ORIGINAL RESEARCH

# Does the Protrusion of Corticobasal Implants in the Maxillary Sinuses Affect Sinus Health? A Retrospective Study

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## Abstract

**Aim:** The aim of this retrospective study is to investigate the effect of corticobasal implant penetration in the nasal and maxillary sinuses on sinus health and implant survival rate in cases of severely atrophid ridges.

**Materials and methods:** This retrospective study was conducted on thirty patients with 172 implants who underwent corticobasal implant treatment between 2014 and 2018. Implants were divided into two groups according to the penetration depths (Group A, <4 mm; Group B, 4 mm). Inclusion criteria for the study included: (A) patients with severe maxillary ridge resorption with an immediately loaded corticobasal implant-supported prosthesis that showed implant protrusion inside the maxillary sinus on cone-beam computed tomography (CBCT); and (B) patients with a preoperative and postoperative follow-up CBCT scan using the same standard technique and machine. (C) Patients without any history of sinusitis before implant insertion patients who fulfilled the inclusion criteria were recalled for follow-up. The presence of sinus complications was clinically assessed according to the clinical practice guidelines for adult sinusitis of the American Academy of Otolaryngology—Head and Neck Surgery and Radiologically using CBCT. Moreover, patient satisfaction was evaluated using yes-or-no questions. The result was statistically analyzed using Fisher's Exact test.

**Results:** Despite the differences in implant penetration depths, no clinical signs of sinusitis were evident in any patient. One patient presented with transient epistaxis after the surgery, and 2 patients with nine implants revealed nonsignificant thickening of the sinus membrane radiologically ($p = 0.055$). All implants showed optimum bone-implant contact with a 100% survival rate. A significant relationship was reported between the thickness of the membrane and the patient's gender, hypertension, and smoking habits. ($p = 0.001$*, $p = 0.002$*, and $p = 0.034$*, respectively).

**Conclusion:** Penetration of corticobasal implants in the maxillary sinus did not compromise the health of the maxillary sinus or implant survival rate.

**Clinical significance:** Limited posterior maxillary bony support and maxillary sinus pneumatization present challenges in implant dentistry and increase the possibility of implant protrusion inside the maxillary and nasal cavities. Hence, studying the effect of this protrusion on the maxillary sinuses' health and implant survival is highly significant.

**Keywords:** Atrophic ridges, Corticobasal implants, Maxillary sinus, Protrusion, Retrospective study.

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## Introduction

With advancements in dentistry, implant-retained prosthetic restorations have become the treatment of choice for a vast number of patients with complete and partial edentulism. However, the treatment of severely resorbed ridges and geriatric patients remains challenging, owing to the limited amount of bone available in the posterior maxilla and progressive maxillary sinus pneumatization.[1–5]

Limited bone height for implant placement can be managed by bone augmentation procedures, the use of short implants, all-on-4, and even all-on-3 techniques implant insertion in remote bony areas such as zygomatic and tubero-pterygoid regions, and the use of basal implants.[1,2,6–25]

Although short implants are conservative, minimally invasive, and relatively cost-effective, they require few surgical operations or interventions and cause limited complications.[1,2] Longer and wider implants are required to improve the biomechanical prognosis of the prosthesis.[6,8]

In contrast, the technical complexity, difficulty in cleaning, and need for expertise in maxillofacial surgery may limit the routine use of pterygoid and zygomatic implants.[2,12]

Another alternative treatment approach is bone regeneration in the maxillary sinus (sinus lift procedure), a procedure initially described in 1980 by Boyne et al.[26] and performed using the crestal or lateral window approach.[1] In 1994, Summers[27] advocated the elevation of the sinus membrane using osteotomes through a crestal approach accompanied by simultaneous implant placement.

