Retrospective analysis of sinus membrane thickening: profile, causal factors, and its influence on complications

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Retrospective analysis of sinus membrane thickening: profile, causal factors, and its influence on complications

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끝으로 지금의 제가 있기까지 길러주시고 사랑해주신 부모님, 멀리 떨어져 있지만 항상 힘이 되는 동생 현주, 우승이에게도 항상 고맙고 사랑한다 말하고 싶습니다. 감사합니다.

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ABSTRACT

Retrospective analysis of sinus membrane thickening: profile, causal factors, and its influence on complications

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Objectives: To retrospectively determine the profile of the sinus membrane (SM), potential factors affecting SM thickening (SMT), and the correlation between SMT and sinus augmentation (SA) complications.

Materials and Methods: In the patients received lateral SA, SMT was classified in sagittal sections of CBCT according to its thickness and morphology. The correlation between SMT and the following factors was analyzed: age, sex, endodontic and periodontic statuses of neighboring teeth, and shape of the sinus inferior border. The association between SMT and SA complications was investigated.

Results: SMT ≤ 2 mm was prevalent (60%). Irregular SM was mostly observed for SMT > 2 mm. There was no statistically significant association between SMT and the included factors. SM thickness was not significantly correlated with either perforation or postoperative complications. There was a statistically significant increase in implant failure when SM thickness was >2 mm, but it was hard to determine that the failure was solely affected by SMT.

Conclusion: SMT was not influenced by the factors included in this study, and might not be a risk factor for SA and implant failure.

Keywords: maxillary sinus, mucosal thickening, dental implant, etiology

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I. Introduction

The posterior maxilla is still regarded as a clinically challenging area for rehabilitation using dental implants. Tooth extraction in the posterior maxilla can lead to resorptive change on the sinus floor progresses toward the coronal direction, resulting in sinus pneumatization[1]. This results in bone augmentation procedures for the placement of implants of adequate length and diameter being required in many cases [2-4]. Lateral and crestal sinus augmentation (SA) procedures with several modifications have been developed, and their predictability has been supported by the findings of numerous studies[2,5-7].

The literature indicates that various factors should be comprehensively evaluated for SA[8]. A low residual bone height, the presence of septa, a low position of vascular anastomosis, and steep angles between the bony walls are known to increase the surgical difficulty[9,10]. The management of these anatomical conditions has been well documented [4,11,12] and seems straightforward. Sinus membrane thickening (SMT) is also a finding of interest due to its prevalence being higher than other anatomical risks. Previous studies found SMT in more than one-third of sinuses[13-15]. SMT may represent sinus pathology or be an indicator for potential complications [13,15]. However, the effects of SMT on SA and implant placement are still unclear[16]. Furthermore, SMT is characterized by various magnitudes and morphologies, which increases the difficulty of evaluations[13-15].

Factors influencing SMT have been investigated previously, such as sex, age, smoking, number of missing teeth, endodontic and periodontic statuses of neighboring teeth, septum, and season, but this has produced heterogeneous results[15-20]. Irrespective of the uncertainty regarding causation, SMT is a finding that needs to be critically assessed. Although based on a small number of studies, when the thickness of the SM is within a certain range, this is related to the rate of complications and the potential risk[13,15,17,21]. Previously it was demonstrated that a thin SM is susceptible to membrane perforation during surgery[17,21]. Also, an SM thickness of >5 mm with a polypoid shape or a circumferential and irregular appearance is strongly associated with ostium obstruction[13,15].

Nowadays cone-beam computed tomography (CBCT) is widely utilized in implant dentistry[22]. CBCT has several advantages over routine orthopantomography and computed tomography, including yielding three-dimensional information with high resolution and reduced radiation exposure and cost[23]. Especially for SA, it is recommended to perform CBCT preoperatively[24] in order to identify risk factors including SMT more easily and clearly. Recently published researches have obtained interesting findings about clinical implications of SMT using CBCT[13,15,18-20,25]. However, a paucity of guidelines for handling SMT[13] or a limited field of view (FOV) of CBCT scans[16] may make clinicians more confused about three-dimensionally visualized SMT.

It is very important not only to identify the causal factors for SMT but also to investigate the impact of SMT on outcomes related to SA and implantation. The aim of the present study was to retrospectively determine the profile of the SM, potential factors affecting SMT, and the correlation between SMT and complications.

