ORIGINAL RESEARCH

Clinical Effects of Simultaneous Implant Placement in Hydraulic Maxillary Sinus Lift Without Bone Grafting

Shuhuai Zhang, BD; Xiaoping Lu, BD; Zhimin Chen, BD

ABSTRACT

Context • Tooth absence is a pervasive oral condition and mostly occurs as maxillary tooth absence. The only way to treat tooth absence in adults is prosthesis implantation, and implant therapy usually requires repair of the maxillary sinus to its original state using a maxillary sinus lift (MSL). MSL has usually included bone augmentation with bone grafting simultaneously with the placement of the dental implant.

Objective • The study intended to examine the clinical effects of placement of dental implants using the hydraulic maxillary sinus lift (MSL), without bone grafting, to offer new guidance, to make suggestions for future clinical treatment of tooth absence, and also to lay a reliable foundation for subsequent research on MSL without bone grafting.

Design • The research team designed a randomized controlled trial.

Setting • The study occurred at Suzhou Kowloon Hospital at the Shanghai Jiaotong University School of Medicine in Suzhou, China.

Participants • Participants were 68 patients at the hospital with tooth defects between February 2019 and December 2019.

Intervention • Participants were randomly assigned to the intervention group or the control group. Both groups received dental-implant placement in the hydraulic MSL, but the intervention group's surgery didn't include bone grafting, while the control group's included simultaneous bone grafting.

Outcome Measures • Participants' surgical experience were evaluated using a visual analog scale (VAS) and the General Comfort Questionnaire (GCQ), and inflammatory factors were quantified using an enzyme-linked immunosorbent assay (ELISA). Participants' periodontal conditions after surgery were assessed, using tests for bone mineral density (BMD), periodontal probing depth (PPD), clinical attachment level (CAL), plaque index (PLI), and bleeding index (BI) as well as measurements of the implant retention rate, new bone acquisition around implants, and vertical bone loss. Participants' surgical costs were also evaluated. At a one-year follow-up, a masticatory function score and the Medical Outcomes Study (MOS) 36-Item Short-Form Health Survey (SF-36) were used for an evaluation of participants' prognoses.

Results • The intervention group had a significantly lower incidence of postoperative adverse reactions, lower intraoperative blood loss, and shorter operation time than did the control group (all $P<.05$). After surgery at week1, the intervention group showed significantly lower levels of inflammatory factors than the control group did (all $P<.05$). Postoperatively at month 6, the intervention group had a significantly higher implant retention rate than did the control group ($P<.05$).

Conclusions • Simultaneous implant placement in a hydraulic MSL without bone grafting can deliver favorable therapeutic effects, with a high safety profile, which can effectively optimize the surgical process, improve patients' postoperative feelings, and reduce surgical expenses, making it easy to popularize clinically. (*Altern Ther Health Med.* 2022;28(7):111-119).

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Tooth absence is a pervasive oral condition with a high incidence, probably caused by caries, trauma, abrasion, and developmental malformation.[1] Out of every 50 individuals, 1-3 cases of tooth absence exist worldwide, and over 40% of those individuals have underlying factors that have induced tooth absence.[2,3]

Tooth absence mostly occurs as maxillary tooth absence, mainly involving the incisors, premolars, and third molars.[4] The development of tooth absence can give rise to abnormal

development of contralateral teeth, bringing about functional hazards, such as alveolar bone atrophy, malocclusion, facial muscle disorder, and decreased masticatory function, which can further aggravate tooth absence.[5] Due to tooth absence, periodontal tissues are more likely to accumulate pathogenic bacteria, and thus, suffer a series of periodontal diseases, even life- threatening malignant diseases such as oral cancer and tongue cancer in severe cases.[6]

Adult teeth are incapable of redeveloping and growing, so the only way to treat tooth absence in adults is prosthesis implantation, which can have remarkable effects.[7] However, many individuals don't pay enough attention to their tooth absence due to a lack of medical and health knowledge or to the fact that the tooth absence hasn't yet compromised their normal living conditions; few patients get teeth implanting in time to prevent adverse outcomes.[8]

According to Pjetursson et al's survey, only approximately 20%-30% of patients receive timely treatment with dental implants, and most of them are young or in middle age.[9] In the 1980s and 1990s when the medical technology and medical issues were poorly publicized, even fewer patients received dental implants.[10] Patients with maxillary tooth absence who haven't received dental implants usually suffer severe displacement of the maxillary sinus wall.