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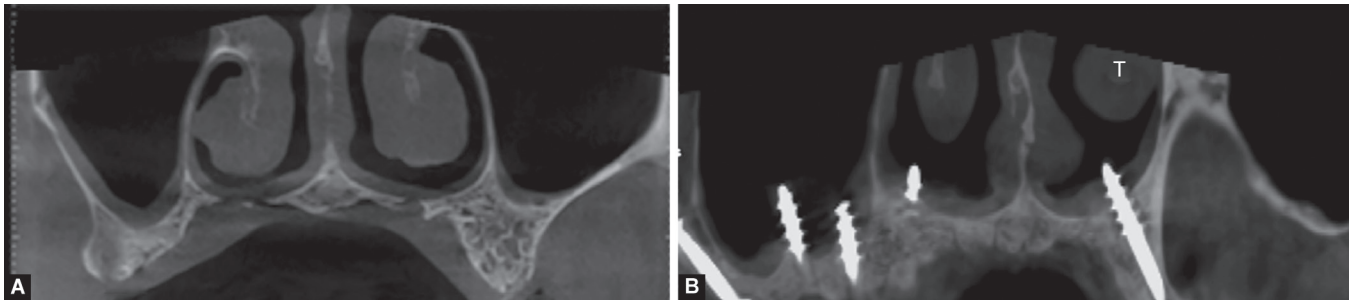



**Figs 1A and B:** The Cone-beam computed tomography scan of patient code no. 03; (A) The preoperative cone beam (coronal cut) shows the nasal and maxillary sinus cavities; (B) The coronal cut shows implant protrusion inside the nasal and maxillary sinus cavities 4 years post-implant insertion no change in the maxillary sinus was detected

Although implants inserted using this technique revealed a high survival rate, their use may be restricted to cases with limited bone resorption for adequate primary stability of the implants.[1,2] Moreover, sinus pneumatization may add another obstacle and increase the possibility of implant protrusion inside the maxillary cavity due to sinus membrane perforation.[1–3,14,28–38] In a review conducted by Al-Salman and Almas,[28] they documented that perforation of the Schneiderian membrane (range 7–35%), infection, bleeding, migration of the implant, loss of the graft, and complications related to the presence of preoperative pathoses are the most likely complications associated with maxillary sinus augmentation. In accordance with that, Stacchi et al.[29] reported 15.7% sinus membrane perforation, while Beck-Broichsitter et al.[30] documented 25 membrane perforations among the 34 patients they investigated.

According to the literature, there is controversy regarding the effect of this perforation; some studies reported no adverse effect on the survival of implants or maxillary sinus health.[1–3,31–38] On the other hand, thickening of the sinus membrane has been reported as a radiographic consequence of implant protrusion in the maxillary sinuses while some studies reported the incidence of manageable complications ranging from epistaxis to sinusitis.[1,3,32,34,35]

The use of corticobasal implants as an alternative treatment in cases with compromised alveolar ridge support has shown high success and survival rates.[2,18,22–25] Pałka and Lazarov[18] reported a cumulative survival of 99.3, 98.6, and 97.0%, respectively, at 12, 24, and 35 months after bicortical/corticobasal implant placement. Patel et al.[22] reported a survival rate of 97.5% after 1 year. Moreover, Awadalkreem et al.[23,24] reported a 100% survival rate of corticobasal implants after 5 years of follow-up in a patient with marginal mandibulectomy and a 100% survival rate in cases of compromised ridge support after 18 months of follow-up with limited manageable complications. Furthermore, Gosai et al.[25] documented a survival rate of 96.8%.

One of the advantages of corticobasal implants is the elimination of bone grafting, which reduces the number, time, and cost of required surgical procedures, as well as, the susceptibility to complications.[2,13–25] Moreover, it provides bi-cortical or even tri-cortical implant anchorage that enhances implant stability.[2,13–25] As a consequence of proper placement, implants may protrude in the nasal and maxillary sinuses.[1–3,28–38] Nevertheless, the effects of the protrusion of corticobasal implants in the maxillary sinus and nasal cavity on the health of the sinus and implant survival rate have not been clarified and are based on limited data.

Therefore, this study aimed to retrospectively evaluate the effect of potential protrusion of corticobasal implants into the maxillary sinus or nasal cavity on maxillary sinus health and implant survival.

