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ORIGINAL

CLINICAL EFFECTS OF BONE AUGMENTATION TECHNOLOGY FOR IMPLANT RESTORATION IN ATHLETIC PATIENTS WITH MISSING MAXILLARY ANTERIOR TEETH

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ABSTRACT

Objective: The purpose of this study is to analyze the clinical outcomes of bone augmentation technology for implant restoration in athletic patients with missing maxillary anterior teeth and analyze its application values. **Methods:** The subjects of this study were 168 individuals who presented to our hospital between March 2018 and February 2020 and were missing all four of their upper front teeth (maxillary anterior teeth). Bone augmentation technology was used to restore implants in the study's participants, while the athletic patients in the control group were treated with conventional implant restoration. Moreover, the researchers randomly divided into a research group and a control group, with 84 athletic patients in each group. All athletic patients in the study group and the control group had their demographic information recorded, including gender, age and the location of missing maxillary anterior teeth; the implant restoration effects in the research group and the control group were compared at 3, 6 months and 2 years after restoration; six months after receiving an implant restoration, athletic patients in the study group and the control group were polled about their level of satisfaction with the procedure; Belser white aesthetic scores (WES) and Furhauser pink aesthetic score (PES) were scored at 3, 6 months and 2 years of implant restoration in the research group and the control group to compare the aesthetic effects; Comparison of the research group to the control group was used to establish the complication rate; the restoration effects were better in the research group than in the control group after 3, 6, and 2 years after implant restoration (P 0.05). The participants in the research study identified nine distinct patterns of marginal bone resorption surrounding the implants that met their criteria for success. **Results:** There was

no statistically significant difference between the study group and the control group in terms of gender, age, or the position of the missing maxillary anterior teeth. This was determined by comparing the two groups' demographic information. ($P > 0.05$). There was no statistically significant difference between the research group and the control group in terms of restoration outcomes three and six months after implant restoration. ($P > 0.05$); At two years' post-implant restoration, the restoration effect of the study group was statistically significantly superior than that of the control group ($P < 0.05$). Athletic Patients in the study group reported a greater level of subjective satisfaction (97.62%) compared to those in the control group (88.10%). ($P < 0.05$). At 3, 6, and 2 years after restoration, the PES and Wes scores of the research group were higher than those of the control group. ($P < 0.05$). Complication rates in the study group were 3.57 percent, significantly lower than the 13.10 percent seen in the comparison group. ($P < 0.05$). At 3, 6, and 2 years after restoration, bone resorption at the implant margin was less in the study group than in the control group. ($P < 0.05$). **Conclusion:** Bone augmentation technology has a high success rate of implant restoration, which can not only help to restore the dental function of athletic patients with missing maxillary anterior teeth, maintain the beautiful color of teeth, reduce the amount of bone resorption of implant margin, in addition to enhancing patient contentment and decreasing complication rates with missing maxillary anterior teeth, which has clinical popularization and a high application value.

KEYWORDS: bone augmentation technology; Implant restoration; missing Maxillary anterior teeth

1. INTRODUCTION

Complete dentition is closely linked to the chewing and speaking functions of teeth, and it can help keep the face's natural shape and beauty (Montaruli et al., 2017). The maxillary anterior dentition is an important aesthetic oral area and the loss of maxillary anterior teeth will lead to alveolar bone atrophy(Chu et al., 2019), lip and cheek soft tissue invagination, meaning the patient's face will seem less attractive as a result(Vetromilla, Brondani, Pereira-Cenci, & Bergoli, 2019).

In addition, the loss of maxillary anterior teeth will cause language barriers, periodontal disease, dental caries(Barakat, Bakdach, & Youssef, 2021), etc., and the adjacent teeth in the defect area of severe athletic patients will become loose and fall off due to excessive chewing pressure (Zhuang, Mao, Yang, & Wang, 2021).

At this stage, with the etiology of trauma, periodontal disease, dental caries and other causes, the incidence of the loss of maxillary anterior teeth shows an increasing trend, which brings inconvenience to athletic patients' daily

life and affects facial beauty (Sun et al., 2021). Therefore, the treatment of maxillary anterior teeth loss should take into account the restoration of tooth function, morphology and facial aesthetics(Cooper et al., 2021). Presently, porcelain fused to metal crown and bridge work or an invisible denture are the mainstays of clinical treatment for missing maxillary anterior teeth(Buser, Martin, & Belser, 2004).

Preparing adjacent teeth to act as abutments necessitates the use of a porcelain fused to metal crown and bridge, which is easy to damage dental nerves and cause acute pulpitis or pulp necrosis. Invisible denture is retained by the elastic base, but it does not have snap ring as retainer, increasing the burden of base and in the long run, it will lead to rapid absorption of periodontal tissue and loosening of adjacent teeth (Kuroda, Shinya, & Gomi, 2019). With the progress of medical technology, implant restoration is widely used in clinical dentistry(Kim et al., 2021; W. Li, 2020).

