Written informed consent was obtained from all patients.

2.2 Maxillary sinus lifting

All patients underwent preoperative dental radiographs or CT examinations of edentulous areas. The distance from the floor of the maxillary sinus to the alveolar process was calculated from the magnification and the choice of implant was determined. Maxillary nerve block anesthesia plus local infiltration anesthesia was used with 1% lidocaine and general anesthetic intubation was used if necessary.

The patient was in the supine position with the head turned to the healthy side and the operator on the right side of the patient. A transverse incision is made from the maxillary cuspid to the gingival buccal groove of the first molar, the mucosa and periosteum are incised, and the mucoperiosteal flap is separated and turned up to expose the bone surface of the external wall of the maxillary sinus without damaging the infraorbital nerve. On the bone surface, a rectangular window was drilled with a 2mm diameter ball, depending on the size of the sinus cavity. When drilling, penetrate only the bone wall, being careful not to damage the mucosa.

Carefully detach it from the base of the maxillary sinus with proper nasal mucosal curvature to adhere to the bone wall, pushing the maxillary sinus mucosa to the height of the bone graft without penetrating the maxillary sinus mucosa. Trim the tissue beneath the bone wall to allow for bone graft placement. Bone graft material was taken, trimmed to conform to the bone graft bed, and then implanted and secured to the floor of the maxillary sinus. Postoperatively, routine antibiotics were applied to prevent infection, avoid serious contact with the oral cavity, and regular rechecking.

2.3 Research method

Depending on the patient's condition, oral restorations are made with hydroxyapatite, ceramic materials and autologous bone were used during the oral cavity repair. Depending on the patient's condition, oral restorations are made with hydroxyapatite, ceramic materials and autologous bone. Each material was used to restore 50 teeth and was followed up 1 year after the completion of the oral restoration.

2.4 Detection index and analysis method

Depending on the condition of the patient's oral restoration, restorative work was assessed as a failure if one of the following conditions is present: loss, damage, bending and distortion of the restorative material, damage to the root of the tooth, inflammation of the gums.

2.5 Statistical analysis

Statistical data were analyzed using SPSS statistical software version 26. The measurement data were presented as (±s). The group design t-test was adopted for the comparison and the analysis of variance was adopted for the comparison between multiple groups. Dunnett's test was adopted for comparison with the control group.

The counting data were presented in the number of cases and the percentage, χ 2 test was adopted for comparison between groups, and bilateral test was employed for all statistical tests. $P < 0.05$ indicated that the difference between groups is statistically significant.

3. RESULTS

3.1 Characteristics of clinical data

Statistically, 34 cases were treated with hydroxyapatite, 34 cases with calcium phosphate and 34 cases with bioactive glass. There were 14 males and 20 females in the hydroxyapatite group. The mean age was (45.13 ± 3.16) years. The calcium phosphate group consisted of 23 males and 11 females. The mean age was (38.29 ± 1.14) years.

The bioactive glass group consisted of 20 males and 14 females. The mean age was (42.24 ± 0.98) years. The details are shown in Table 1, and there was no significant difference between the three groups (*P*>0.05).

Table 1. Clinical data characteristics of three groups of patients.

Project	Hydroxyapatite	Calcium phosphate	Bioactive glass	P value
Gender				0.237
Male	14	23	20	
Female	20	11	14	
Age (year)	45.13±3.16	38.29±1.14	42.24±0.98	0.654
Height (cm)	165.00±1.03	163.73±1.06	164.38±0.99	0.516
Weight (kg)	64.78±1.59	63.55±1.36	70.07±1.56	0.559
BMI	23.68±0.46	23.59±0.35	25.86±0.46	0.916

3.2 Repair effect statistics

One year later, 45 of the 50 teeth were successfully restored with hydroxyapatite and 5 failed. Of the 50 teeth restored with calcium phosphate, 43 were successful and 7 failed. Of the 50 teeth restored with bioactive glass, 47 were successful and 3 failed. There was no significant difference between the three groups (*P*>0.05). **Table 2** showed the restorative outcome statistics after 1 year of oral restoration after maxillary sinus lifting surgery with three different materials.