## Materials and Methods

This retrospective study was conducted in 2018 after obtaining the approval of the ethical committee issued by the third author's institute number: (WK/OS/AETEA/44/5) before the commencement of the study.

The records of the patients who had corticobasal implant treatment (BCS, Dr. Ihde Dental AG, 8737 Gommiswald, Switzerland) at the implant department between 2014 and 2018, including CBCT scans, were screened for the inclusion criteria. The inclusion criteria of the study were: (A) Patients with severe maxillary ridge resorption with an immediately loaded corticobasal implant-supported prosthesis that showed implant protrusion inside the maxillary sinus on CBCT; (B) Patients with a preoperative and postoperative follow-up CBCT scan using the same standard technique and machine (Planmeca ProMax; Planmeca, Budapest, Hungary) (Fig. 1); and (C) Patients without a history of sinusitis before implant insertion. The exclusion criteria included patients without either preoperative and/or postoperative CBCT scans and patients with a history of or who have been diagnosed with sinusitis.

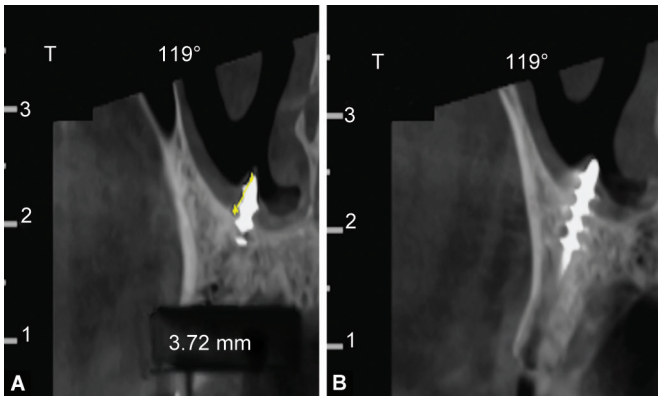
All the patients who fulfilled the inclusion criteria agreed to participate in this research and signed the written informed consent were recruited.

An expert radiologist analyzed the postoperative CBCTs and measured the implant penetration depth on the sagittal section using CBCT software (Blue Sky Plan 4 Version 4.3.10). Consequently, implants were categorized into two groups based on the depth of implant penetration measured. Group A included implants with a penetration depth of <4 mm (Fig. 2). and Group B included implants with a penetration depth of ≥4 mm (Fig. 3).[1,2]

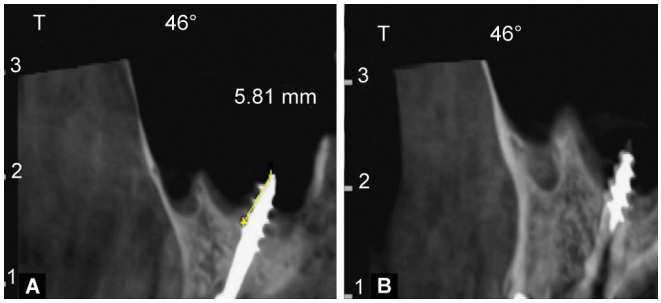
The intra-rater reliability for the investigator (radiologist) was assessed through repeated measurements at intervals performed at a varying number of days apart. The reliability score was found to be 0.67.

### Maxillary Sinus Assessment

All patients who had fulfilled the inclusion criteria were recalled for follow-up; they were examined for the presence of signs and symptoms of sinusitis according to the clinical practice guideline for adult sinusitis by the American Academy of Otolaryngology-Head and Neck Surgery, such as mucopurulent drainage, facial pain, decreased sense of smell, nasal obstruction, headache, and halitosis.[39]




**Figs 2A and B:** The Cone-beam computed tomography scan of patient code no. 03 (sagittal cut); (A) Showing an implant with a penetration depth of 3.72 mm; (Group A: <4 mm depth); (B) At the 4-year follow-up visit. There are no signs of sinusitis and no inflammatory reactions at or around the implant




**Figs 3A and B:** The cone-beam computed tomography scan of patient code no. 012 sagittal section; (A) Showing an implant with a penetration depth of 5.81 mm (Group B: <4 mm depth); (B) At the 5-year follow-up visit. Showing only thickness of the maxillary membrane that is not associated with clinical signs and symptoms of sinusitis

Additionally, radiologic evaluation was performed to detect any change in the nasal cavity and maxillary sinus from the preoperative condition using the same standard CBCT.