Implant therapy usually requires repair of the maxillary sinus to its original state, and a maxillary sinus lift (MSL) is one indispensable treatment for it.[11] The MSL is a frequently adopted surgery in clinical practice because some patients who need a dental implant don't have enough bone to support it.The MSL raises the membrane on the floor of the maxillary sinus to provide a space between the membrane and the floor. During the MSL, bone tissues or artificial bone-substitute materials are implanted in that space to repair the normal structure of the maxilla and periodontium, and this bone augmentation occurs simultaneously with the placement of the dental implant.[12]

Implantation of bone or bone materials during MSL can help form new and complete bone tissues in the maxillary sinus, and thus, provide a stable basic environment for subsequent implantation.[13] Some prior research has suggested that materials must be implanted to repair damaged bone structures in MSL to ensure the stability and firmness of implants.[14] However, since the 1980s when MSL with bone grafting emerged, increasing evidence has indicated that MSL without bone grafting can also deliver excellent results.[15,16] The two methods are the subject of great controversy.

Recent research has repeatedly shown that the maxillary sinus mucosa possesses obvious osteogenesis ability, and bone formation can still be seen at the bottom of the maxillary sinus after removing the residual root in the maxillary sinus.[17,18] This is of profound significance for simplification of the MSL process, shortening of the operation time and reduction of treatment cost. Other research has revealed clearly expressed alkaline phosphatase, bone morphogenetic protein, and osteocalcin and other osteogenic molecules in the mucosal cells of maxillary sinus floor,[19] which is the basis of MSL without bone grafting.

Implant surgery can penetrate a patient's maxillary sinus wall, giving rise to serious infections and pain.[20] It's imperative to conduct maxillary sinus lift (MSL) to correct the maxillary sinus wall and ensure the successful placement of the implants in the maxilla.[21] Because implanted bone material enhances the coverage rate of the maxillary sinus, a maxillary sinus perforation may not be found in time to fix during the surgery. [22] Without bone grafting, this limitation can be addressed, and maxillary sinus lesions can be monitored and evaluated more effectively, which is also helpful in reducing the incidence of adverse reactions.

In one study by Zheng et al,[23] patients undergoing MSL without bone grafting suffered fewer complications after surgery. Eliminating bone grafting during MSL allows a shorter operation and causes less intraoperative blood loss. In addition, because of the simplification of surgical procedures, patients have a substantially better postoperative experience.

Pjetursson et al and Zhou et al have pointed out that implant implantation in hydraulic MSL without bone grafting can achieve dental implantation.[24,25] However, that process of MSL without bone grafting is still controversial because of the absence of authoritative research guidance.

Accordingly, the current study intended to examine the clinical effects of placement of dental implants using the hydraulic MSL, without bone grafting, to offer new guidance, make suggestions for future clinical treatment of tooth absence, and also to lay a reliable foundation for subsequent research on MSL without bone grafting. The osteotome sinus floor elevation is performed at the same time as the dental implant.

METHODS

Participants

Participants were patients with tooth defects who had been admitted to Suzhou Kowloon Hospital at the Shanghai Jiaotong University School of Medicine in Suzhou, China between February 2019 and December 2019.

Potential participants were included if they: (1) were older than 18 years of age, (2) had maxillary tooth absence, (3) had occlusal spacing of that missing-teeth area that was greater than 4 mm, and (4) had detailed case data available.

Potential participants were excluded if they: (1) had any tumors; (2) had cardiovascular or cerebrovascular diseases, autoimmune disease or organ dysfunction, osteoporosis or osteosclerosis; (3) had received radiotherapy, chemotherapy, surgery, or antibiotics within the six months prior to admission, (4) had a drug allergy, and (5) weren't successfully followed up for the prognosis evaluation.

The study was conducted with approval of the Ethics Committee of Suzhou Kowloon Hospital (Ethical Approval Number: LLS2018ky027), and informed consent forms were signed by all enrolled individuals.

Procedures

Randomization. Participants were randomly assigned to an intervention group or a control group using the random number table method.

Evaluation of teeth. Before surgery, each participant was given an X-ray examination to judge the condition of his or her teeth and periodontal condition, based on which a standard operation procedure was developed.

Intervention. Both groups received dental-implant placement in the hydraulic MSL, but the intervention group's surgery didn't include bone grafting, while the control group's included simultaneous bone grafting. For both groups, an incision was made in the alveolar ridge in the implant area after anesthesia, and the participant's mucoperiosteal flap was peeled off to begin the surgery.

After surgery, the participants in both groups were required to avoid opening their mouths and to bite a gauze ball to stop the bleeding after surgery. They were also told to avoid gargling and brushing teeth for six hours after surgery. In addition, participants were required to take oral antibiotics to prevent infection and to eat mainly light liquid or semi-liquid foods. The participant's stitches were removed on the tenth day after surgery.

At six months after surgery, participants without obvious complications or negative conditions were treated with the second-stage repair operation of a porcelain-fused-to-metal crown or porcelain-fused-to-metal bridge.

