

Relationship Between Preoperative Cone Beam Computed Tomography and Intraoperative Findings in Sinus Augmentation

Gokhan Gurler, DDS, PhD¹/Cagri Delilbasi, DDS, PhD²

Purpose: To investigate whether the presence of bony septum, thickness of sinus membrane (schneiderian membrane), and residual alveolar bone height affects membrane perforation and the duration of sinus augmentation. **Materials and Methods:** Preoperative cone beam computed tomography (CBCT) images obtained from patients undergoing lateral sinus augmentation were evaluated for the presence of bony septum, thickness of sinus membrane, and residual alveolar bone height. During the operation, membrane perforation and duration of surgery were noted. The Student *t* test was used to compare descriptive statistics (mean, standard error) and quantitative variables between groups. The Fisher exact χ^2 test was used to compare the qualitative data, and Pearson correlation test was used to evaluate the correlation between data. $P < .05$ was considered significant. **Results:** Data from 57 patients were evaluated. Membrane perforation occurred in 14 patients included in the study and in 8 patients with sinus septum. A significant relationship was found between the presence of septum and membrane perforation during sinus augmentation ($P = .014$). However, the relationship among other CBCT and intraoperative findings was not significant. **Conclusion:** Presence of septum in the maxillary sinus increases the risk of membrane perforation, but does not extend the duration of the sinus augmentation. *INT J ORAL MAXILLOFAC IMPLANTS* 2015;30:1244–1248. doi: 10.11607/jomi.3797

Key words: CBCT, perforation, sinus augmentation, sinus membrane

Endo-osseous implants are widely used in dental practice to restore tooth loss. Because of reduced bone height and low bone density, it is challenging to insert implants in the maxillary posterior region.^{1,2} Sinus floor elevation is a predictable and safe procedure to overcome this obstacle.¹ Sinus floor augmentation is the preferred technique to handle this problem, particularly when residual alveolar bone height is less than 5 mm. However, anatomical and pathologic variations of maxillary sinus may complicate the surgical procedure; therefore, the maxillary sinus must be evaluated before sinus floor augmentation to decrease intraoperative and postoperative complications.^{3,4}

Panoramic radiographs were extensively used for this purpose until the introduction of cone beam computed tomography (CBCT). CBCT was first described by Mozzo et al⁵ and has become a popular technique in dental practice. Compared with panoramic radiographs and conventional computed tomography (CT), CBCT images present the accurate location of anatomical structures without distortion and provide information about bone dimensions and morphology with the advantage of lower radiation than CT, but slightly higher dose than panoramic radiography.^{6–8}

The assessment of anatomical characteristics of the sinus cavity before sinus augmentation is important in surgical treatment planning. CBCT is increasingly being used in dental practice and has been drawing more attention when used for the assessment of incidental findings and anatomical variations.

The most common complication encountered in sinus floor augmentation is perforation of the sinus membrane. The membrane is usually perforated during opening of the bony window, but it can also occur during elevation of the membrane, especially when there are some irregularities or bony septum in the sinus cavity, thin sinus membrane, and low residual alveolar bone height.^{6,9–12}

The objective of this study was to investigate whether the presence of bony septum, thickness of

¹Assistant Professor, Istanbul Medipol University School of Dentistry, Department of Oral and Maxillofacial Surgery, Unkapani-Istanbul, Turkey.

²Professor, Istanbul Medipol University School of Dentistry, Department of Oral and Maxillofacial Surgery, Unkapani-Istanbul, Turkey.

Correspondence to: Dr Gokhan Gurler, DDS, PhD, Istanbul Medipol University School of Dentistry, Department of Oral and Maxillofacial Surgery, Atatürk Bulvarı No:27, 34083 Unkapani-Istanbul. Fax: +90 212 531 75 55. Email: ggurler@medipol.edu.tr

©2015 by Quintessence Publishing Co Inc.

sinus membrane (Schneiderian membrane), and residual alveolar bone height affects membrane perforation and duration of sinus augmentation.

MATERIALS AND METHODS

This study evaluated maxillary sinus CBCT scans of patients who were undergoing sinus floor augmentation at Istanbul Medipol University School of Dentistry, Department of Oral and Maxillofacial Surgery (Unkapani-Istanbul, Turkey). The patients who were in good general health status and had no symptoms of maxillary sinus diseases were included in the study. However, patients having any sinus pathology and who smoked more than 10 cigarettes per day were treated, but excluded from the study. Only one side was randomly included (by flipping a coin) in the study even if the patient needed bilateral surgery. Two surgeons with similar experience in sinus augmentation performed the procedures. The flap design for sinus floor augmentation in our clinic includes horizontal incision on the alveolar crest and a mesial vertical releasing incision. The scans were taken using i-CAT Next Generation cone beam computed tomography (Imaging Sciences International). Tomography settings were as follows: 120 kV, 5 mA, and a field of view of 16×8 cm. Images were analyzed using i-CAT software in axial, coronal, and sagittal planes with 2-mm slices.