II. Materials and Methods

1. Patient selection

The present study was approved by the Institutional Review Board of Yonsei University Dental Hospital (IRB no. 2-2015-0011). The charts of patients receiving SA using a lateral approach from January 1, 2009 to December 31, 2013 in the Dept. of Periodontology at Yonsei University Dental Hospital were reviewed. In total, 263 patients were initially screened, and those who had undergone preoperative CBCT and had a residual bone height of <4 mm were included in this study. Patients who had any self-reported symptoms related to the maxillary sinus or a history of surgical or long-term pharmacologic treatment for the sinus were excluded. Consequently, this study included 262 sinuses in 227 patients, comprising 115 men and 112 women aged 17–77 years, with a mean age of 46.3 years.

2. Evaluation

CBCT images

CBCT images were obtained using two systems: Alphard 3030 (Asahi Roentgen, Kyoto, Japan) and Rayscan Symphony (Ray, Suwon, Korea). The settings for the former system were a tube voltage of 80 kV, a tube current of 5 mA, a shooting time

of 17 seconds, an FOV of 102×102 mm^2, and a voxel size of 0.2 mm; the corresponding settings for the latter system were 90 kV, 10 mA, 19.5 seconds, 142×97 mm^2, and 0.38 mm, respectively. The CBCT images were saved in DICOM (Digital Imaging and Communications in Medicine) format and analyzed using three-dimensional image analysis software (OnDemand3D, CyberMed, Seoul, Korea).

For SM measurement, the sagittal views from the most buccal section to the most palatal section were serially evaluated. The maximum thickness of SM from the sinus floor was selected as a representative value. The thickness was divided into the following five categories: ≤2 mm, >2 mm and ≤5 mm, >5 mm and ≤10 mm, >10 mm and ≤15 mm, and >15 mm. The morphology of SMT was classified with reference to a previous study[13] as follows: normal, round (polypoid), irregular, and complete obstruction in the FOV (Fig. 1).

In the CBCT images, the periodontic and endodontic statuses of neighboring teeth and the shape of the sinus inferior border were recorded as possible factors affecting SMT. The periodontic status of neighboring tooth was divided into healthy and periodontally involved, where a periodontally involved tooth was defined as >3 mm of bone loss and/or furcation involvement. The endodontic status of neighboring tooth was divided into no endodontic treatment, incomplete filling, and complete filling. Moreover, the shape of the sinus floor was classified into round, flat, and irregular for extrapolating the relationship with the condition of sinus membrane.

Chart review

Patient charts were thoroughly reviewed in order to detect complications following SA. Any implant-related biological complications that occurred up to the most recent follow-up were also recorded. Such complications included membrane perforation (intraoperative complications), infection, wound dehiscence, severe swelling, hematoma (post-SA complications), lack or loss of osseointegration, and peri-implant diseases (implant-related complications).

Examiner alignment

Twenty CBCT images were randomly selected and analyzed by a single investigator (J.Y.N.). All measuring processes were monitored by one of the senior investigators (S.H.C.). Two measurement sessions were performed with an interval of 2 weeks.

3. Statistics

Statistical analysis was performed using statistical software (SPSS Statistics 21.0, IBM, Armonk, NY, USA). The intraexaminer reliability was assessed by calculating the intraclass correlation coefficient, which was 0.984 with a 95% confidence interval of 0.967 to 0.992, indicating excellent agreement. The Pearson chi-square test was used to analyze the associations between SMT and the potential factors of age, sex, endodontic and periodontic statuses of neighboring teeth, and shape of the sinus inferior border. The association between SMT and the intraoperative complication of

membrane perforation or postoperative complications (infection, wound dehiscence, severe swelling, and hematoma) following SA was analyzed using the Pearson chi-square test. Kaplan-Meier analysis was applied to the cumulative implant survival rate, and Cox hazard regression analysis was performed to evaluate the effect of potential risk factors. The cutoff for statistical significance was set at $P<0.05$.

III. Results

An SM thickness of ≤2 mm (60%) was the most common, followed by thicknesses of 5–10 mm (15%), 2–5 mm (11%), 10–15 mm (9%), and >15mm (6%). When the SM thickness was >2 mm, the SM most commonly had an irregular shape. The SMT occupying completely in FOV was observed in seven sinuses (Table 1).