Outcome measures. Evaluation of participants' surgical experience included a visual analog scale (VAS) and the General Comfort Questionnaire (GCQ). To evaluate safety, adverse reactions from the time point after surgery until discharge were counted, and the incidence was calculated. To assess the surgery, operation time and intraoperative blood loss were measured. An enzyme-linked immunosorbent assay (ELISA) was used to measure inflammatory reactions.

To measure participants' periodontal condition after surgery, the research team used tests for bone mineral density (BMD), periodontal probing depth (PPD), clinical attachment level (CAL), plaque index (PLI), and bleeding index (BI) as well as measurements of the implant retention rate, new bone acquisition around implants, and vertical bone loss. Participants' surgical costs were also evaluated.

At a one-year follow-up, the masticatory function score and the MOS 36-Item Short-Form Health Survey (SF-36) were used for an evaluation of participants' prognoses.

Intervention

Control group. For the control group, the top of alveolar ridge in the edentulous area was exposed, and then the implant site was determined. A hole was prepared with a drill (OSSTEM CAS-KIT hydraulic system, OSSTEM Implant, Seoul, South Korea) and a stop ring, and the hole depth was made to reach a site about 1-2 mm below the maxillary-sinus floor wall. Then the hole was reamed step by step to prepare an implant socket.

After the implant socket had the required diameter, a drill of an equal diameter was used to deepen the stop ring to one mm and repeatedly explored the sinus-floor mucosa. Subsequently, the implant socket was sealed with silica gel and injected with a proper amount of normal saline. When a mucosal resistance could be felt, the maxillary sinus and the bottom wall of the maxillary sinus were completely separated by repeated injection-based re-extraction. When the participant's nasal-ventilation-test result was negative, bone powder was implanted, and an dental implant was simultaneously placed during the operation. Finally, the incision was sutured.

Intervention group. Each participant had a dental implant placed during the hydraulic MSL, without bone grafting. The osteotome sinus floor elevation is performed at the same time as the dental implant. The operation was the same as that of the control group,[26,27 30,31] and when the participant's nasal-ventilation-test result was negative, a dental implant was placed.

Outcome Measures

VAS.[28] The VAS was used to assess participants' pain after surgery. The VAS score is divided into 10 grades: 0 = no pain, 1-3 = mild pain, 4-6 = moderate pain, and 7-10 is severe pain.

GCQ.[29] The GCQ is used to assess participants' comfort after surgery. The score includes four items related to physiology, psychology, spirit, and social culture and environment and has 28 survey items, with a full score being 80 points. The higher the score, the higher the comfort level.

ELISA. Taking the concentration of the standard as the ordinate and the OD value as the abscissa, calculate the polynomial quadratic regression equation of the standard curve, substitute the OD value of the sample, and calculate the sample concentration. The higher the concentration, the more severe the inflammatory reaction. The aggravation of inflammation is the main cause of postoperative pain, stress reactions, infections, and many other adverse conditions. Therefore, it's necessary to pay attention to the changes in the level of inflammatory factors in patients in clinical practice. An ELISA was conducted for quantification of serum interleukin-6 (IL-6), IL-8, and tumor necrosis factor-α (TNF-α), with the corresponding kits being purchased from Beijing Soleibo Technology Co., Ltd. (Beijing, China). The operation was conducted in a sterile environment in strict accordance with the kits' instructions.

BMD. The lower the bone density, the worse the patient's skeletal state. Oral BMD was measured in both groups to assess the stability of the oral cavity after implantation. BMD was measured using an X-ray BMD detector (Shanghai Huanxi Medical Equipment Co., Ltd., SGY-II, Shanghai, China.), and digital tooth slices were photographed.

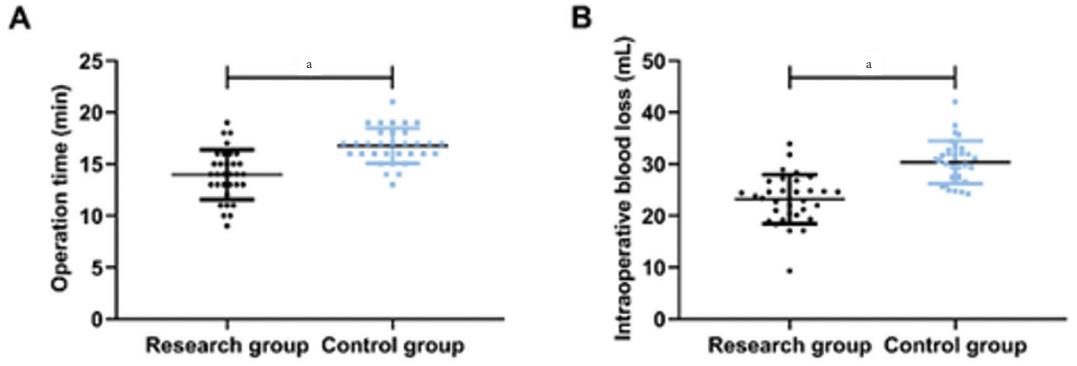
PPD, CAL, PLI, and BI. Higher test results indicate worse periodontal health. The health status of periodontal tissue is an important factor affecting tooth defects. For patients with oral repair, it's necessary to pay close attention to their periodontal health after treatment. Therefore, the research team evaluated the periodontal conditions of patients in the two groups after surgery.

