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Original Article

Characteristics and impacts of dental implant displacement into the maxillary sinus

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KEYWORDS
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Abstract *Background/purpose:* Dental implants displaced into the maxillary sinus are considered to require surgical removal as the treatment of choice. However, displaced implants have been reported to affect the maxillary sinus in different ways. This study aimed to evaluate characteristics and impacts of dental implant displacement into the maxillary sinus.
Materials and methods: Fourteen sinuses with displaced implants into the maxillary sinus were included. Demographic data and radiographic images were analyzed, with a focus on the impact of various factors such as demographic data, timing of displacement, duration of retention, and residual bone height on maxillary sinus opacification and sinus wall thickness.
Results: Implants were displaced during or in the early stage after implant placement in 9 cases and after functional loading in 5 cases. Radiographic evaluations showed higher sinus opacification score ($P = 0.019$) and increased wall thickness ($P = 0.198$) in cases with displacement after functional loading, although the difference in wall thickness was not statistically significant. When the duration of implant retention in the sinus was longer, higher sinus opacification and sinus wall thickness were observed, although the differences were not statistically significant. Univariate regression analysis demonstrated that the timing of displacement significantly influenced maxillary sinus opacification ($P = 0.013$) and sinus wall thickness ($P = 0.013$). For all cases, evidence of site preparation and the use of short implants were not observed.
Conclusion: This study suggests that adequate pre-implant site preparation and timely intervention are essential to prevent and manage implant displacement into the maxillary sinus.

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Introduction

Implant rehabilitation for the edentulous posterior maxilla is challenging due to anatomical characteristics.[1] The posterior maxilla is composed of type IV bone, which has thin cortical bone and low-density cancellous bone, leading to poor bone quality and a lack of primary stability for implants.[2] Additionally, post-extraction alveolar bone resorption and maxillary sinus pneumatization lead to insufficient bone quantity, complicating conventional implant placement.[3] To overcome poor bone quality, various techniques such as modified drilling protocols, bone condensing protocols, and use of specially designed implants are employed.[4] Procedures such as sinus elevation with subsequent bone grafting for ridge augmentation, short implants, or zygomatic implants are utilized to address insufficient bone quantity.[4–6] Despite these efforts, implant-related complications still occur during implant treatment in the posterior maxilla, and their incidence has increased alongside the exponential growth in implant restorations. These complications include impaired osseointegration, sinus membrane perforation, oroantral fistula, paranasal sinusitis, and displacement of graft material and implants into the maxillary sinus.

Displacement of dental implants into the maxillary sinus is becoming increasingly frequent as an implant-related complication. Although the true incidence is unknown due to a lack of large-scale cohort studies, the number of reported cases has increased significantly, from 13 cases between 1990 and 2000 to 222 cases from 2011 to 2021, representing a roughly 17-fold increase.[7–10] Patients with displaced implants may exhibit clinical symptoms including purulent nasal discharge, nasal obstruction, foul smell, and facial swelling and discomfort. In rare cases, displaced implants may lead to pan sinusitis or intracranial infection or could migrate into other spaces such as the nasal cavity or other paranasal sinuses. Regarding the management of displaced implants, surgical removal is regarded as the gold standard treatment and has been reported to yield successful treatment outcomes. The removal of implants displaced into the maxillary sinus has primarily been performed using three approaches: the Caldwell-Luc procedure, lateral window approach, and endoscopic endonasal approach.[11–13]

While most previous studies have focused on these surgical approaches to address displaced implants, research on the impacts of displaced implants on the maxillary sinus is limited.[7,14] Furthermore, implant displacement can occur at various time points from implant placement to application of functional loading, but previous studies have mostly addressed displacements that occur before functional loading. The aims of this study were to analyze the clinical and radiographic characteristics of patients experiencing implant displacement into the maxillary sinus and to evaluate the impacts of timing of implant displacement and the duration of implant retention in the sinus on the maxillary sinus.