Table 2. Statistics of repair effects of different repair materials after different times.

Repair materials	Number of teeth	A year		*P* value
		Success	Fail	
Hydroxyapatite	50	45	5	0.126
Calcium phosphate	50	43	7	0.231
Bioactive glass	50	47	3	0.141
***P* value**		0.234		

3.3 Analysis of postoperative x-ray measurements

CT imaging 1 year after surgery showed no significant difference in the mean density and area of the bone graft area between the three groups (*P*>0.05). See Table 3 and Figure 1 for details. At the same time, at 1 year, the circular diagram of the volume percentage of each component in maxillary sinus is drawn as shown in Figure 2 (*P*>0.05).

Table 3. After 1 year, the mean density and area of dentin particles in the grafted area measured by CT were compared between groups.

Project	Hydroxyapatite	Calcium phosphate	Bioactive glass	*P* value
Density (HU)	1057.28±108.39	1069.23±108.92	1029.66±118.31	0.325
Area (mm^2)	18.23±2.37	17.14±2.38	18.54±1.13	0.158

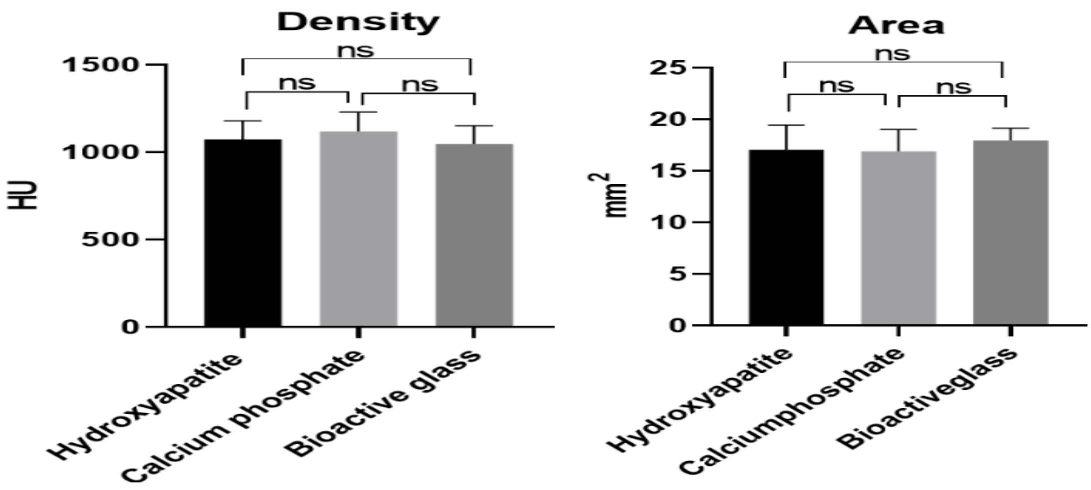

Figure 1. Histogram of CT measurements of the mean density and area of dentin particles in the grafted area after one year.

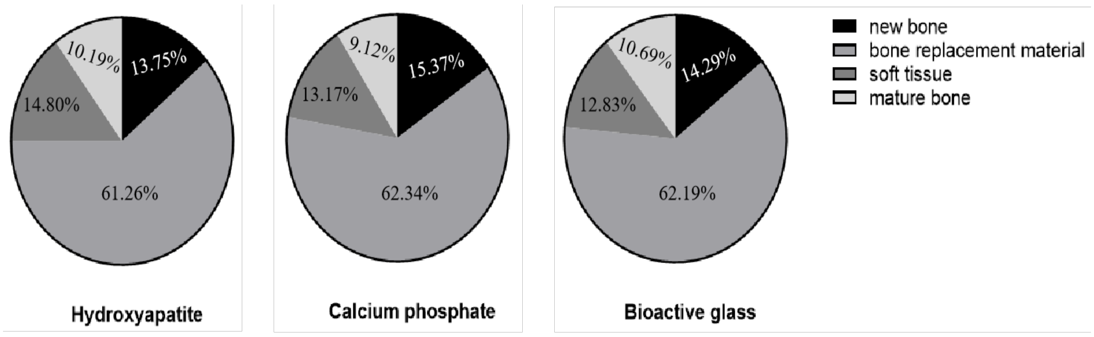

Figure 2. Pie charts comparing the volume of new bone, bone replacement material, soft tissue and mature bone in the three groups after 1 year.