Especially for athletic patients with missing maxillary anterior teeth, implant restoration technology does not damage adjacent teeth, but also can restore mastication and language function, and ensure the aesthetic degree of teeth and face after restoration (Katafuchi, Weinstein, Leroux, Chen, & Daubert, 2018). However, the alveolar bone in the missing part may be partially absorbed, affecting the survival rate of the implant(Rammelsberg, Lorenzo‐Bermejo, & Kappel, 2017).

On the other hand, most athletic patients with maxillary anterior teeth loss caused by root fracture, traumatic loosening, and residual root restoration failure may have insufficient bone mass in the missing part of the base bone and the alveolar ridge is like blade, leading to the difficulty on the implant restoration.

Therefore, bone augmentation technology for implant restoration came into being, which has become a new treatment method for maxillary anterior teeth loss (Urban, Monje, Lozada, & Wang, 2017). Therefore, the goal of this study is to investigate the efficacy and feasibility of bone augmentation technology for implant restoration in athletic patients with missing anterior maxillary teeth(S. Li, Gao, Zhou, & Zhu, 2021).

2. Data and methods

2.1 General data

From March 2018 through February 2020, 168 athletic patients were selected from those who presented to our hospital with missing maxillary anterior teeth; they were then randomly assigned to one of two groups, the study group or the control group, with 84 athletic patients in each group. Bone augmentation technology was used to restore implants in the study's

participants, while the athletic patients in the control group were treated with conventional implant restoration.

Inclusion criteria: ① The athletic patients with stable occlusal relationship; ② The patients with no obvious soft tissue damage; ③ There was healthy bone around the implant area in the patients; ④ Athletic Patients had good oral hygiene habits. Exclusion criteria: ① Athletic Patients with acute periodontal inflammation; ② Athletic Patients with apical periodontitis; ③ Patients with torn gums; ④ The root angle was not ideal in patients; ⑤ Those with blood diseases and infectious diseases.

2.2 Therapeutic method

168 athletic patients with missing maxillary anterior teeth were treated with mouthwash for 5min, local disinfected with 1% iodine tincture and alcohol, and then local anesthetized, and the incision area was determined by X-ray film. Athletic Patients who participated in the research study were given the care that included the restoration of implants using bone augmentation technology. After determining where the implant would be placed, an incision was made at the top of the alveolar ridge to allow the bone graft to penetrate the bone surface. The incision was made to correspond with the shape and size of the bone graft, and then separate the mucoperiosteal membrane. The high-speed drilling needle was prepared for the holes step by step in the pre implantation site to prepare the implant socket. During this period, combined with bone extrusion and bone splitting, the initial stability of the implant was increased. The bone material tricalcium phosphate was implanted in the newly formed space, and the implant was installed at the same time. The bone material was filled and sutured again, and then it was well fixed and tightly covered with soft tissue to prevent the bone graft from being exposed and necrotic due to cracks during using period. After restoration, dexamethasone and antibiotics were given for 7-10 days to prevent infection, and mouthwash was used to keep the oral cavity clean. Athletic Patients in the control group had conventional implant restoration placed in their mouths. The incision, the mucoperiosteal separation, the exposing of the alveolar ridge, and the advancement of the alveolar ridge were the highlights of the procedure, preparation of implant sockets, and implant placement after irrigation with normal saline, and finally reduction and suture. And the anti-infection measures were the same as those in the research group.

2.3 Observation indications

2.3.1 evaluation of implant restoration effect

The outcomes of the implant restorations at 3, 6, and 2 years were compared between the research group and the control group. Evaluation criteria of implant restoration: ① Implant stability is good and there is no sign of activity; ② X-ray examination shows that the visible transmission area

around the implant is less than 0.25mm; ③ Two years after implantation, the vertical bone resorption is less than 4mm; ④ The periodontal depth pocket in the vertical direction of the implant is less than 5mm; ⑤ After restoration, the athletic patients do not have persistent infection, abnormal tooth sensitivity, pain and other symptoms. If the above five standards were met, it was recorded as good, and if one of them was not met, it was recorded as poor.

2.3.2 Subjective satisfaction

Both the individuals in the research group and the participants in the control group expressed the same levels of satisfaction with their implant restorations six months after the first survey. The degrees of happiness of the respondents were first categorized into three groups: pleased, basic, and dissatisfied. Then, the rate of satisfaction was calculated based on the satisfied group. Estimated percentage of satisfied customers = (caseload + satisfied cases) / count × 100%.

2.3.3 Evaluation of aesthetic effects of restoration

Belser white aesthetic scores (WES) and Furhauser pink aesthetic score (PES) were scored at 3, 6 months and in this study, the aesthetic results of dental implant restoration were compared between the study group and the control group 2 years after treatment. The PES score mainly evaluates the distal and proximal gingival papilla, the horizontal degree and contour of the gingival margin of soft tissue, alveolar bone fullness, gingival color and texture. The total score is 14 points, with a possible range of 0 to 2. The higher the rating, the more aesthetically pleasing the result.(Chen, Chiang, & Zhang, 2018). The WES score primarily evaluates the crown shape, contour, crown color, surface texture, and transparency personalization. If there is no difference, you receive 2 points; if there is a small difference, you receive 1 point; and if there is a significant difference, you receive 0 points out of a possible 10. The result will have a greater degree of aesthetic appeal proportional to the rating.(Genetti et al., 2022).