A periodontal probe was used to measure the distance from the gingival margin to the bottom of the periodontal

Table 1. Safety Comparison

	Chronic Upper Sinusitis n (%)	Bleeding n (%)	Loose Implant n (%)	Infection n (%)	Total Incidence n (%)
Intervention group	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0.00%
Control group	1 (2.94)	1 (2.94)	1 (2.94)	1 (2.94)	11.76%
χ^2					4.250
P value					0.039

Figure 1. Comparison of Operation Time (Figure 1A) and Intraoperative Blood Loss (Figure 1B) Between the Intervention and Control Groups. The intervention group's mean operation time was 13.97 ± 2.42 min, and the control group's was 16.78 ± 1.72 min. The intervention group's mean intraoperative blood loss was 23.20 ± 4.73 mL and the control group's was 30.35 ± 4.11 mL.



[a]*P* < .05, indicating a significantly shorter operation time and significantly less blood loss for the intervention group compared to the control group

pocket along the long axis of the implant, with a probe pressure of 0.2N, and the PPD and CAL were calculated. The PLI and BI were also recorded.

Treatment Costs. Oral implant restoration is an expensive treatment and can be a great burden to and cause pressure for patients. Therefore, in modern oral treatment, economic effects are worthy of close attention. Statistics of all treatment-related expenses during the patient's hospital stay.

Masticatory function score.[30] To measure participants' prognostic quality of life, a masticatory function score was obtained. The full score is 100. The higher the score, the better the chewing ability of the patient.

SF-36.[31] To measure participants' prognostic quality of life, the SF-36 was used. Including 8 areas and 36 survey items, the higher the score, the better the quality of life.

Statistical Analysis

All results were statistically processed using SPSS22.0 (IBM, Armonk City, New York, USA). Data such as implant retention rates (%s) were compared using the chi-square test, and for data such as bone mineral density, the means ± standard deviations (SDs) were found using the paired *t* test, independent-samples *t* test, repeated measures analysis of variance (ANOVA), and least significant difference (LSD) paired t test. *P* < .05 indicated a significant difference.

RESULTS

The study included and analyzed the data of 68 patients with tooth defects.

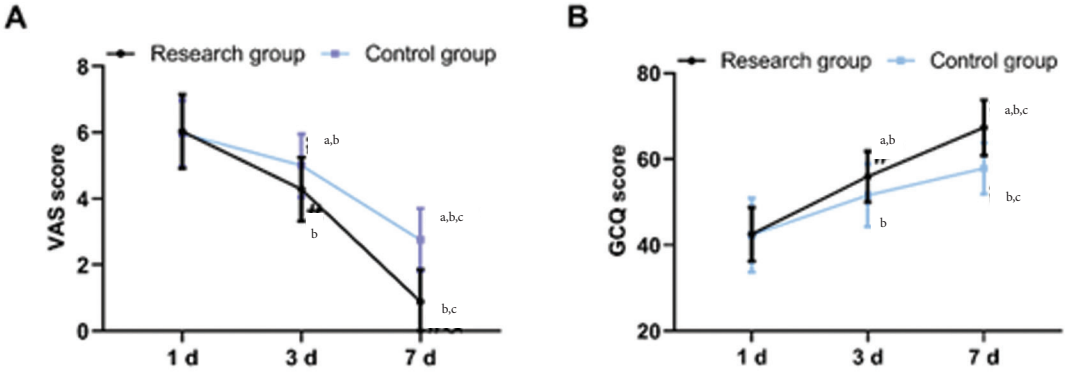
Safety

The intervention group showed a lower incidence of adverse reactions than the control group after surgery, at 0.00% and 11.76%, respectively, with *P* < .05 (Table 1). The intervention group experienced no adverse effects. In the control group, the adverse reactions included one case of chronic sinusitis maxillary (2.94%), one case of bleeding (2.94%), one case of dental-implant loosening (2.94%), and one case of infection (2.94%).