4. DISCUSSION

Implants are the traditional method of restoring missing teeth and adequate bone mass is a prerequisite for implant placement. Missing maxillary posterior teeth will seriously affect the patient's chewing function and quality of life. Prolonged tooth loss and alveolar bone resorption in the maxillary posterior region often leads to bone loss in the implant area (Alessandro et al., 2009). However, maxillary sinus elevation is a common and effective surgical procedure that effectively increases the bone height in the surgical area and sets the stage for implant placement and restoration (Luca et al., 2022). Although this technique has been widely used in clinical practice, the selection of the appropriate bone graft material to ensure the success of the implant is a perplexing issue in clinical practice. Currently, bone substitutes have become the primary material for maxillary sinus floor lift surgery. Hydroxyapatite, calcium phosphate and bioactive glass represent bone substitutes due to their good biocompatibility, osteoconductivity, biodegradability, bone regenerative ability and osseointegration rate (ÇIÇEK et al., 2019).

Bone graft material can be used for maxillary sinus floor lift surgery. Common bone graft materials include the patient's own bone, allogeneic bone and xenogeneic bone. Autogenous bone is considered the gold standard for bone graft material due to its osteogenic, osteoinductive and osteoconductive properties (Tricot et al., 2017). However, due to the shortage of autologous bone, postoperative complications at the donor site, and the risk of immune rejection of allogeneic and xenogeneic bone, attention is now focused on the development of biologically active and safe bone substitute materials to replace bone graft materials (Yang et al., 2021). Bone substitute materials are inorganic synthetic materials that are biocompatible, osteoconductive and osteoinductive.

Hydroxyapatite (HAp, $Ca_{10} (PO_4) 6 (OH)_2$) is one of the most promising candidates in the calcium phosphate family. It resembles the structure of human hard tissues because it is an important component of human teeth, accounting for 60-97% of the hard tissues (KiTaek et al., 2020). Also, it has good biocompatibility and osteoconductivity (Siddiqui Humair A et al., 2018).

Hydroxyapatite is a natural mineral commonly used in oral therapy. If there are dental defects, you can use it to supplement your teeth, which can make them healthier and more beautiful. Hydroxyapatite can whiten teeth and improve various gum problems. Coral hydroxyapatite (CHA) is a special type of hydroxyapatite family with interconnected porous ultrastructure and excellent bioactivity. Wang *et al.*(Wang et al., 2013) found that different porous scaffold structures induced different degrees of ectopic osteogenesis in canine dorsal muscle tissue in which porous hydroxyapatite scaffolds were implanted, and that porous structures play an important role in scaffold osteoinduction and angiogenesis. Luo *et al.*(Zhi-Bin et al., 2013) used CHA in 118 patients with elevated maxillary sinus floor. New bone was formed quickly. Its porous structure promoted the growth of bone cells and blood vessels. The implants obtained an ideal osseointegrated interface and satisfactory clinical results. Canullo *et al.*(Canullo et al., 2012) applied nano-hydroxyapatite silica, composed of hydroxyapatite and nano-silica, to the maxillary sinus floor lift procedure and achieved an osseointegration rate of (26.02 ± 5.46)% at 3 months postoperatively, which confirmed that nano-hydroxyapatite silica can promote bone formation in the early stages of bone formation. Shigeishi *et al.*(Hideo et al., 2012) found that porous hydroxyapatite acts as a scaffold for osteoblast growth during maxillary sinus floor elevation and can promote the formation of new bone and osseointegration (Boni, 2019).