2.3.4 The incidence of complications

At 2 years' post-restoration, the incidence of complications was compared between the research group and the control group. including implant fracture, inflammatory response and gingival edge recession, and the complication rate was calculated. The complication rate = (frequency with which implants break + number of people who have an inflammatory response+ number of gingival edge recession cases) / cases counted in total×100%.

2.3.5 The amount of bone resorption at implant margin

A comparison was made between the study group and the control group

based on the amount of bone resorption that occurred at the implant margin at 3, 6, and 2 years after the restoration of the implant. The amount of bone resorption at the implant margin was measured and calculated by taking X-ray apical films.

2.4 Statistical analysis

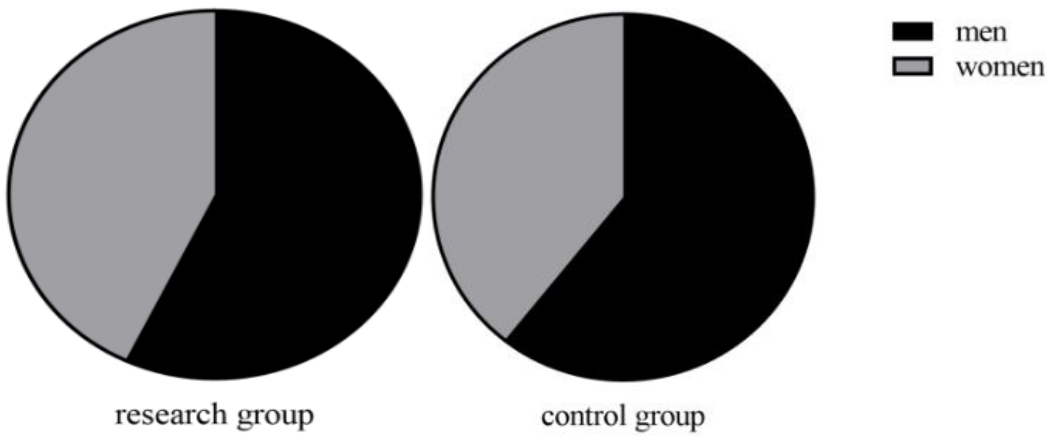
SPSS 21.0 was used to conduct statistical analysis on the experimental data, and the results were presented in the form of ($\bar{x} \pm s$). In order to determine the statistical significance between the two groups, an independent-sample t test was run, and the numerical results were presented as [n (%)], and statistical analysis was conducted by x^2 test. When P < 0.05 displayed a statistically significant distinction.

3. Results

Comparison of research and control group general data: There was no statistically significant difference between the study group and the control group with regards to gender, age, or the position of the missing maxillary anterior teeth ($P > 0.05$), as shown in Table 1 and Figure 1.

Table 1: Comparison of research and control group data (n=84)

GENERAL DATA	RESEARCH GROUP	CONTROL GROUP	X^2/T	P
GENDER (N,%)			0.221	0.638
MALE	48 (57.14)	51 (60.71)		
FEMALE	36 (42.86)	33 (39.29)		
AGE (YEARS)	46.04±8.40	45.75±8.57	0.218	0.828
MISSING MAXILLARY ANTERIOR TEETH (N,%)			0.132	0.936
MAXILLARY CENTRAL INCISOR	50 (59.52)	48 (57.14)		
MAXILLARY LATERAL INCISOR	21 (25)	23 (27.38)		
MAXILLARY CANINE	13 (15.48)	13 (15.48)		