CBCT images from 57 patients (27 men and 30 women; age range, 22–78 years; mean age \pm standard deviation [SD], 49.6 ± 1.14 years) were evaluated. The images were assessed by one of the authors (G.G.). For calibration and evaluation of intraobserver reliability, 10 randomly selected images were measured twice on two different days, resulting in a mean difference of 0.21 mm per image (range, 0.1–0.35 mm). For further study, each measurement was repeated and the mean value was calculated. When the difference between two values was 0.2 mm or more, a third measurement was taken.¹ This study was approved by the local ethical committee of Istanbul Medipol University, and informed consent was obtained from all patients. The following parameters were assessed and measured.

Thickness of Sinus Membrane

Thickness of the sinus membrane was measured on coronal images. The deepest point of the sinus inferior wall was used as a reference point. At the reference point, membrane lining and residual alveolar bone height were measured. Mucosal thickness was measured with the digital ruler of i-CAT software in millimeters (Fig 1). Sinus membrane thickness of more than 3 mm was classified as pathologic according to the criteria of White and Pharoah.¹³

Membrane Perforation

Opening of lateral bony window and elevation of the maxillary sinus membrane was carried out with a piezosurgery device (EMS Piezon Master Surgery, EMS Electro Medical Systems) and sinus elevators. Membrane perforation during surgery was noted but the size of the perforation was not measured.

Presence of Bony Septum

Bony septum in the maxillary sinus (Underwood septum) was defined as bony walls partitioning the sinus generally in a vertical direction.¹⁴ Axial images were examined for the presence of bony septum (Fig 2).

Height of Residual Alveolar Bone

Residual alveolar bone height was measured starting from the reference point at the inferior border of the maxillary sinus extending to the alveolar crest in sagittal sections of CBCT. The highest measurement was recorded (Fig 3).

Duration of Surgery

The length of time from the beginning of the incision to the completion of suturing was defined as duration of surgery.

Statistical Analysis

Statistical analysis was carried out using Statistical Package for Social Sciences software for Windows 15.0 (SPSS). The Student *t* test was used to compare descriptive statistics (mean, standard deviation) and quantitative variables between groups, and the Fisher exact χ^2 test was used to compare qualitative data between the groups. Pearson correlation test was used to evaluate the correlation between data. *P* < .05 was considered significant.

RESULTS

Sinus membrane perforation occurred in 14 patients, for a prevalence of 24.5%. Similarly, maxillary sinus septum was also observed in 14 patients, for a prevalence of 24.5%. Membrane perforation occurred in 8 cases with septum (57.1%). Collagen membrane was used to cover the membrane perforations. The relationship between the presence of septum and membrane perforation was significant (*P* = .014). The mean (\pm SD) duration of surgery in the presence of sinus septum was 34.18 ± 8.27 minutes and without the presence of sinus septum was 30.94 ± 9.08 minutes. There was no significant effect of septum presence on the duration of surgery (*P* = .3). The mean sinus membrane thickness was 3.96 ± 2.01 mm in all patients. Membrane perforations occurred when the mean membrane

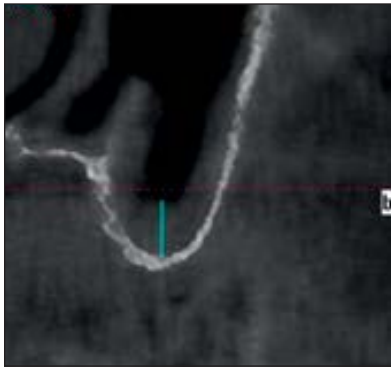


Fig 1 (left) Measurement of sinus membrane thickness in coronal sections.

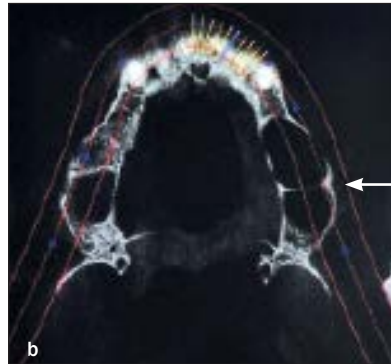


Fig 2 (below) Presence of sinus septa in axial section (a; arrow) and panoramic view (b; arrow).