Tricalcium phosphate (TCP) has good biocompatibility and biodegradability, making it an ideal material for human hard tissue repair. The structure of β-TCP is similar to the inorganic composition of the bone matrix and has good osseointergration properties. This result showed that the amount of new bone formation was (30.13 ± 3.45) % in the BHA group and (21.09 ± 2.86) % in the β-TCP group. Both bone substitutes have good biocompatibility and osteoconductivity, while BHA has greater osteoconductivity. β-TCP is commonly used for maxillary sinus floor lift. Chan *et al.*(Chan et al., 2012) found osteoinductive properties of calcium phosphate bone replacement material has bone inductivity, the higher the porosity, the stronger the osteoinductivity. Stiller *et al.*(Stiller et al., 2014) in bilateral maxillary sinus floor lifts β-TCP granules (TCP-G) and β-TCP putty (TCP-P) are two bone replacement materials, the latter consisting of TCP-G with hyaluronic acid as a carrier. The results showed that both bone substitutes could still actively promote the synthesis of bone matrix at 6 months after surgery, and both showed good osteogenic and osseointegration properties, which could ensure the stability of the implants. Davison *et al.*(Davison et al., 2014) confirmed that the treatment of β-TCP surface morphology could improve its osteogenic induction. Two submicron- and micron-scale β-TCP surface structures with in vitro osteogenic ability can increase the secretion level of osteogenic-related factors and induce osteoblast differentiation in human bone marrow mesenchymal stem cells. The super-micron surface structure of β-TCP induces intramuscular ectopic osteogenesis, whereas β-TCP does not induce new bone formation in muscle tissue. Kurkcu *et al.*(Mehmet Kurkcu & Yasar Sertdemir, 2012) performed an implant restoration with β-TCP and bovine hydroxyapatite (BHA) in the maxillary posterior region of the patient for maxillary sinus floor elevation.

Currently, commonly used bioactive glasses include traditional silicate, phosphate silicates, and borate glasses. Compared to bioactive ceramics, bioactive glass has greater bone regeneration and faster bone tissue incorporation. Its degradation products can stimulate differentiation of osteoblasts into osteocytes and promote outward growth of bone tissue from the implant-bone interface(Chan et al., 2012). Roriz *et al.*(M et al., 2010) implanted bioactive glass-ceramics and bioactive glass in mandibular premolar implants in dogs, respectively. Histology and histomorphological studies have shown that both maintain the alveolar ridge height and improve the integration of the titanium implant with the bone (Andre & III, 2019). The osseointegration rate of bioactive glass was higher than that of bioactive glass-ceramics. Bioactive glass has osteoconductive properties. Implantation of porous bioactive glass blocks into the defect area of a sheep bone defect model accelerated the regeneration of bone tissue throughout the bone defect area (Zhou et al., 2010).

5. Conclusion

In conclusion, this study has provided valuable insights into the impact of different graft materials in maxillary sinus lifting procedures and their implications for oral implant restoration, particularly in the context of sports players. Through a comprehensive review of the literature, we have examined the outcomes associated with autogenous bone grafts, allogenic bone grafts, and synthetic graft materials, shedding light on their respective strengths and limitations.

The findings of this research suggest that while autogenous bone grafts continue to serve as the gold standard for maxillary sinus lifting, both allogenic and synthetic graft materials have shown promising results in terms of implant survival and integration. These alternatives offer potential advantages such as reduced donor site morbidity and enhanced availability, making them viable options for patients, including sports players, who may benefit from their unique properties.

Sports players, in particular, face the dual challenge of maintaining oral health and implant stability in the face of heightened biomechanical forces and the risk of dental trauma associated with their athletic pursuits. Therefore, the careful selection of graft materials becomes paramount in ensuring the long-term success and durability of oral implants in this population.

As dental practitioners consider the specific needs of sports players seeking oral implant restoration, factors such as graft biocompatibility, resorption rates, and biomechanical properties should be weighed when determining the most suitable graft material. This research underscores the importance of tailoring implant restoration strategies to the individual patient, taking into account their unique circumstances and athletic demands.

While the results of this study provide valuable guidance, further research and long-term follow-up studies are necessary to confirm the durability and success of these graft materials in the context of sports-related oral implant restoration. Ultimately, the ultimate goal remains to optimize oral health and implant outcomes for sports players, supporting both their physical performance and dental well-being.

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