### Implant Assessment

Implant survival was examined and recorded. Implant survival was defined as the implant seen inside the oral cavity during the examination.[40]

Radiographically, the peri-implant bone contact and the presence or absence of peri-implant radiolucency were observed.

### Patients Satisfaction Assessment

Patient satisfaction was evaluated using yes/no answer-type questions and asking patients about their overall satisfaction and their satisfaction in relation to esthetics, mastication, phonation, comfort, and if they reported any complaints.[23,24,41]

### Data Collection and Statistical Analysis

A customized database form was designed to document the records of patients, including demographic, implant, prosthesis, and follow-up data during the study period. The demographic data of patients included age, gender, occupation, past medical and dental history, and smoking habits. The implant data included the date of implant insertion and number. Additionally, the follow-up records were reported, including the investigated clinical, radiographical, and patient satisfaction assessment records.

Results were statistically analyzed using the statistical package for the social sciences (SPSS) software (SPSS version 22; IBM Corp., New York, NY, USA). $p < 0.05$ was considered statistically significant. Fisher's Exact test was used for statistical analysis.

**Table 1:** Participants' characteristics

| *Variables* | *Number* | *Percentage %* |
|---|---|---|
| Gender | | |
| Male | 12 | 40% |
| Female | 18 | 60% |
| Past medical history | | |
| Hypertension | | |
| Yes | 2 | 6.7% |
| No | 28 | 93.3% |
| DM | | |
| Yes | 2 | 6.7% |
| No | 28 | 93.3% |
| Smoking habit | | |
| Yes | 6 | 20% |
| No | 24 | 80% |

## Results

Thirty patients [18 (60%) female; 12 (40%) male; mean age, 51.8 years; age range, 20–80 years] with 172 implants showed implant protrusion in the nasal cavity and maxillary sinus with different penetration depths. Of these, two (6.7%) patients had hypertension, two (6.7%) had controlled diabetes, and six (20%) were smokers (Table 1).

Of the total implants, 92 (53.49%) were included in Group A (Fig. 2). while 80 (46.51%) were in Group B (Fig. 3).

The mean follow-up duration for the implants was 3.76 years (range, 2–5 years).

### Maxillary Sinus Assessment

Preoperatively, no patient had a history of maxillary sinusitis, as presented in the inclusion criteria of the study. Additionally, no patient reported any clinical signs and/or symptoms of sinusitis or nasal congestion throughout the follow-up period. Only 1 patient reported transient epistaxis after implant surgery that stopped spontaneously.

Radiologically, all the examined nasal and maxillary sinus cavities were clear without any pathological changes (Figs 2 and 3). Only 2 patients with 9 implants showed an increase in the thickness of the sinus membrane without any clinical signs of sinusitis. The depth of implant penetration did not have any effect on the maxillary sinus or implant health; no significant difference was reported between the penetration depth and the thickness of the sinus membrane using Fisher's Exact test ($p = 0.055$).

A significant association was reported between the patient's gender and the thickness of the sinus membrane ($p = 0.001$*), and the percentage of thickness is higher in males than females. Both hypertension and smoking had an influence on the thickness of the sinus membrane using Fisher's Exact test ($p = 0.002$*, $p = 0.034$*; Table 2).