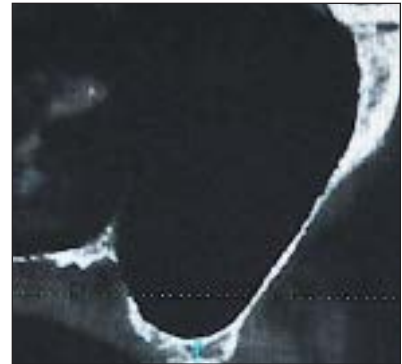


Fig 3 (below right) Measurement of residual alveolar bone height in coronal sections. -

thickness was 3.64 ± 2.19 mm. Mean thickness of non-perforated membrane was 4.34 ± 2.71 mm. There was no significant relationship between the membrane thickness and occurrence of perforation ($P = .44$). The mean thickness of sinus membrane with and without septum was 3.78 ± 2.19 mm and 4.26 ± 2.73 mm, respectively. The presence of sinus septum did not have a significant effect on the membrane thickness ($P = .66$). The mean residual alveolar bone height was 4.04 ± 1.96 mm in all patients. Membrane perforations occurred when the mean residual alveolar bone height was 3.18 ± 1.27 mm. Mean bone height in nonperforated membrane was 4.32 ± 2.01 mm. The relationship between the residual alveolar bone height and occurrence of perforation was not significant ($P = .08$). There was also no correlation between sinus membrane thickness and duration of surgery ($r = -0.163$; $P = .28$) as well as between residual alveolar bone height and duration of surgery ($r = -0.14$; $P = .33$). None of the patients showed signs of postoperative sinus infection.

DISCUSSION

Maxillary sinus floor augmentation is a surgical procedure that increases the bone volume at the posterior

maxilla making it possible to place dental implants. The procedure is usually predictable with satisfactory results; however, as with any other surgical procedure, this procedure has some complications.^{3,14,15} One of the most common complications during surgery is perforation of the sinus membrane, with an incidence of 7% to 35%.^{11,16} The integrity of sinus membrane is essential for graft healing without the risk of migration into the antral cavity, prevention of postoperative sinusitis, and success of the implant therapy.^{10,14} Anatomical variations, pathologic conditions in the sinus, as well as iatrogenic factors may increase the risk of perforation. In the present study, a perforation rate of 24.5% was noticed, all of which occurred during the elevation of the membrane.

The sinus membrane, characterized by a periosteum overlaid with a thin layer of pseudociliated stratified epithelium, plays an important role in protecting the sinus cavity. If mucus production and thus clearance of the mucosa is hindered, the risk for sinus infection increases.^{1,9,12,17} The thickness of sinus membrane was studied in several studies. In a postmortem study, Tos and Mogensen¹⁸ found the mean thickness of the membrane to range from 0.3 to 0.8 mm, but it may increase 10- to 15-fold in the presence of inflammation. Janner et al¹ reported a high prevalence of

mucosal pathologies (55%) in a study carried out on 68 CBCT images. This high result can be attributed to acceptance of 2-mm thickness as a threshold value to define a pathologic membrane. Cagici et al¹⁹ considered 2 mm as a threshold for pathologic swelling because mucosa could be seen only at a thickness of 2 mm or more. White and Pharoah¹³ considered a mucosal thickening of more than 3 mm to be pathologic. In the present study, 33 (57.8%) of 57 sinuses revealed a thickness of more than 3 mm in asymptomatic patients. The clinical significance of the membrane thickness in sinus floor augmentation is still controversial.¹ It is stated that perforations are most likely to occur in thin membranes, thus membranes less than 1.5 mm in thickness are more susceptible to perforation.^{12,14} The results of this study demonstrated that the rate of membrane perforation increased as the thickness of the membrane decreased but the difference was not significant. In addition, no significant relationship was found between membrane thickness and other parameters. Nevertheless, in clinical conditions with evidence of sinus pathology or when sinus drainage is impaired, which may risk success of the treatment, it is advisable that an ear, nose, and throat specialist be consulted.²⁰

Antral septum was defined as a pointed bone structure originating from the maxillary sinus wall. It is generally seen in an incomplete form, but rarely it can divide the maxillary sinus cavity into compartments (complete form).²¹⁻²³ In previous studies, the prevalence of antral septum was reported as 16% to 33%, with a mean height of 8 mm.¹⁴ It is seen vertically in an anteroposterior direction and is higher at the level of the medial wall. Multiple septum formation is rare.¹⁴ Septum was found in 24.5% of the maxillary sinuses in the present study. It was reported that in about half of the CBCT examinations in which an antral septum was revealed, the risk of membrane perforation during maxillary sinus lift surgery may be increased.^{22,23} Whether the increased possibility of perforation depends on the thinning of the membrane or the difficulty of membrane elevation in the presence of septum is debatable. In their study conducted on CTs, Cakur et al²⁴ found that sinus septum may be the reason for membrane thinness. The present study had a similar result but the difference is not significant.