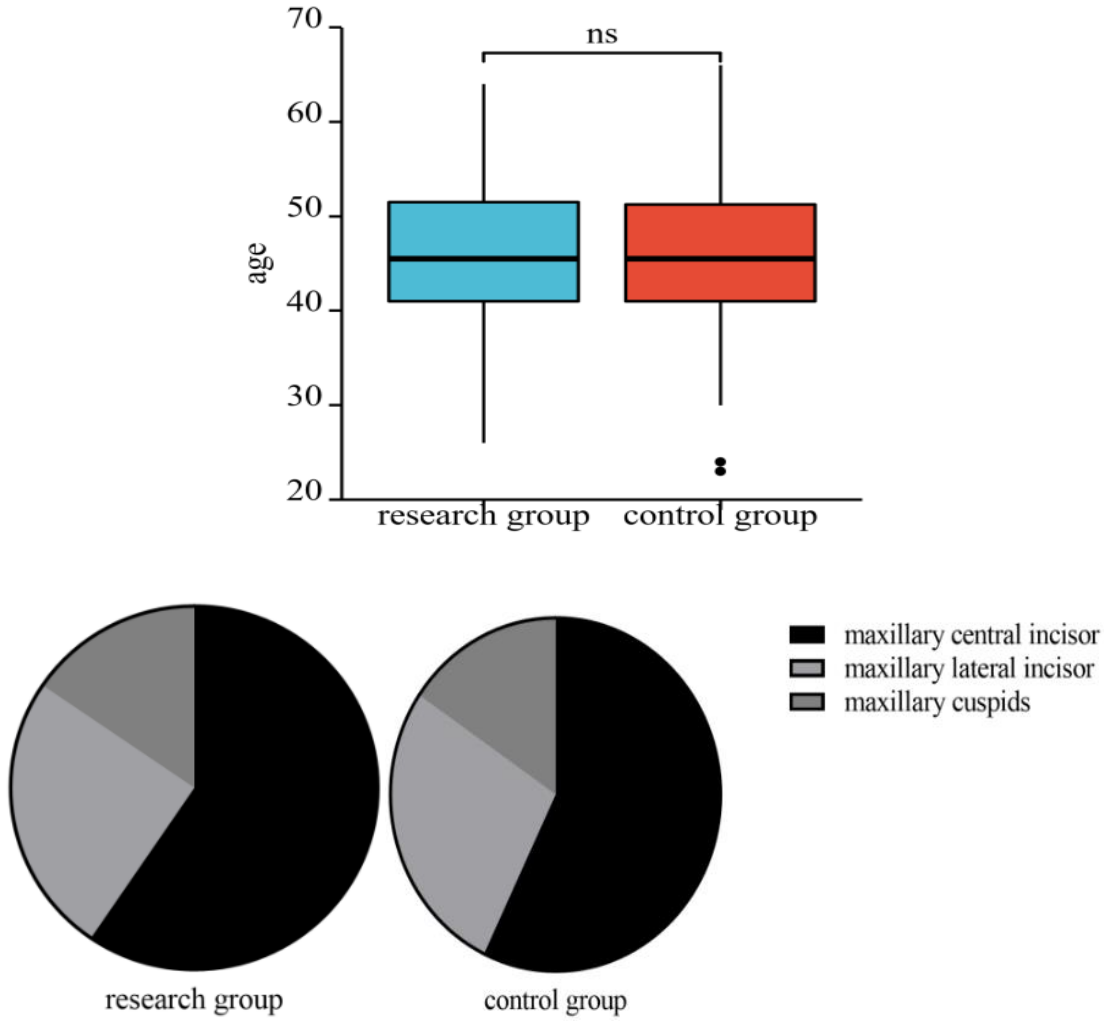


Figure 1: Comparison between study and control group general data

Research group and control group implant restoration effects: Both the study group and the control group experienced comparable success rates with regard to implant repair at the three and six month marks. ($P > 0.05$); two years after receiving implant repair, the restoration effect of the group that participated in the research was considerably superior to that of the group that served as the control. ($P < 0.05$), as shown in Table 2 and Figure 2.

Table 2 Research and control group implant restoration evaluation (n, %)

GROUPING	N	3 MONTHS		6 MONTHS		TWO YEARS	
		GOOD	POOR	GOOD	POOR	GOOD	POOR
RESEARCH GROUP	84	83 (98.81)	1 (1.19)	81 (96.43)	3 (3.57)	79 (94.05)	5 (5.95)
CONTROL GROUP	84	81 (96.43)	3 (3.57)	78 (92.86)	6 (7.14)	68 (80.95)	16 (19.05)
X^2	-	1.024		1.057		6.585	
P	-	0.311		0.304		0.010	