Materials and methods

Study design

We designed and implemented a retrospective cohort study in accordance with the principles of the Helsinki Declaration. All included patients provided informed consent prior to the study. The study protocol was approved by the Institutional Review Board of Seoul National University Dental Hospital (Approval No. ERI24010). The study population comprised patients who visited the Department of Oral and Maxillofacial Surgery, Seoul National University Dental Hospital from October 2020 to January 2024 for treatment of dental implant migration into the maxillary sinus. Patients who fulfilled the following criteria were included in this study: 1) retrieval of a dental implant displaced into the maxillary sinus and 2) available pre- and postoperative radiographs including panoramic view, Waters view, and computed tomography (CT) data. Among the study population, patients who did not undergo retrieval of a dental implant from the maxillary sinus or who had no available pre- or postoperative radiographs were excluded. To evaluate clinical characteristics, medical records including demographic data (age, gender, smoking status, systemic diseases), history of preimplant surgical procedures, site of displaced dental implant, timing of displacement, and duration of retention in the sinus were examined.

Surgical procedures

All patients underwent modified endoscopic-assisted sinus surgery for retrieval of the displaced implant with or without closure of the oroantral communication under intravenous sedation or general anesthesia.[12,13,15–18] Briefly, a 1.5–2 cm mucoperiosteal incision was made on the vestibular area, followed by flap elevation. Two vertical osteotomy lines were placed on the anterolateral wall of the sinus to create a bony window for access to the maxillary sinus. The distance between the vertical osteotomy lines was determined with consideration of the application of a four-hole microplate. After applying the microplate on the planned bony window, superior and inferior horizontal osteotomies were performed to complete the bony window osteotomy. The microplate-attached bony window was then separated and stored in a warm-saline bath. A small horizontal incision was made on the sinus membrane using a No. 12 scalpel, and the location of the displaced implant was identified under endoscopic view, along with an evaluation of the maxillary

sinus membrane and the ostium. The displaced implant was removed using a suction tip, sinus forceps, or curettes commonly used in sinus elevation procedures. In cases where inflamed, edematous mucosa was present, pathological tissue was selectively removed. After gentle warm irrigation of the sinus cavity, the bony window was repositioned and fixed to its original position using microscrews. The surgical wound was closed using 4-0 Vicryl.

Radiographic evaluation

The type of implant displaced within the maxillary sinus (fixture only or a combination of fixture and abutment) was evaluated using a panoramic radiograph (Fig. 1). The location of the displaced implant within the sinus and the evidence of previous sinus bone graft were examined using CT images (SOMATOM Definition Edge, Siemens AG, Erlangen, Germany). The alveolar bone height at the location where the implant was planned or existed before migration was measured on the coronal view of CT images. Sinus opacification and maxillary sinus wall thickness were evaluated to assess the influence of displacement on the maxillary sinus. Sinus opacification was scored as follows: 1) Score 0, no opacification; 2) Score 1, mucosal thickening; 3) Score 2, partial opacification (opacification less than $<$70 % of the maxillary sinus); 4) Score 3, subtotal opacification (70 % $\leq$ opacification $<$100 %); and 5) Score 4, total opacification (opacification by 100 % of the sinus with or without spread to adjacent sinus) (Fig. 2).[19] The thickness of the maxillary sinus wall was measured 8 mm above the sinus floor at the implant site on the axial-view CT images. The measurements were performed at the midpoints of both anterior and lateral walls, and the mean value was calculated (Fig. 3). A maxillary sinus wall thickness of 3 mm or greater is considered indicative of osteitis.[20] Postoperative healing of the sinus after implant removal was evaluated using Waters radiographs at 6 months after surgery.