**Table 2:** Association between thickening of the sinus membrane and implant penetration depth, patient's gender, hypertension, and smoking

| | | *Thickening of the maxillary sinus membrane* | | | |
|---|---|---|---|---|---|
| *Variable* | *Yes* | | *No* | *Total* | *p-value* |
| Implant penetration depth | | | | | |
| <4 mm | Count | 2 | 90 | 92 | |
| | % within implant depth | 2.2% | 97.8% | 100.0% | |
| ≥4 mm | Count | 7 | 73 | 80 | |
| | % within implant depth | 8.8% | 91.3% | 100.0% | |
| Total | Count | 9 | 163 | 172 | |
| | % within implant depth | 5.2% | 94.8% | 100.0% | **0.055** |
| Gender | | | | | |
| Male | Count | 9 | 10 | 19 | |
| | % within gender | 47.4% | 52.6% | 100.0% | |
| Female | Count | 0 | 18 | 18 | |
| | % within gender | 0.0% | 100.0% | 100.0% | |
| Total | Count | 9 | 28 | 37 | |
| | % within gender | 24.3% | 75.7% | 100.0% | **0.001*** |
| Hypertension | | | | | |
| Yes | Count | 2 | 0 | 2 | |
| | % within hypertension | 100.0% | 0.0% | 100.0% | |
| No | Count | 0 | 28 | 28 | |
| | % within hypertension | 0.0% | 100.0% | 100.0% | |
| Total | Count | 2 | 28 | 30 | |
| | % within hypertension | 6.7% | 93.3% | 100.0% | **0.002*** |
| Smoking | | | | | |
| Yes | Count | 2 | 4 | 6 | |
| | % within smoking | 33.3% | 66.7% | 100.0% | |
| No | Count | 0 | 24 | 24 | |
| | % within smoking | 0.0% | 100.0% | 100.0% | |
| Total | Count | 2 | 28 | 30 | |
| | % within smoking | 6.7% | 93.3% | 100.0% | **0.034*** |

Bold values indicate as Non significant

### Implant Assessment

No signs of bone loss or radiolucency were detected around the investigated implants, and all implants revealed optimum bone-implant contact and a 100% survival rate.

### Patient Satisfaction Assessment

All the patients described their satisfaction and reported improved comfort, phonetics, esthetics, and mastication after treatment (Table 3). Only 1 patient reported a history of porcelain chipped supra-structure after 1 year of function. The prosthesis was repaired, and an occlusal adjustment was performed.

**Table 3:** Patients' satisfaction results

| *Satisfaction parameter* | *Patient satisfaction* | *Number of patients* | *Percentage %* |
|---|---|---|---|
| Esthetic | Satisfied | 30 | 100% |
| | Not satisfied | 0 | 0% |
| Phonetic | Satisfied | 30 | 100% |
| | Not satisfied | 0 | 0% |
| Mastication | Satisfied | 30 | 100% |
| | Not satisfied | 0 | 0% |
| Comfort | Satisfied | 30 | 100% |
| | Not satisfied | 0 | 0% |
| Overall satisfaction | Satisfied | 30 | 100% |
| | Not satisfied | 0 | 0% |

## Discussion

Implant treatment in cases of severe alveolar ridge resorption is challenging.[1,2] The compromised bone quantity and quality, as well as the approximation to the important anatomical structures, including the maxillary sinus and inferior alveolar nerve, may further complicate the situation.[1,2,10,19,23] In advanced ridge resorption, the use of long implants with high primary stability may not be applicable.[1,2,10,19,23] Several authors have recommended the use of bi-cortical or even tri-cortical implants to achieve excellent implant stability.[10,17,42,43] Ivanoff et al.[42] reported the need for a greater implant removal torque in implants with bi-cortical anchorage. Strecha et al.[43] recommended the use of implants with bi-cortical engagement as a highly successful and affordable option for various types of patients. In the same line, Ihde et al.[17] stated that corticobasal implants exhibit bi-cortical, tri-cortical, or even quadri-cortical implant anchorage, which is a profoundly improved implant anchorage, and hence, a higher survival rate. To achieve a successful bi-cortical anchorage, implants should be inserted following the

16 proven methods of corticobasal implant targeting the second and/or third cortex, including the maxillary sinus and nasal floor.[44]