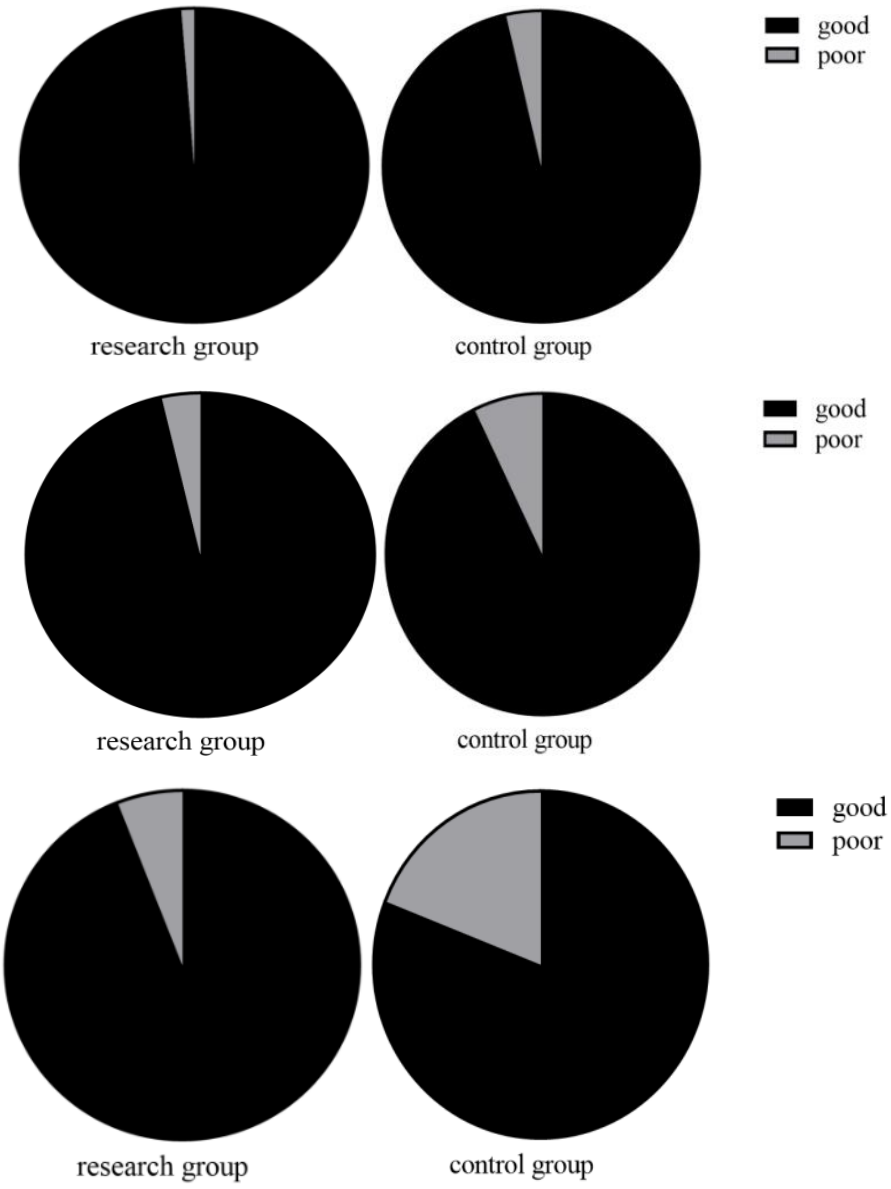


Figure 2: Research group and control group implant restoration effects at 3, 6 months, and 2 years

Subjective satisfaction was higher among athletic patients in the research group (97.62%) than among athletic patients in the control group (88.10%). This was statistically significant. (P <0.05)

Table 3 Satisfaction of research and control group athletic patients (n, %)

GROUPING	N	SATISFACTION	BASICALLY SATISFIED	DISSATISFIED	SUBJECTIVE SATISFACTION
RESEARCH GROUP	84	69 (82.14)	13 (15.48)	2 (2.38)	82 (97.62)
CONTROL GROUP	84	51 (60.71)	23 (27.38)	10 (11.90)	74 (88.10)
X^2	-	-	-	-	10.811
P	-	-	-	-	0.004

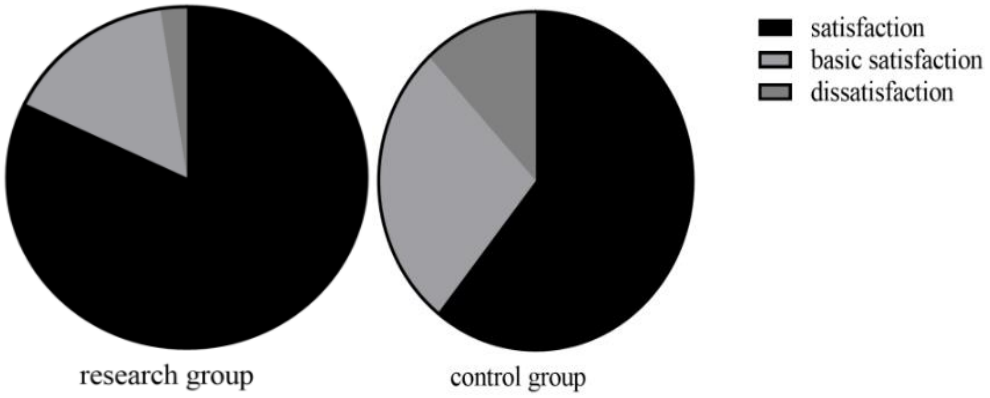


Figure 3: Research group and control group patient satisfaction

When comparing the cosmetic results of restoration in the study group and the control group, the PES and WES scores of the study group were significantly higher than those of the control group after 3,6 months and 2 years of restoration. ($P < 0.05$), as shown in Table 4 and Figure 4.