Statistical analysis

All statistical analyses were performed using SPSS 26.0 for Windows (IBM Corporation, Armonk, NY, USA). Descriptive statistics were expressed as the mean $\pm$ standard deviation for continuous data and proportions for categorical data. Mann–Whitney U test and Fisher's exact test were performed to evaluate differences in characteristics depending on displacement timing and the duration of retention in the sinus. The Wilcoxon signed rank test was conducted to compare normal sinuses and sinuses with displaced implants and to assess postoperative outcomes after removal of displaced implants. To determine causative factors for preoperative sinus opacification and maxillary sinus osteitis, univariate linear regression analysis was performed using variables including age, sex, smoking, systemic diseases, duration of retention in the sinus, timing of displacement, and residual bone height. The significance level was set at $P < 0.05$.

Results

Demographics

Among the 15 patients who underwent removal of displaced dental implants from the maxillary sinus, 13 who met the inclusion and exclusion criteria were recruited for this study. Two patients were excluded due to the lack of CT images. Of 13 patients, one experienced displacement of the dental implant twice in different locations at different times. Eight patients (61.5 %) were male and 5 patients (38.5 %) were female (Table 1). The mean age was 64.6 $\pm$ 9.9 years (age range, 44–78 years). Ten patients had a smoking habit, and 1 patient did not have a history of smoking, while smoking status for the other 2 patients was unknown. Regarding systemic diseases, five patients had no systemic diseases, while among those with systemic diseases, four had hypertension and three had diabetes. Before displacement into the maxillary sinus, the original locations of the implants were the second maxillary molars in 9 implants, accounting for 64.3 %, followed by the maxillary first molar (5 implants, 35.7 %). There were 9 implants displaced in the peri-implant surgery phase, and 5 displacements occurred after functional loading following prosthetic restoration. Based on the duration of retention in the sinus before implant removal, 7 implants were present in the maxillary sinus for less than 3 months, while the remaining 7 implants were present for more than 3 months.

Radiographic evaluation

In radiographic evaluations, 12 implants were found within the maxillary sinus, and 2 implants were located across the maxillary sinus floor (Table 2). Residual alveolar bone

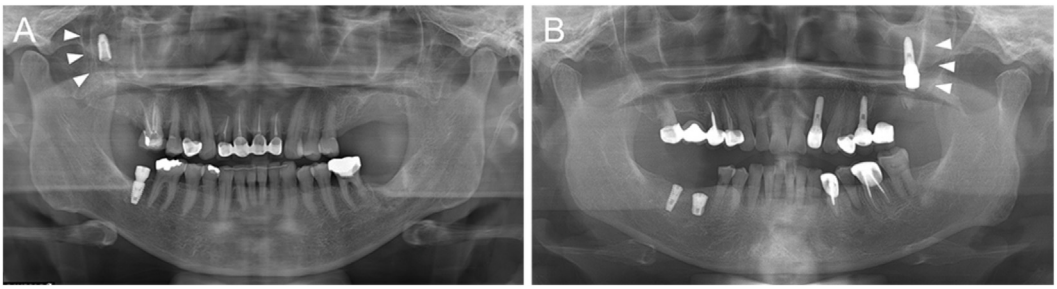

Figure 1 Displacement of dental implants into the maxillary sinus. (A) Fixture only, displaced during or immediately after surgery (B) A combination of implant fixture and abutment, displaced after functional loading.

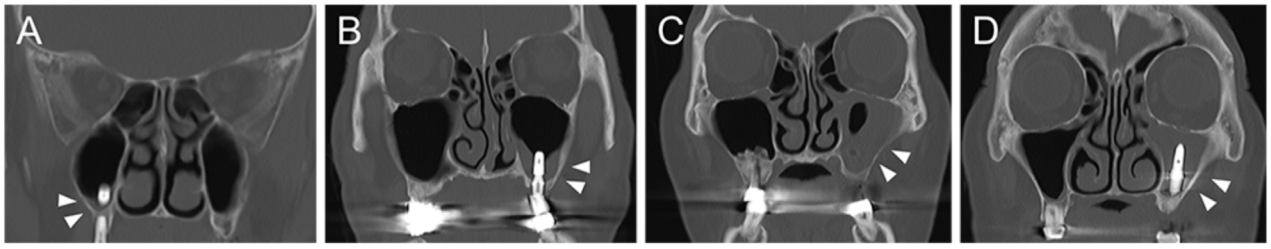

Figure 2 Sinus opacification (arrowhead) score. (A) Score 1, mucosal thickening (right sinus). (B) Score 2, partial opacification (left sinus). (C) Score 3, subtotal opacification (left sinus). (D) Score 4, total opacification (left sinus).