In the present study, implants protrude inside the nasal and maxillary cavities owing to the limitation of the bone height in the posterior maxilla as well as maxillary sinus pneumatization which increases the potential susceptibility of implant exposure of the implant fixture into the nasal and sinus cavities after maxillary membrane perforation, as reported by many investigators.[1–5,28–38] Al-Salman and Almas[28] and Stacchi et al.[29] documented 7–35% and 15.7% incidences of membrane perforation, respectively. In accordance with this, Beck-Broichsitter et al.[30] reported the incidence of 25 membrane perforations in 34 patients.

The implant survival rate reported in this study is in line with Kim et al.[34] who documented the same survival rate with reported post-surgical nasal bleeding in 3 patients out of 39 patients. Moreover, Awadalkreem et al.[2] reported a 100% survival rate after 18 months of follow-up. Ragucci et al.[1] documented a 95.6% survival rate after a 52.7-month follow-up of implants. Furthermore, Ghnaem et al.[36] reported a survival rate of 100% after 6 years of follow-up, while Nooh[35] stated a survival rate of 98.4% and concluded that implant penetration even up to 3 mm does not affect implant stability but may be associated with minor manageable complications such as epistaxis and sinusitis. In the same line, Pałka and Lazarov[18] documented a survival rate of approximately 99% when 1019 BECES/BCS corticobasal implants were examined in 22.2 ± 7.3 months of follow-up, through a retrospective cohort study.

The absence of sinus pathology revealed in this study can be directly attributed to the smooth surface of the penetrating implants and the thin penetrating depth and it is in accordance with Jung et al.,[5] who analyzed the effects of implant penetration in the maxillary sinus of mongrel dogs during an observation period of 6 months and found out that none of the examined maxillary sinus cavities showed any inflammatory signs. Abi Najm et al.[4] reported the absence of sinus complications following 83 implant penetration inside the maxillary sinus after a follow-up period of 20 years. Moreover, Lazarov[19] stated that corticobasal implant penetration per se has no adverse effect either on maxillary sinus health or on the survival rate of the implant after investigating 217 implants penetrating 131 maxillary sinuses, with none of the implants failing and only one reported maxillary sinus adverse reaction. Furthermore, Jung et al.,[3] Tabrizi et al.,[32] Zhong et al.,[33] Kim et al.,[34] Elhamruni et al.,[37] and Shihab Ol[38] reported the same observation.

In the same line, using a Sinuoscopy instead of clinical and radiographical examination, no inflammation was observed around the implant fixtures of the 14 patients examined by Petruson[31] after a one-year follow-up period.

On the other hand, Nooh[35] reported the occurrence of sinusitis in one patient out of the 63 patients they investigated who were treated with antibiotics. This difference in the result could be related to the smooth surface of the implants used in the present study.

The results of this study showed that the penetration depth of implants does not correlate with the implant survival rate; this result is in line with Ragucci et al.[1] and Awadalkreem et al.[2] using the same penetrating depths. In accordance with this, Zhong et al.[33] investigated the effect of implant protrusion inside the maxillary sinuses of dog models using different depths (Group A: 0 mm; Group B: 1 mm; Group C: 2 mm; Group D: 3 mm), the same result was obtained. Elhamruni et al.[37] reported the same result with different penetration depths, including control Group A with 0 mm penetration and study Groups B, C, and D with 1, 2, and 3 mm penetration depths, respectively).

The incidence of epistaxis reported in this study corresponds with the findings of Nooh[35] who reported the occurrence of mild epistaxis during the immediate postoperative period in 7 of the 63 patients included in that study. Similar results have been reported by Kim et al.[34] in 3 patients out of the 39 examined immediately postoperatively. Moreover, Ragucci et al.[1] stated that the most common complication associated with implant pentation inside the maxillary sinus is epistaxis.