Table 4 Evaluation of research group and control group aesthetic restoration (n=84, $\bar{x} \pm s$)

GROUPING	3 MONTHS		6 MONTHS		TWO YEARS	
	PES SCORE	WES SCORE	PES SCORE	WES SCORE	PES SCORE	WES SCORE
RESEARCH GROUP	8.12 ± 0.39	6.30 ± 0.46	10.12 ± 0.42	7.65 ± 0.48	12.25 ± 0.62	8.45 ± 0.55
CONTROL GROUP	6.96 ± 0.24	5.26 ± 0.44	8.26 ± 0.44	6.15 ± 0.36	9.83 ± 0.37	7.30 ± 0.46
X^2	22.917	14.876	27.830	22.876	30.624	14.813
P	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

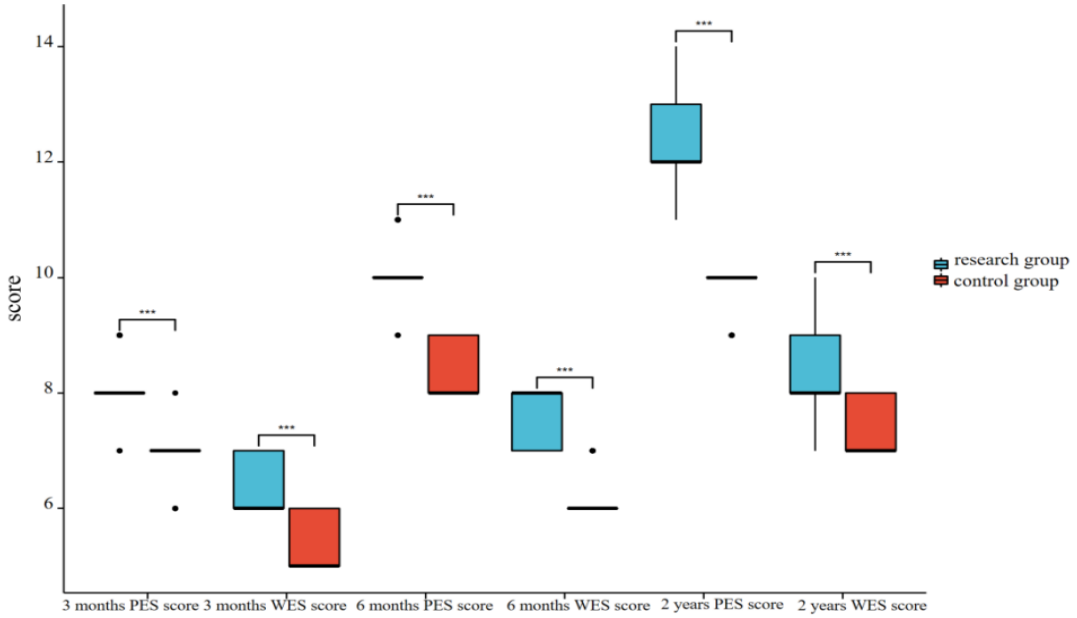


Figure 4: Evaluation of restoration aesthetics in research and control groups

The difference between the rate of complications in the study's control group (13.1%) and that of the research group (3.57%) is statistically significant when the two rates are compared to one another. ($P < 0.05$), as shown in Table 5 and Figure 5.

Table 5: Comparing experimental and control group complications (n, %)

GROUPING	N	IMPLANT FRACTURE	INFLAMMATORY RESPONSE	GINGIVAL MARGIN RECESSION	INCIDENCE RATE
RESEARCH GROUP	84	0 (0)	2 (2.38)	1 (1.19)	3 (3.57)
CONTROL GROUP	84	3 (3.57)	5 (5.95)	3 (3.57)	11 (13.10)
X^2	-	-	-	-	4.987
P	-	-	-	-	0.026