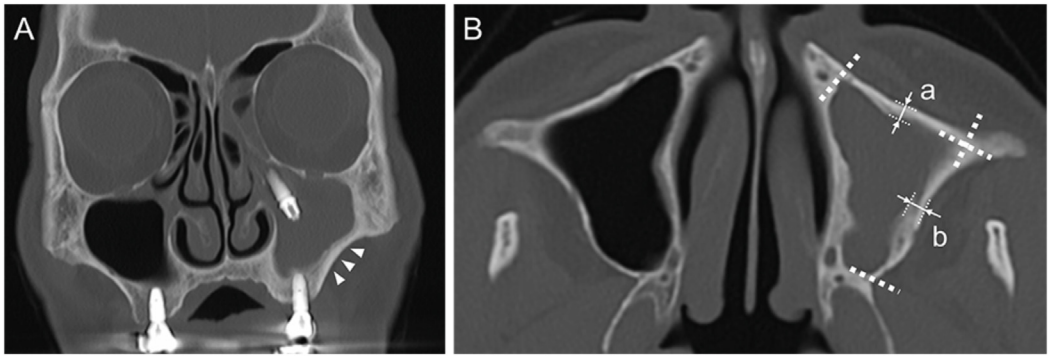

Figure 3 Computed tomographic image for maxillary sinus wall thickening suspected to be osteitis (A, arrowheads) and measurements of sinus wall thickness (B). a, thickness of anterior sinus wall; b, thickness of lateral sinus wall; dotted line, reference lines for determining midpoints of anterior and lateral sinus walls.

height at the implant site was 4.7 ± 1.9 mm. According to the timing of displacement, residual bone height for the implants displaced perioperatively was 3.9 ± 1.6 mm, while that for implants displaced after functional loading was 5.9 ± 1.8 mm ($P = 0.067$) (Table 3). Regarding sinus opacification, the mean opacification score was 2.4 ± 1.5 before removal of displaced implants, and patients with the implant displaced after functional loading (3.6 ± 0.9) exhibited significantly higher sinus opacification scores than those with the implant displaced during surgery (1.7 ± 1.3) ($P = 0.019$). Postoperative Waters radiographs revealed improvement of sinus opacification in all cases. In particular, for 11 cases with postoperative CT images, sinus opacification scores decreased significantly to 0.4 ± 0.8 on average at 6 months after implant removal ($P = 0.002$). Mean maxillary sinus wall thickness for sinuses with displaced implants was 1.6 ± 0.8 mm, which was significantly greater than that of normal maxillary sinuses (1.1 ± 0.2 mm, $P = 0.002$). Although there was no significant difference in maxillary sinus wall thickness depending on the timing of displacement ($P = 0.198$), mean maxillary sinus wall thickness was greater in cases with implant displacement after functional loading (2.3 ± 1.1 mm) than in those with perioperative implant displacement (1.2 ± 0.2 mm). Furthermore, osteitis was not observed in cases where the implant was displaced perioperatively but was observed in 2 of 5 cases (40 %) where the implant was displaced after functional loading. According to the duration of retention of the displaced implant in the sinus, cases with a greater than 3 months duration showed greater sinus opacification and sinus wall thickness (sinus opacification, 3.0 ± 1.2; sinus wall thickness; 2.0 ± 1.1 mm) than those with less than 3 months (sinus opacification, 1.7 ± 1.6; sinus wall thickness, 1.2 ± 0.2 mm); however, the difference was not significant (sinus opacification, $P = 0.165$; sinus wall thickness, $P = 0.209$).