Although two patients in our study showed evidence of thickening in the Schneiderian membrane, there was no evidence of sinusitis, which is in accordance with previously published studies.[1,3,19,32] Eleven of the 98 cases that did not show preoperative thickening of the sinus membrane examined by Lazarov[19] revealed radiographic thickening of the sinus membrane following implant treatment without any evidence of maxillary sinusitis. The same observation was documented by Jung et al.[3] around 14 implants out of the 23 penetrated implants that were investigated. Moreover, Tabrizi et al.[32] reported thickening of the sinus membrane in 2 patients out of the 13 patients they studied with no signs or symptoms of sinusitis. In the same line, Ragucci et al.[1] stated that thickening of the sinus membrane was the most common radiographical observation associated with implant penetration in the maxillary sinus.

The result of the present study revealed that the thickness of the sinus membrane can be related to the patient's gender, medical history, and smoking habits. Both patients who showed membrane thickness in the present study were men and smokers. Monje et al.[45] and Munakata et al.[46] mentioned several predisposing factors that are associated with increased sinus mucosal thickness, including patient-related factors (age, smoking habits), tooth-related factors (periapical lesions, periodontitis, and bone loss), and morphological factors associated with the maxillary sinus (sinus septa and nasal septum deviation).

In the present study, all implants showed optimum bone contact, which is in accordance with Khairnar and Gaur,[47] who reported an increase in bone apposition and excellent implant stability in bi-cortical implants anchored in rabbits. Moreover, Kim et al.,[34] reported a significant increase in peri-implant bone level when the initial bone height was less than 5 mm, but no increase in peri-implant level when it was 5 mm or more. Furthermore, all the penetrated implants in the study conducted by Tabrizi et al.[32] were well integrated after 12 months of follow-up without radiographic signs of bone loss. In the same line, Awadalkreem et al.,[2] reported the absence of any osteolytic reaction around the penetrated implants with increased bone-implant contact after 18 months of follow-up.

The patient satisfaction result reported in the study is in line with that in other studies where corticobasal implant-retained prosthesis had significantly improved the patients' esthetics, mastication, phonetics, and comfort, with a positive impact on their quality of life.[2,22–24,48–50] Awadalkreem et al.[48] documented a significant improvement in the overall patient satisfaction from (5.4 ± 1.7) to (7.7 ± 0.7) following immediate loaded basal implant treatment. Moreover, Lazarove AB[49] reported a significant improvement in the patient quality of life in patients treated with corticobasal implants, with a reduction or even absence of oral health problems. Furthermore, Aggarwal S[50] documented a positive impact of basal implant treatment modality on the patient satisfaction of 11 investigated patients with a total of 58 implants using the oral health impact profile questionnaire-14 (OHIP-14). In a study conducted by Patel et al.,[22] all the patients were satisfied with respect to chewing ability, speech, and esthetics.

The limitation of this study is the relatively small sample size. Further clinical research is needed to support the results of this study.

## Conclusion

Immediately loaded corticobasal implant-supported prostheses are one of the treatment modalities that can be used in cases of severely atrophid ridges; consequently, implant tips may protrude inside the nasal and maxillary sinuses. Based on the results of this study, corticobasal implants can be safely protruded in the nasal and maxillary sinuses without clinical or radiographic evidence of sinusitis or a negative effect on implant survival, and with a positive effect on patient satisfaction.

## Author Contributions

Ahmad A formulated the study design, contributed to the conceptualization, treating the cases, validation, and finalizing the manuscript.

Awadalkreem F formulated the study design, contributed to the conceptualization, treating the cases, data interpretation, writing, editing, validating and finalizing and submission of the manuscript.

Osman M formulated the study design, contributed to the conceptualization, treating the cases, validation, and finalizing the manuscript.

Palka L critically revised the manuscript and performed literature searches and finalizing the manuscript.

All authors have read and approved the final version of the manuscript.

## Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

## Ethical Approval

The study was approved by the ethical committee of Khartoum Dental Teaching Hospital (Khartoum, Sudan) and the Sudanese Ministry of Health, State Khartoum. (No. WK/OS/ AETEA/44/5).

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