In all variables (sex, age, periodontic and endodontic statuses of neighboring teeth, and the shape of the sinus inferior border), SM thickness ≤2 mm was the most commonly found. Male and female patients were similarly distributed for SM thicknesses of ≤15 mm, but SM thicknesses of >15 mm were more common in male patients (n=14) than in female patients (n=1). The SM thickness did not differ significantly with sex (P=0.08). All patients younger than 19 years had an SM thickness of ≤2 mm. Among those older than 20 years, the SM thickness was >2 and ≤5 mm in 1.5–6.9%, >5 and ≤10 mm in 1.5–9.2%, >10 and ≤15 mm in 1.1–5.7%, and >15 mm in 0.7–4.2%. Age did not exert a significant effect (P=0.855). Regardless of the endodontic and periodontic statuses of neighboring teeth, the SM was observed to be a healthy in all cases (thickness of ≤2 mm). Endodontic fillings, whether inadequate or complete, did not affect the SMT (P=0.08); nor did the periodontic status (P=0.056). The shape of the sinus inferior border was distributed as follows:

round (*n*=137, 52%), irregular (*n*=74, 28%), and flat (*n*=51, 20%). When the SM thickness was >2 mm, a round shape was the most frequently observed (*n*=50), followed by an irregular shape (*n*=35) and a flat shape (*n*=20). There was no statistically significant association between SMT and the shape of the inferior border (*P*=0.625) (Table 2).

Perforation of the sinus membrane was the most common complication (17/262, 6.5%). The following post-SA complications occurred: infection (*n*=2), wound dehiscence (*n*=2), severe swelling (*n*=1), and hematoma (*n*=1). None of these complications was associated with the membrane perforation. The implant-related complications (n=3), such as loss of osseointegration, peri-implant mucositis, and peri-implantitis occurred in three, two, and one sinuses, respectively. None of those complications (irrespective of their timing) was associated with SMT (*P*>0.05) (Table 3).

In total, 466 implants were placed in 262 sinuses. The Kaplan-Meier test demonstrated a cumulative survival rate of 97.7% over a mean of 56 months. Ten implants in six sinuses were lost during the follow-up period. All of the implant failures occurred before delivering the definite prosthesis. Implant failure was not significantly associated with SMT when the SM thickness was divided into the five categories (i.e., ≤2 mm, >2 and ≤5 mm, >5 and ≤10 mm, >10 and ≤15 mm, and >15 mm; *P*=0.382). However, a statistically significant association was found between the implant failure and SMT when the SM thickness was divided into ≤2 and >2 mm

(*P*=0.041), because all of the failures occurred in sinuses having an SM thickness of ≤2 mm (Fig. 2). No implants installed in the sinuses underwent SM perforation were lost.

IV. Discussion

CBCT is a useful tool in contemporary implant dentistry, especially sinus augmentation. It reveals residual bone height/width, vascular anastomosis and septa with accuracy, which greatly helps surgical planning. Also, SM thickness is visualized in CBCT, but its diverse magnitude and morphology may give uncertainty in surgical decision. Thus, the present study investigated (i) the potential factors affecting SMT and (ii) the association between SMT and complications.

Many studies have analyzed the factors affecting SMT, such as age, sex, septum, periodontic and endodontic statuses of the neighboring teeth, periapical lesions, cortical thickness of the inferior border, and season[15-19]. The threshold for SMT indicating a pathologic state has not been determined[16,26-28], but an SM thickness of >2 mm has generally been regarded as a pathologic state[13,15,16,29], which is consistent with the mean SM thicknesses in asymptomatic orthodontic patients and clinically healthy patients seeking implant therapy in the posterior maxilla being 1.58 and 1.68 mm, respectively[18,30]. A recent systematic review found that the SM becomes thicker in male patients and in areas having apical pathology[16]. However, no correlation with any factors included in the present study was detected. In interpreting such heterogenous findings, differences in populations, sample sizes, and diagnostic

thresholds for SMT measurement should be taken into consideration. Especially, the periodontic and endodontic statuses of the teeth measured in the present study may have some limitation; radiographically-evaluated periodontal bone loss and endodontic filling state itself may not be surrogates for inflammatory state.

SM perforation is the most-common surgical error during SA, and the SM thickness has been identified as a potential risk factor for perforation. Cakur et al. (2011) reported that a thin SM in conjunction with septa increases the risk of SM perforation[17]. More specifically, Lin et al. (2015) reported that SMs with thicknesses of <1 or ≥2 mm are more susceptible to perforation than are those with thicknesses of ≥1 and <2 mm[21]. In the present study, septum were found only in 3 of 17 perforated sinuses, and SM thickness > 2 mm was observed in 3 perforated sinuses. Due to small number of such cases, it was hard to conjecture that a certain SM thickness with/without septum is a risk for the perforation. Possibly, the surgical technique might influence the perforation. Among 17 perforations, 8 occurred during SM elevation, 2 occurred during osteotomy (1: diamond bur, 1: piezosurgery), and there was no clear documentation for 7.