Table 1 Demographic and clinical data of the patients included in this study.

Variable	Descriptive statistics
Age at operation (years)	64.6 ± 9.9
Sex	
Male	8 (61.5)
Female	5 (38.5)
Systemic diseases	
Hypertension	4 (30.8)
Diabetes	3 (23.1)
Hyperlipidemia	2 (15.4)
Arrhythmia	1 (7.7)
None	5 (38.5)
Implant site[a]	
First molar	5 (35.7)
Second molar	9 (64.3)
Timing of displacement[a]	
Perioperatively	9 (64.3)
After functional loading	5 (35.7)
Implant retention in the sinus[a]	
<3 months	7 (50.0)
≥3 months	7 (50.0)

Data are presented as mean ± standard deviation or n (%).
[a] One patient experienced dental implant displacement twice at different times and locations, and each displacement was evaluated individually.

Table 2 Radiographic evaluation.

Variable	Descriptive statistics	*P*-value[a]
Location of displaced implant		
Within the sinus	12 (85.7 %)	
Across the sinus floor	2 (14.3 %)	
Residual bone height (mm)	4.7 ± 1.9	
According to duration of retention		0.879
<3 months	4.7 ± 1.7	
≥3 months	4.6 ± 2.2	
Sinus opacification score	2.4 ± 1.5	
According to duration of retention		0.165
<3 months	1.7 ± 1.6	
≥3 months	3.0 ± 1.2	
Maxillary sinus wall thickness (mm)	1.6 ± 0.8	
According to duration of retention		0.209
<3 months	1.2 ± 0.2	
≥3 months	2.0 ± 1.1	

Data are presented as mean ± standard deviation or n (%).
[a] Mann–Whitney U test.

Prognostic factors for sinus opacification and maxillary sinus wall thickness

Univariate regression analysis revealed a significant influence of age, diabetes, and timing of displacement on preoperative sinus opacification (age, $P = 0.034$, coef. 0.088, 95 % CI 0.008 to 0.168; diabetes, $P = 0.025$, coef. 2.091, 95 % CI 0.309 to 3.872; timing of displacement, $P = 0.013$, coef. 1.933, 95 % CI 0.478 to 3.388) (Table 4). Other variables, such as sex, systemic diseases other than diabetes, duration in the sinus, residual bone height, and smoking did not demonstrate a significant impact on sinus opacification. Regarding maxillary sinus wall thickness, only the timing of displacement showed a significant association with sinus wall thickness ($P = 0.013$, coef. 1.094, 95 % CI 0.292 to 1.917).

Discussion

In the present study, we analyzed clinical and radiographic characteristics of patients who experienced displacement of dental implants into the maxillary sinus, and explored the potential factors that may contribute to pathological changes of the sinus.

Displacement of implants into the maxillary sinus can irritate the sinus mucosa or obstruct the ostiomeatal complex, potentially causing sinusitis. Although the onset of sinusitis can be delayed by several months or even years, previous studies reported that not all patients with displaced implants exhibited clinical symptoms or moderate to severe radiographic pathological lesions. Petruson[21] reported that the presence of dental implants within the maxillary sinus does not necessarily cause sinus pathology. In a report describing 9 cases by Ridaura-Ruiz et al.,[22] 3 patients experienced sinus infection, while the other 6 were asymptomatic. Other studies also reported am incidence of sinusitis ranged from 33 % to 48 %.[10,11] Chiapasco et al.[11] reported that 14 of 27 patients did not show relevant foreign body reactions or infections in the involved maxillary sinus. In the present study, prior to implant removal, complete and subtotal opacification were observed in 5 (35.7 %) and 2 (14.3 %) sinuses, respectively, while the remaining 7 sinuses (50.0 %) exhibited partial or no opacification.

Table 3 Comparisons according to the timing of displacement.