Operation Time and Blood Loss

The intervention group's mean operation time was 13.97 ± 2.42 min, which was significantly shorter than that of the control group, at 16.78 ± 1.72 min, with *P* < .05 (Figure 1A). Similarly, intraoperative blood loss was significantly lower for the intervention group, at 23.20 ± 4.73 mL compared with that of the control group, at 30.35 ± 4.11 mL, with *P* < .05 (Figure 1B). These findings indicate that the intervention group's surgical process was faster and less invasive than that of the control group, with a higher surgical safety profile.

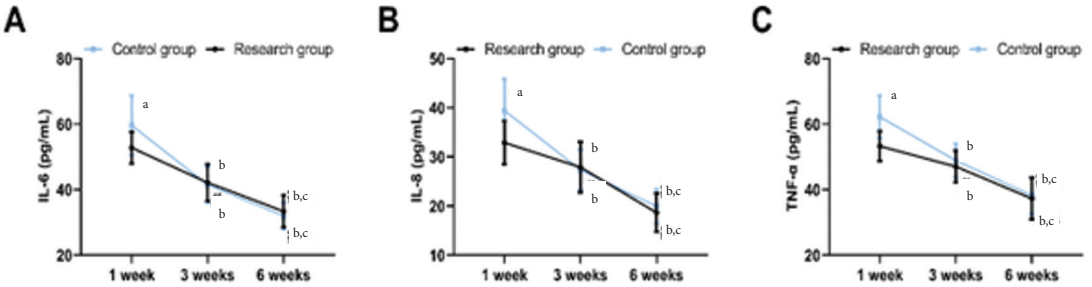
Figure 2. Comparison of the Surgical Experience Between the Intervention and Control Groups at Days 1, 3, and 7 After Surgery. Figure 2A compares the VAS scores, and Figure 2B compares the GCQ scores.



[a]$P < .05$, indicating significantly lower VAS scores and significantly higher GCQ scores after surgery at days 3 and 7 for the intervention group compared to the control group
[b]$P < .05$, indicating significant decreases after surgery in the VAS scores and significant increases in the GCQ scores between days 1 and 3 and days 1 and 7 for both groups
[c]$P < .05$, indicating significant decreases after surgery in the VAS scores and significant increases in the GCQ scores between days 3 and 7 for both groups

Abbreviations: VAS, visual analog scale; GCQ, general comfort questionnaire.

Figure 3. Comparison of Inflammatory Reactions Between the Intervention and Control Groups at Weeks 1, 3, and 6 After Surgery. Figure 3A shows the IL-6 comparison; Figure 3B shows the IL-8 comparison; and Figure 3C shows the TNF-α comparison.



[a]$P < .05$, indicating significantly higher IL6, IL8, and TNF-α after surgery for the control group compared to the intervention group at week 1
[b]$P < .05$, indicating significant decreases after surgery in the IL6, IL8, and TNF-α between weeks 1 and 3 and weeks 1 and 6 for both groups
[c]$P < .05$, indicating significant decreases after surgery in the IL6, IL8, and TNF-α between weeks 3 and 6 for both groups

Abbreviations: IL, interleukin; TNF-α, tumor necrosis factor alpha.

Surgical Experience

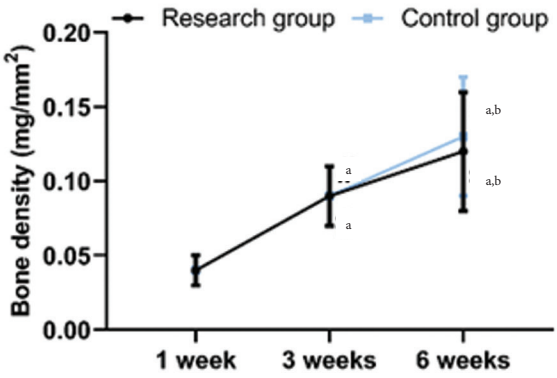
The two groups showed no significant differences in the VAS and GCQ scores after surgery on day 1, with $P > .05$; at days 3 and 7 days postoperatively, the intervention group's mean VAS score was significantly lower than that of the control group, while its mean GCQ score was significantly higher, with $P < .05$ for both scores (Figures 2A and 2B). In addition, the VAS scores of both groups significantly decreased gradually with time, while the GCQ scores significantly increased gradually with time, with $P < .05$ for all scores. Both groups' pain showed a steady and gradual decrease, while their comfort levels gradually increased, but pain relief and comfort improved significantly faster in the intervention group than in the control group.

Inflammatory Reactions

The levels of the inflammatory factors IL-6, IL-8 and TNF-α in both groups decreased gradually over time. The level after surgery was highest for both groups at week 1 and lowest at week 6, and both groups showed significant decreases between weeks 1 and 3, weeks 1 and 6, and weeks 3 and 6 ($P < .05$).