The authors encountered 57% membrane perforation in sinuses with bony septum, which is statistically significant. In the presence of bony septum, the duration of surgery also extends, albeit not significantly, possibly because of the increased attention given by the surgeon during membrane elevation or the extra time spent in the repair of the membrane perforation.

Maxillary sinus membrane perforation is the most commonly encountered complication of sinus

augmentation. The membrane is usually perforated during the opening of the bony window, but it can also occur during elevation of the membrane, especially when it is thin or in the presence of bony septum in the sinus cavity.^{9,10,12,25} Preoperative detection of any antral septum is very important for preventing unexpected membrane perforations. Treatment options depend on the size of the perforation. The general trend is to close the tear with a resorbable collagen membrane^{10,14} as performed in the present study. This result was similar to that of Kasabah et al²⁶ who also found no relation between mucosa perforation, mucosa thickening, and cystlike lesion in the sinus.

Residual alveolar bone height is the key factor in determining the level of bone osteotomy for lateral window opening. Alveolar bone height less than 5 mm needs a lateral sinus lift approach. Ardekian et al¹² reported that maxillary sinus membrane perforation occurred more frequently with a small residual alveolar bone height. However, the present study showed no relationship between alveolar bone height and membrane perforation. The authors assumed that the residual alveolar bone height may affect the duration of the surgery, because parallel to bone height increase, the lateral window osteotomy must be performed distant to the alveolar crest; thus the need for an extensive flap reflection led to the flap design used in the present study.

CBCT is a novel three-dimensional imaging modality preferred for planning paranasal surgery. Because the anatomical structure of both the posterior maxilla and antrum is complex, advanced radiologic evaluation before lateral sinus lifting is suggested. CBCT is preferred over conventional CT because of the lower dose of radiation to the patient.^{7,8,20,27,28} The use of CBCT increases the surgeon's confidence and makes it possible to predict complications in sinus surgery. Baciu et al²⁹ compared panoramic radiography and CBCT for the evaluation of maxillary sinus before sinus lifting procedure and implant placement. They recommended that CBCT be performed before sinus floor augmentation to aid in the accuracy of the surgical technique.

CONCLUSIONS

In this study, membrane perforation occurred in 8 (57.1%) of 14 patients with septum. Presence of septum in the maxillary sinus may increase the risk of membrane perforation during sinus augmentation, but does not significantly extend the duration of the surgical procedure. Further studies are needed to reveal the relationship between anatomical variations of the maxillary sinus and outcomes of sinus augmentation.

ACKNOWLEDGMENTS

The authors reported no conflicts of interest related to this study.