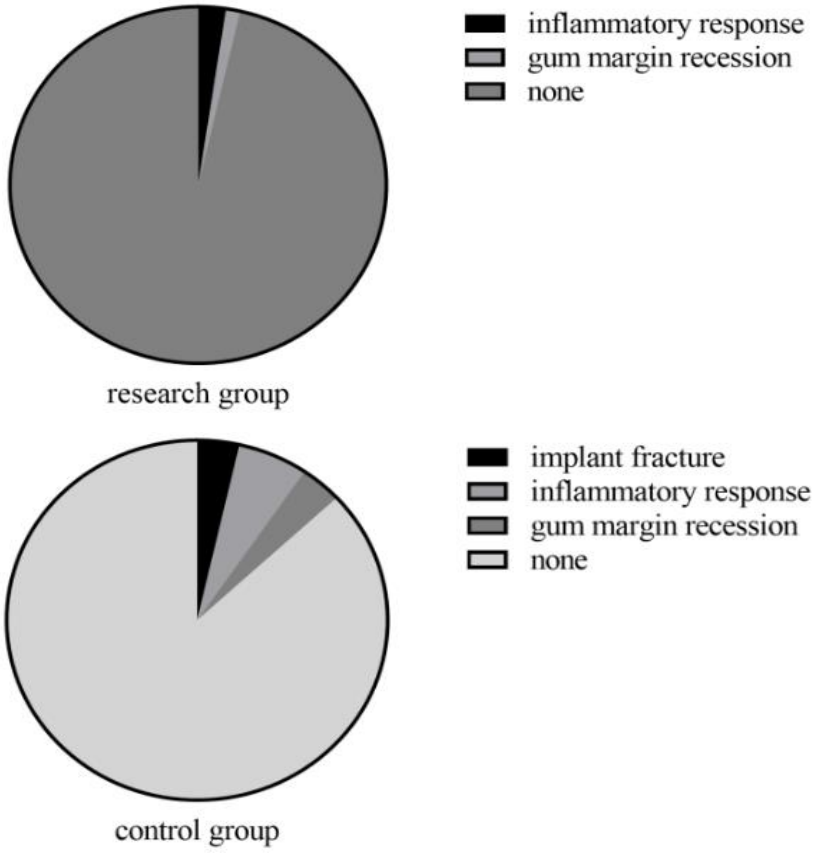


Figure 5: Research and control group complications

Comparing the study group and the control group statistically in terms of bone resorption at the implant margin: There was a statistically significant difference between the research group and the control group in terms of the amount of bone resorption at the implant margin at 3, 6 months and 2 years after restoration. This finding was based on the fact that there was a comparison between the two groups. ($P < 0.05$), as shown in Table 6 and Figure 6.

Table 6 Quantitative analysis of implant margin bone resorption in the study group versus the control group (n=84, $\bar{x} \pm s$)

GROUPING	3 MONTHS (MM)	6 MONTHS (MM)	TWO YEARS (MM)
RESEARCH GROUP	0.32 ± 0.04	0.58 ± 0.06	0.73 ± 0.05
CONTROL GROUP	0.53 ± 0.06	0.71 ± 0.08	0.88 ± 0.09
X^2	26.667	12.098	13.252
P	< 0.001	< 0.001	< 0.001

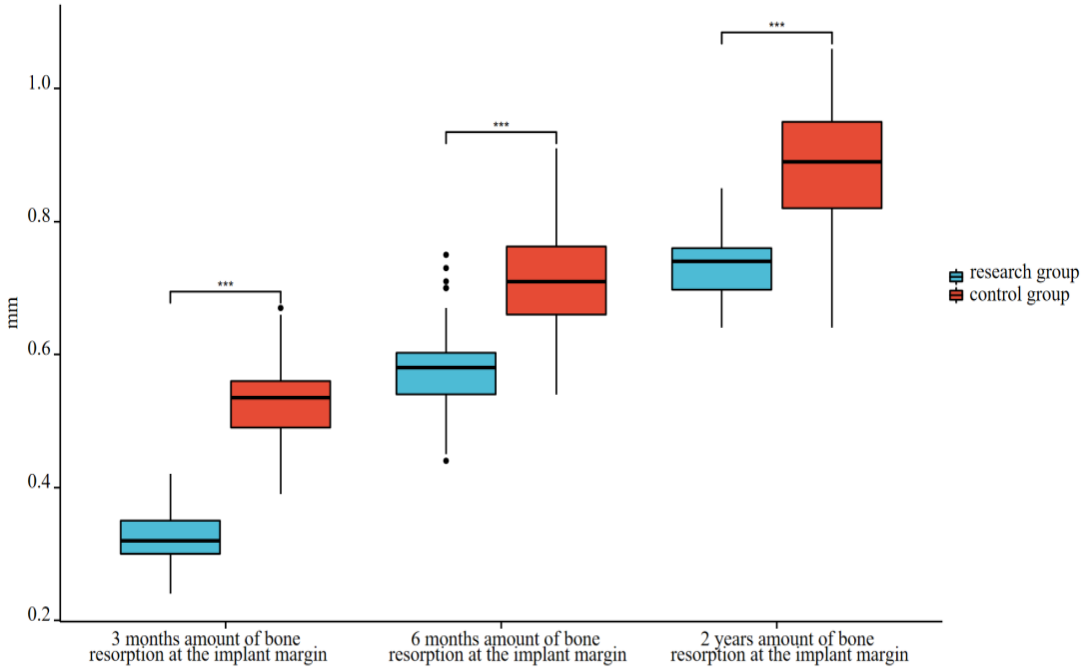


Figure 6: Quantitative comparison of implant margin bone loss in the study and control groups

4. Discussion

The missing maxillary anterior teeth is one of the common types of dentition loss in clinic, which refers to the loss of teeth in the maxillary anterior region(Keceli et al., 2017), resulting in incomplete permanent dentition, affecting the patient's language function, chewing function and facial beauty, and is not conducive to the patient's healthy life (Jung et al., 2009). Most of the maxillary anterior teeth are missing due to root fracture, periapical lesions, periodontal lesions, caries and other reasons.

The missing situation is complex, which makes the alveolar bone absorption and reconstruction of athletic patients obvious, and most athletic patients are accompanied by insufficient bone volume of the tooth base, maxillary anterior teeth coverage, alveolar ridge stenosis in the missing tooth area and other conditions, so it is difficult to restoration (Owsley et al., 2006).