SMT can be regarded as a risk factor for SA because SMT may be an indicator of sinus pathology. However, in the present study SMT was not significantly associated with the postoperative complications of infection, wound dehiscence, severe swelling, or hematoma. SM perforation during SA (which only occurred when the SM thickness was ≤2 mm) did not result in any postoperative complications.

Successful SA could be achieved in sinuses having severe SMT. Moreover, stratification of SMT was not significantly associated with implant failure. However, dichotomizing SMT revealed that implant failure significantly increased in cases with an SM thickness of >2 mm. Six of 10 failed implants were placed in a staged approach on the bilateral sinuses of 1 patient who had an extremely thin residual bone height (<0.5 mm). For other one implant, accidental biting on the healing abutment and subsequent loosening of the implant were documented in the patient`s record. No specific reason could be assumed from the patient records for the other three implants. Due to the above-mentioned causal factors and uncertainty, it seems difficult to conclude that an SM thickness of >2 mm increases the risk of implant failure, despite the presence of a significant correlation. Additionally, the biomaterial-related factor was inspected. The biomaterial for 10 failed implants was either biphasic calcium phosphate (n=4) or deproteinized bovine bone mineral (n=6). Considering the safety and effectiveness of those biomaterials have been demonstrated [31], the grafting material-derived failure could not be suspected.

In previous studies, SMs with thicknesses of >5 mm and exhibiting specific shapes (polypoid, irregular, and circumferential) were related to ostium obstruction[13]. Ostium patency is very important for the normal physiologic functioning of the sinus[32]. Ostium obstruction results in inadequate mucociliary clearance and drainage of the sinus. In the present study, the FOV of the CBCT scans was not sufficiently large to visualize the entire ostiomeatal complex, which means that the sinuses

classified as complete obstruction (i.e., within the FOV) might not have actually been complete obstruction. Ensuring ostium patency requires CBCT scans that have a larger FOV combined with appropriate consultation with ENT specialists[13,33]. However, it should be noted that none of the patients in the present study had self-reported symptoms regarding maxillary sinus pathology or a history of associated ENT treatment. While subjective data from patients are not totally trustable, the results of the present study may indicate that SMT alone without other accompanying symptoms is not risky for SA.

V. Conclusion

Within the limitations of the present study, sinus membrane thickening is not correlated with sex, age, endodontic and periodontic statuses of neighboring teeth, or the shape of the sinus inferior border. Moreover, the degree of sinus membrane thickening might not be a risk factor for sinus augmentation or a sign of potential future implant failure.

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Figures

Figure 1. Classification of sinus membrane (SM) thickening in the coronal section of the cone-beam computed tomography scans: (A) normal, (B) round (polypoid), (C) irregular, and (D) complete obstruction in the field of view.