REFERENCES

- Janner SF, Caversaccio MD, Dubach P, et al. Characteristics and dimensions of the Schneiderian membrane: A radiographic analysis using cone beam computed tomography in patients referred for dental implant surgery in the posterior maxilla. *Clin Oral Implants Res* 2011;22:1446–1453.
- Jemt T, Lekholm U. Implant treatment in edentulous maxillae: A 5-year follow-up report on patients with different degrees of jaw resorption. *Int J Oral Maxillofac Implants* 1995;10:303–311.
- Esposito M, Grusovin MG, Rees J, et al. Effectiveness of sinus lift procedures for dental implant rehabilitation: A Cochrane systematic review. *Eur J Oral Implantol* 2010;3:7–26.
- Zijdeveld SA, van den Bergh JP, Schulten EA, ten Bruggenkate CM. Anatomical and surgical findings and complications in 100 consecutive maxillary sinus floor elevation procedures. *J Oral Maxillofac Surg* 2008;66:1426–1438.
- Mozzo P, Procacci C, Tacconi A, Matini PT, Andreis IA. A new volumetric CT machine for dental imaging based on the cone beam technique: Preliminary results. *Eur Radiol* 1998;8:1558–1564.
- Lana JP, Carneiro PM, Machado Vde C, et al. Anatomic variations and lesions of the maxillary sinus detected in cone beam computed tomography for dental implants. *Clin Oral Implants Res* 2012;23:1398–1403.
- Ritter L, Lutz J, Neugebauer J, et al. Prevalence of pathologic findings in the maxillary sinus in cone-beam computerized tomography. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2011;111:634–640.
- Suomalainen A, Kiljunen T, Käser Y, Peltola, J, Kortensniemi M. Dosimetry and image quality of four dental cone beam computed tomography scanners compared with multislice computed tomography scanners. *Dentomaxillofac Radiol* 2009;38:367–378.
- Pikos MA. Maxillary sinus membrane repair: Update on technique for large and complete perforations. *Implant Dent* 2008;17:24–31.
- Ding X, Zhu XH, Wang HM, Zhang XH. Effect of sinus membrane perforation on the survival of implants placed in combination with osteotome sinus floor elevation. *J Craniofac Surg* 2013;24:e102–e104.
- Valassis JM, Fugazzotto PA. A classification system for sinus membrane perforations during augmentation with option to repair. *J Periodontol* 1999;70:692–699.
- Ardekian L, Oved-Peleg E, Mactei EE, Peled M. The clinical significance of sinus membrane perforation during augmentation of the maxillary sinus. *J Oral Maxillofac Surg* 2006;64:277–282.
- White SC, Pharoah MJ. *Oral Radiology – Principles and Interpretation*, 5th Edition. St. Louis, MO: Mosby, 2004.
- Meleo D, Mangione F, Corbi S, Pacifici L. Management of the Schneiderian membrane perforation during the maxillary sinus elevation procedure: A case report. *Ann Stomatol (Roma)* 2012;3:24–30.
- Testori T, Weinstein RL, Taschieri S, Del Fabbro M. Risk factor analysis following maxillary sinus augmentation: A retrospective multicenter study. *Int J Oral Maxillofac Implants* 2012;27:1170–1176.
- Tang ZH, Wu MJ, Xu WH. Implants placed simultaneously with maxillary sinus floor augmentations in the presence of antral pseudocysts: A case report. *Int J Oral Maxillofac Surg* 2011;40:998–1001.
- Daud Galli SK, Lebowitz RA, Giacchi RJ, Glickman R, Jacobs JB. Chronic sinusitis complicating sinus lift surgery. *Am J Rhinol* 2001;15:181–186.
- Tos M, Mogensen C. Mucus production in the nasal sinuses. *Acta Otolaryngol Suppl* 1979;360:131–134.
- Gagici CA, Yilmazer C, Hurcan C, Ozer C, Ozer F. Appropriate interslice gap for creating coronal paranasal sinus tomography for mucosal thickening. *Eur Arch Otorhinolaryngol* 2009;266:519–525.
- Schneider AC, Bragger U, Sendi P, et al. Characteristics and dimensions of the sinus membrane in patients referred for single-implant treatment in the posterior maxilla: A cone beam computed tomographic analysis. *Int J Oral Maxillofac Implants* 2013;28:587–596.
- Ella B, Noble Rda C, Lauverjat Y, et al. Septa within the sinus: Effect on elevation of the sinus floor. *Br J Oral Maxillofac Surg* 2008;46:464–467.
- Orhan K, Seker BK, Aksoy S, et al. Cone beam CT evaluation of maxillary sinus septa prevalence, height, location and morphology in children and an adult population. *Med Princ Pract* 2013;22:47–53.
- Koymen R, Gocmen-Mas N, Karacayli U, et al. Anatomic evaluation of maxillary sinus septa: Surgery and radiology. *Clin Anat* 2009;22:563–570.
- Cakur B, Sümbüllü MA, Durna D. Relationship among Schneiderian membrane, Underwood's septa, and the maxillary sinus inferior border. *Clin Implant Dent Relat Res* 2013;15:83–87.
- Beaumont C, Zafropoulos GG, Rohmann K, Tatakis DN. Prevalence of maxillary sinus disease and abnormalities in patients scheduled for sinus lift procedures. *J Periodontol* 2005;76:461–467.
- Kasabah S, Krug J, Simůnek A, Lecaro MC. Can we predict maxillary sinus mucosa perforation? *Acta Medica (Hradec Kralove)* 2003;46:19–23.
- Ziegler CM, Woerttche R, Brief J, Hassfeld S. Clinical indications for digital volume tomography in oral and maxillofacial surgery. *Dentomaxillofac Radiol* 2002;31:126–130.
- Koong B. Cone beam imaging: Is this the ultimate imaging modality? *Clin Oral Implants Res* 2010;11:1201–1208.
- Baciu M, Hedesiu M, Bran S, et al. Pre- and postoperative assessment of sinus grafting procedures using cone-beam computed tomography compared with panoramic radiographs. *Clin Oral Implants Res* 2013;24:512–516.