The intervention group presented significantly lower levels of IL-6 (Figure 3A), IL-8 (Figure 3B), and TNF-α

Figure 4. Comparison of Bone Mineral Density Between the Intervention and Control Groups at One Week, Three Weeks, and Six Weeks After Surgery



[a]$P < .05$, indicating significant increases in bone density after surgery between weeks 1 and 3 and weeks 1 and 6 for both groups
[b]$P < .05$, indicating significant increases in bone density after surgery between weeks 3 and 6 for both groups

(Figure 3C) at week 1 than the control group did ($P < .05$), indicating its inflammatory response was significantly lighter

No significant differences existed between the two groups after surgery in the IL-6, IL-8, and TNF-α levels at weeks 3 and 6 ($P > .05$).

The findings indicate that all participants' oral functions had been restored to a relatively stable state at week 6.

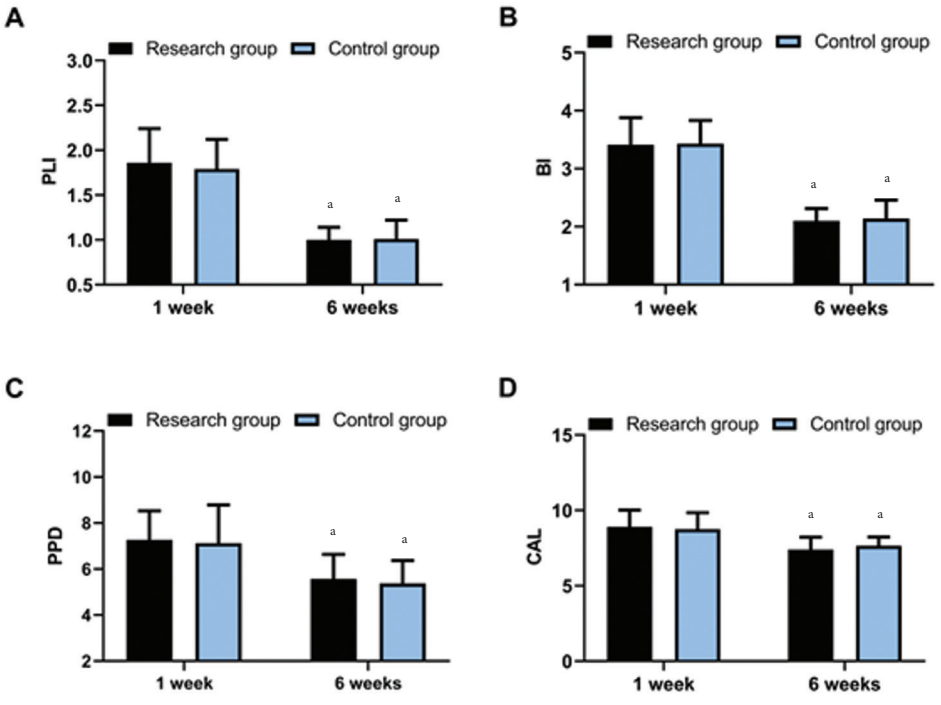
BMD

BMD increased with time in both groups ($P < .05$), with the increases being significant between weeks 1 and 3, weeks 1 and 6, and weeks 3 and 6. No significant differences between the two groups existed in BMD after surgery at weeks 1, 3, or 6, with $P > .05$ (Figure 4). The findings suggest that the oral-restoration methods used in both groups had excellent effects on the stability of the oral cavity.

Periodontal Condition

The two groups weren't significantly different after surgery in the PLT (Figure 5A), BI (Figure 5B), PPD (Figure 5C), or CAL (Fig 5D) at weeks 1 or 6 ($P > .05$). In both groups, the PLTs, BIs, CALs, and PDDs after surgery at week 6 were all significantly higher than those at week 1 ($P < .05$), indicating that participants' periodontal conditions were significantly improved.

Figure 5. Comparison of Periodontal Condition Between the Intervention and Control Groups at One Week and Six Weeks After Surgery. Figure 5A shows the PLT comparison; Figure 5B shows the BI comparison; Figure 5C shows the PPD comparison; and Figure 5D shows the CAL comparison.



[a]$P < .05$, indicating significantly increases in PLT, BI, PPD, and CAL after surgery between at weeks 1 and 6 for both groups

Abbreviations: PLT, plaque index; BI, bleeding index; PPD, probing pocket depth; CAL, clinical attachment loss.