Variable	Perioperative	Functional loading	*P*-value
Age at operation (years)	60.8 ± 9.4	72.9 ± 3.4	0.007[a]
Sex			0.580[b]
Male	5 (55.6)	4 (80.0)	
Female	4 (44.4)	1 (20.0)	
Retention in sinus			0.266[b]
<3 months	6 (66.7)	1 (20.0)	
≥3 months	3 (33.3)	4 (80.0)	
Occluding teeth			0.545[b]
Natural teeth	2 (22.2)	2 (40.0)	
Implant	6 (66.7)	3 (60.0)	
Edentulous	1 (11.1)	0 (0)	
Sinus opacification	1.7 ± 1.3	3.6 ± 0.9	0.019[a]
Residual bone height (mm)	3.9 ± 1.6	5.9 ± 1.8	0.067[a]
Sinus wall thickness (mm)	1.2 ± 0.2	2.3 ± 1.1	0.198[a]
Osteitis			0.110[b]
Absence	9 (100.0)	3 (60.0)	
Presence	0 (0)	2 (40.0)	

Data are presented as mean ± standard deviation or n (%).
[a] Mann–Whitney U test.
[b] Fisher's exact test.

Table 4 Results of univariate linear regression analyses.

Variable	Maxillary sinus opacification		Maxillary sinus wall thickness	
	Regression coefficient, β (95 % CI)	*P*-value	Regression coefficient, β (95 % CI)	*P*-value
Age	0.088 (0.008 to 0.168)	0.034	0.030 (−0.022 to 0.082)	0.229
Sex	−0.566 (−2.419 to 1.308)	0.528	−0.757 (−1.718 to 0.204)	0.112
Smoking	−2.538 (−5.684 to 0.608)	0.104	−0.427 (−2.404 to 1.550)	0.646
Diabetes	2.091 (0.309 to 3.872)	0.025	0.514 (−0.696 to 1.723)	0.373
Residual bone height	0.108 (−0.385 to 0.601)	0.641	0.220 (−0.024 to 0.4656)	0.073
Duration of the retention	1.286 (−0.342 to 2.913)	0.111	0.836 (−0.047 to 1.719)	0.062
Timing of displacement	1.933 (0.478 to 3.388)	0.013	1.094 (0.272 to 1.917)	0.013

CI, confidence interval.

The occurrence of maxillary sinusitis due to displacement of an implant into the sinus can be influenced by several factors. Simultaneous maxillary sinus bone grafting has been proposed as a potential risk factor for sinusitis. Sgaramella et al.[10] found in 8 out of 21 patients exhibiting symptoms of sinusitis that 4 underwent simultaneous bone grafting, corresponding to 66.7 % of the 6 patients who underwent simultaneous bone grafting procedures. In our study, significant differences in sinus opacification were found depending on the timing of displacement into the sinus. Implants displaced after functional loading showed more severe sinus opacification compared to those displaced during or immediately after surgery. Considering that peri-implantitis is one of the causes of implant displacement, it is possible that peri-implantitis induced odontogenic sinusitis that existed before displacement, becoming more severe after displacement. Additionally, implants or abutments exposed to the oral cavity and contaminated by oral pathogens due to transmucosal connections in implant prostheses may cause severe sinusitis when displaced into the maxillary sinus. Finally, residual cement displaced into the sinus along with the implant may also be a cause of sinusitis. Similarly, in univariate regression analysis estimating predictors of sinus opacification, the timing of displacement, along with age and diabetes, showed a significant association with preoperative sinus opacification. Previous studies suggested that a maxillary sinus with a displaced implant may be asymptomatic initially but develop sinusitis over time. In our study, although no significant differences were observed, cases with long-term displacement longer than 3 months showed more severe opacification than those with short-term displacement less than 3 months. These findings indicate that displaced implants should be removed as early as possible to prevent maxillary sinus pathology. Particularly in cases where implants become displaced into the sinus after functional loading, immediate removal is recommended.