The maxillary anterior teeth are located in front of the dental arch, with a

single root, which is relatively fragile, and are significantly exposed to the mouth when speaking and eating, affecting the facial beauty. Therefore, when the restoration is conducted, it not only considers practicality and comfort, but also the aesthetic should be considered (Gomez‐Meda, Esquivel, & Blatz, 2021). Restoration options for missing upper front teeth have shifted in recent years to include both porcelain fused to metal crown and bridge work and full sets of removable dentures. Although these two methods have improved the situation of maxillary anterior teeth loss, they both have certain shortcomings, such as increasing the pressure of adjacent teeth, involving abutments, etc., and the clinical efficacy is not very satisfactory (Castiglione, Tipaldi, Rossi, & Krokidis, 2021; Chai, Bennani, Aarts, & Lyons, 2018).

Because of developments in medical technology and an increase in the number of people seeking medical care, we are currently in a position where implant restoration has become an important treatment method for dentition loss(Stober, Bermejo, Rues, & Rammelsberg, 2019). But implant restoration has higher requirements for alveolar bone absorption and bone mass in the implant area. In general, the alveolar bone of athletic patients with missing dentition are often affected by many factors, then leading the constant absorption, such as the reasons for missing teeth, the time of missing teeth, bone density of alveolar bone, the stress condition of alveolar ridge, the general condition of the body and bone metabolism.

The labial alveolar bone in the maxillary anterior tooth area is relatively weak, which is easy to absorb after the loss of maxillary anterior teeth, causing the defects of the labial bone plate, and the bone absorption of alveolar ridge is not reversible. Bone resorption continues slowly over time, eventually causing a progressive reduction in bone quality and bone mass(Deng et al., 2020). Therefore, for patients undergoing implant restoration, even if the bone quality and bone mass of their alveolar bone meet the minimum implantation standard during treatment, the bone resorption of their alveolar bone will not stop or be improved with the implantation of implants, on the contrary, the absorption of their alveolar bone will proceed slowly.

With the increase of implant implantation time and the aggravation of bone resorption of alveolar bone, complications such as implant exposure, inflammatory response and infection may occur later. Therefore, the bone quality and bone mass in the implant area are important influencing factors for the effects of implant restoration in athletic patients with dentition loss. In addition, successful implant restoration can not only provide sufficient bone bonding, but also meet the aesthetic requirements of soft tissue and face.

In order to be eligible for an implant-retained repair, athletic patients who are missing their front maxillary teeth must have an alveolar bone that is at least 10 millimeters in height and at least 5 millimeters in thickness. Within a year of

a patient losing their maxillary front teeth, the patient's alveolar ridges will have shrunk by approximately a quarter in both height and breadth, and with the passage of time, it may eventually be reduced to half or less. Therefore, the insufficient bone quality and bone mass in the implant area is a thorny problem in the clinical treatment process, which is not conducive to the development and promotion of implant restoration technology, but also reduces the survival rate of implants.

At this stage, bone augmentation technology has been applied to the treatment of oral diseases, and it is increasingly mature, which has expanded the clinical application scope of dental implants to a certain extent. At present, the commonly used bone augmentation technologies in clinical implant restoration mainly include autologous bone extraction, bone splitting, bone extrusion, etc, which make up for the horizontal and vertical bone defects caused by teeth loss and solve the problems of insufficient horizontal width and vertical height of alveolar bone at the missing site, establish a biological barrier between the soft tissue and the bone defect in order to facilitate the colonization of the bone defect site by slower-moving but potentially faster-growing precursor osteoblasts, and at the same time, it protects blood clots, reduces pressure, and achieves bone reparative regeneration in the defect area.

The athletic patients with maxillary anterior teeth missing were included in this study as the research objects. They were treated with bone augmentation technology and conventional implant restoration. After observing the athletic patients' situation, it was found that after bone augmentation technology for implant restoration, the clinical treatment effects of athletic patients were better, the subjective satisfaction, PES score and Wes score were higher, the incidence of complications and the amount of bone resorption at the implant margin were lower, it is suggested that bone augmentation technology for implant restoration can restore the normal teeth, chewing and language functions of athletic patients with good aesthetic effect and high facial and oral aesthetics, this is because implant repair by bone augmentation has the potential to maintain bone quality and bone mass in the area of the maxilla that was originally occupied by the anterior teeth, and bone augmentation technology for implant restoration can also prevent cell fibrosis in soft tissue around the implant, so that the bone surface has sufficient time to generate bone cells, which guarantees the successful Osseo integration of implant and surrounding tissues, and improves the long-term curative effect at the same time.

In conclusion, bone augmentation technology for implant restoration applied to athletic patients with maxillary anterior teeth loss has a good clinical efficacy, which can not only help athletic patients restore dental function, improve language and chewing function, by using a whitening system, you can ensure that you have a healthy smile, improve the aesthetic appeal of your teeth,

and this has a wide range of therapeutic applications and a significant number of practical benefits. It can reduce the risk of bone loss around your implants, improve implant survival, lower the rate of complications, and boost patient satisfaction.

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