Economic Effects

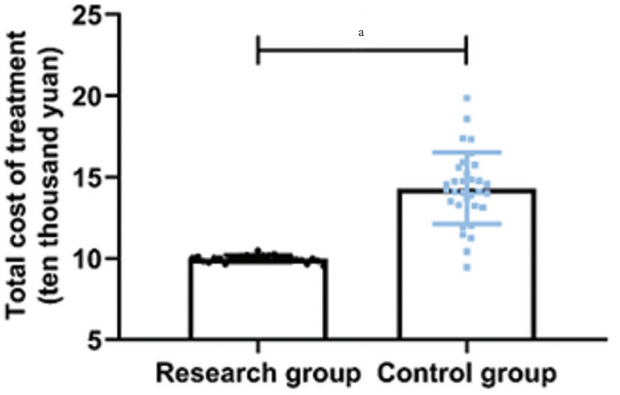
The intervention group's total treatment costs were 9.99 ± 0.19 ten-thousand Yuan, which was significantly lower than that of the control group, at 14.32 ± 2.21 ten-thousand Yuan, with $P < .05$ (Figure 6). This shows that dental restoration without a bone graft that was used by the intervention group had an economic benefit.

Implant Prognosis and Condition of Surrounding Tissues

All participants in the intervention and control groups were successfully followed up for 6 months after surgery. The intervention groups' implant retention rate was 96.61%, which was higher than the 85.00% for the control group, with $P < .05$ (Figures 7A and 7B), indicating that participants in the intervention group had higher stability after dental implantation.

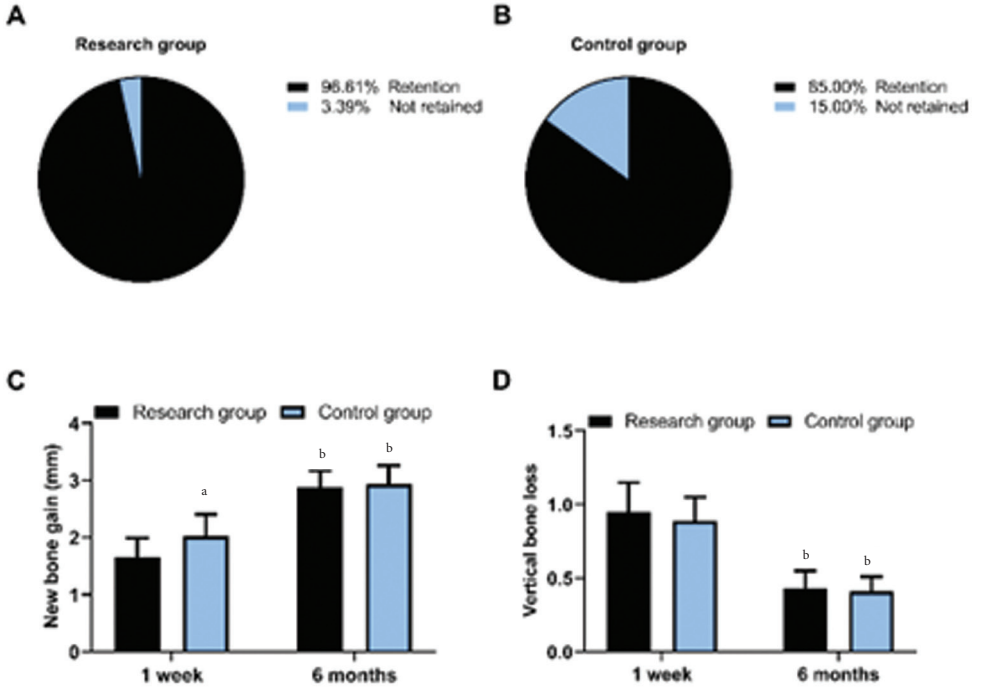
In addition, the intervention group's new-bone gain was significantly higher postoperatively than that of the control group at week 1, with $P < .05$ (Figure 7C). Peri-implant measurements showed no differences postoperatively in the vertical bone loss between the two groups at week 1 or month 6, with $P > .05$ (Figure 7D). In both groups, new-bone gain had significantly increased postoperatively by month 6, while vertical bone loss had significantly decreased, with $P < .05$.

Figure 6. Comparison of Total Cost of Treatment for the Intervention and Control Groups



[a]$P < .05$, indicating significantly higher costs of surgery for the control group than for the intervention group