In chronic maxillary sinusitis, the normal maxillary sinus wall thickness of 0.1—0.9 mm increase to 2.6 mm on average, and the thickness of the maxillary sinus wall is significantly related to the severity of inflammation.[23–25] The increase in maxillary sinus wall thickness under inflammatory conditions is known as osteitis. The term "osteitis" has been used to define the involvement of bony paranasal sinuses with neo-osteogenesis in patients with chronic rhinosinusitis.[20] The impact of osteitis on the treatment of maxillary sinusitis remains under debate.[26] Nevertheless, Saylam et al.[27] reported that patients with positive single-photon emission computed tomography uptake, which is a marker of bone changes and osteitis, showed poorer overall subjective response to treatment. Other studies have reported similar results that chronic rhinosinusitis patients with osteitis do not seem to show clinically significant improvement after endoscopic sinus surgery.[28,29] Based on these findings, osteitis may be an important factor in determining treatment prognosis. In the present study, the thickness of the maxillary sinus wall where the implant was displaced was significantly thicker than on the normal side. The thickness of the sinus wall was particularly increased in cases where displacement occurred after functional loading, with two patients showing a thickness greater than 3.0 mm, which is considered indicative of osteitis.[20] In contrast, cases of displacement during surgery all showed wall thickness less than 1.5 mm. Therefore, in cases of displacement after functional loading, early surgical intervention may be necessary to improve prognosis.

Risk factors for displacement of dental implants into the maxillary sinus have been suggested to include insufficient bone volume, poor bone quality, lack of primary stability, inadequate drilling protocol, unfavorable distribution of occlusal force, failure of osseointegration, and surgical inexperience.[4,7] In our study, the residual bone height at the implant sites averaged less than 5.0 mm, indicating that pre-implant site preparation surgery or the use of short implants is typically necessary. Nevertheless, in all 14 cases included in this study, we found no evidence of such efforts, including grafted bone substitutes or lateral bony windows. These characteristics of patients with displaced implants were also observed in previous studies. Galindo-Moreno et al.[4] found that among 14 patients who experienced displacement of the implants into the maxillary sinus, the alveolar bone height was less than 6 mm in the majority of cases. However, nearly 50 % of these patients did not receive any site preparation treatment prior to implant placement. Of the remaining patients, 5 underwent osteotomy without subsequent bone grafting. Consequently, 73.3 % of the patients did not receive bone grafting to increase the available bone height around the implant. A recent systematic review also revealed that, among 182 patients with implants displaced into the maxillary sinus,

more than half did not undergo any pre-implant surgery.[7] These results suggest that inadequate site preparation in patients with insufficient residual alveolar bone height may increase the risk of implant displacement into the maxillary sinus.

This study has several limitations. First, the number of patients included in this study is small. This is because, although the incidence of implant displacement into the maxillary sinus is increasing, it remains a relatively rare complication. Another limitation is a lack of histopathological evaluation. For patients where implants were displaced into the sinus without significant pathological changes, only the displaced implant was removed without further histopathological examination. Moreover, even for patients who exhibited osteitis radiographically, a wide area of involvement on the maxillary sinus wall and lack of research on the impact and treatment of osteitis have resulted in a lack of consensus on treatment. Therefore, it was difficult to surgically remove and collect samples for histopathological examination for lesions of the osteitis. Future studies may need to include larger numbers of patients and conduct more in-depth histopathological examination of the inflammatory tissue removed along with the displaced implants. This will help clinicians to better understand the occurrence of osteitis and its impact and to establish management of osteitis.

In conclusion, the results of this study suggest that, to prevent displacement of implants into the maxillary sinus, it is important to perform adequate bone grafting following a site-specific approach based on a thorough preoperative analysis of the residual alveolar bone. Additionally, when an implant is displaced into the maxillary sinus, it is necessary to promptly remove the displaced implant to achieve more favorable surgical outcome.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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