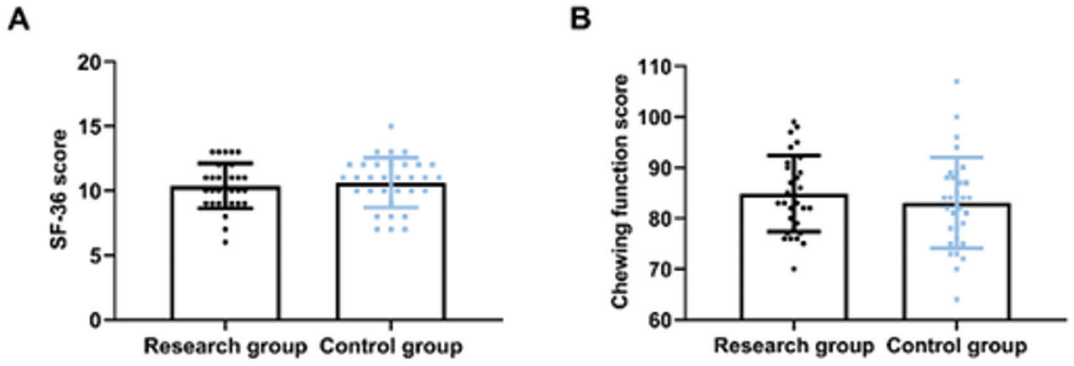
Figure 7. Comparison of the Implant Prognosis and the Condition of Surrounding Tissues at One Week and Six Months Between the Intervention and Control Groups. Figure 7A and Figure 7B show the implant retention at six months after surgery for the intervention group and the control group, respectively. Figure 7C shows the comparison of new bone gain and Figure 7D shows the comparison of vertical bone loss at one week and six months for both groups.



[a]$P < .05$, indicating significantly higher new-bone gain after surgery for the intervention group compared to the control group at week 1

[b]$P < .05$, indicating significant increases in new-bone gain and significant decreases in vertical bone loss after surgery between week 1 and month 6 for both groups

Figure 8. Comparison of Prognosis. Figure 8A shows the life quality score; Figure 8B shows the masticatory function score.



Prognosis

No significant differences existed between the groups in the prognostic quality of life score (Figure 8A) and masticatory function score (Figure 8B), with $P > .05$. That finding demonstrates that both treatments provided a stable and excellent guarantee of a positive prognosis.

DISCUSSION

The current study compared and analyzed the advantages and disadvantages of hydraulic MSL, with and without bone grafting, in various aspects to provide an exact reference and guidance for the follow-up clinical practice of MSL.

The current research team first compared the results for the intervention group compared to those of the control group and found: (1) a significantly lower incidence of adverse reactions in the intervention group and (2) a significantly shorter operation time and lower intraoperative blood loss in the intervention group. These data fully suggest the superiority in safety of MSL without bone grafting.

In addition, after surgery the current study found significantly greater pain alleviation and comfort improvement in the intervention group than in the control group, which suggests that the participants had a notably better surgical experience during MSL without bone grafting.

In the current study, the intervention group showed notably lower levels of inflammatory factors than did the control groups, which may also be explained by the fact that the shorter operation time contributed to a shorter exposure time to air for the periodontal and maxillary sinus tissues in participants and directly may have caused a strong inhibition on the procession of inflammatory reaction and oxidative-stress injury to tissues after postoperative trauma.

In the current study, no notable differences were found in the periodontal condition— bone mineral density, PLT, BI, PPD, and CAL—of the two groups. That result suggests the favorable effects of the two surgical methods.

Currently, the main dispute about bone grafting versus no bone grafting in MSL lies in the effects on implant retention, but in the current study, the intervention group had a higher implant retention rate after surgery at month 6 than did the control group, suggesting that MSL without bone grafting could also substantially maintain the stability of implants.

Moreover, according to the current study's follow-up results, the intervention group had less new bone acquisition around implants after surgery than did the control group after surgery at the week 1 but showed no significant differences in bone acquisition compared to the control group at month 6. Those results confirm that the maxillary sinus has self-osteogenesis ability. However, participants in the control group initially had a greater amount of new-bone formation than did the intervention group because they had bone material implanted during the surgery.

Comparison of the economic effects of surgery between the two groups showed that the intervention group spent less for surgery than did the control group, which can be exampled by the fact that participants in the intervention group didn't receive bone grafting, and thus their surgery costed less in bone powder, periosteum, and use of other equipment. This is of profound value for the popularization of dental implants with MSL in the future.

Finally, according to the current study's follow-up results for prognosis, the two groups didn't significantly differ in masticatory function and life-quality scores. The results indicate the favorable effect of both MSL with bone grafting and without it and have great significance for clinical applications.

Currently, synthetic materials such as bone powder can be selected as bone grafting materials for MSL, and autogenous bone transplantation can also be adopted. Therefore, the current research team speculates that MSL without bone grafting may be better for patients. In addition, the team needs to follow up the prognosis of the enrolled patients for a longer time to understand the effects of simultaneous implant placement in hydraulic MSL without bone grafting on the long-term prognosis of patients. Supplementary research in view of the above limitations can further improve the reliability of the results of this study, lay a better foundation for the clinical application of MSL in the future, and provide better safety for patients.

CONCLUSIONS

Simultaneous implant placement in a hydraulic MSL without bone grafting can deliver favorable therapeutic effect, with a high safety profile, which can effectively optimize the surgical process, improve patients' postoperative feelings, and reduce surgical expenses, making it easy to popularize clinically.

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