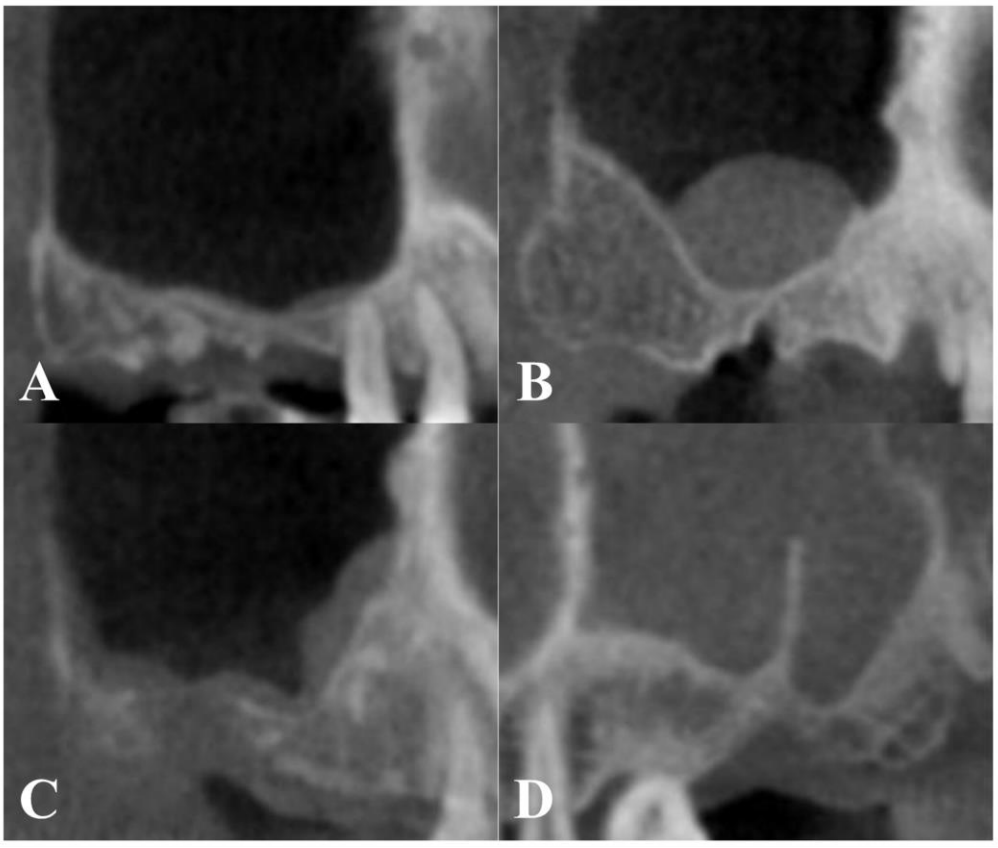
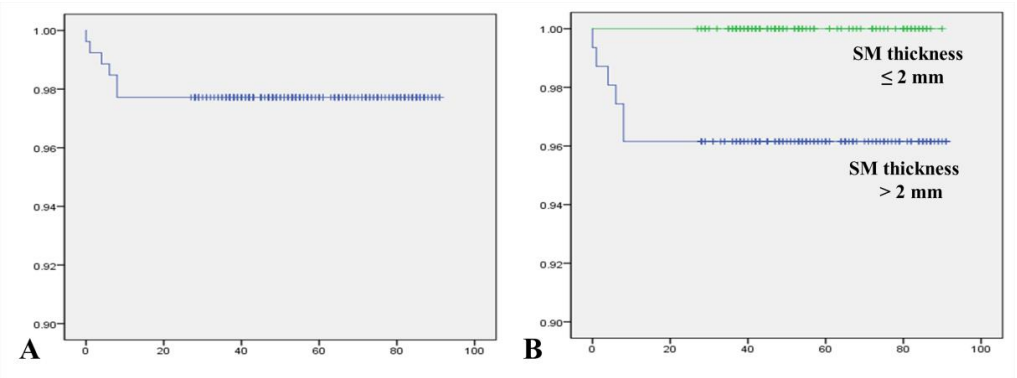


Figure 2. Kaplan-Meier survival curves of implants placed in the augmented sinuses: (A) overall survival curve and (B) survival curves for cases of SM thicknesses of >2 and ≤2 mm. The survival rate was significantly lower when the SM thickness was >2 mm.



Tables

Table 1. Distribution of sinus membrane thickness (SMT) and morphology.

	Thickness	≤2 mm *n* (%)	2–5 mm *n* (%)	5–10 mm *n* (%)	10–15 mm *n* (%)	>15 mm *n* (%)
Morphology	Normal	157 (59.9)	-	-	-	-
	Rounded	-	3 (1.1)	7 (2.7)	5 (1.9)	8 (3)
	Irregular	-	25 (9.5)	31 (11.8)	16 (6.1)	3 (1.1)
	Complete	-	-	-	3 (1.1)	4 (1.5)
	Total	157 (59.9)	28 (10.6)	38 (14.5)	24 (9.1)	15 (5.6)

Table 2. Associations between sinus membrane thickness (SMT) and potentially causative factors.

	Thickness	≤2 mm *n* (%)	2–5 mm *n* (%)	5–10 mm *n* (%)	10–15 mm *n* (%)	>15 mm *n* (%)	*P*
Factors	**Sex**						
	Female	81 (30.9)	11 (4.2)	17 (6.5)	11 (4.2)	1 (0.4)	0.08
	Male	76 (29)	17 (6.5)	21 (8)	13 (5)	14 (5.3)	
	Age (years**)**						
	<20	4 (1.5)	-	-	-	-	
	20–39	21 (8)	5 (1.9)	4 (1.5)	3 (1.1)	2 (0.7)	0.855
	40–59	100 (38.2)	18 (6.9)	24 (9.2)	15 (5.7)	11 (4.2)	
	>59	32 (12.2)	5 (1.9)	10 (3.8)	6 (2.3)	2 (0.7)	
	Endodontic status of neighboring teeth						
	Natural tooth	141 (53.8)	20 (7.6)	35 (13.4)	19 (7.3)	12 (4.6)	
	Complete filling	9 (3.4)	4 (1.5)	-	1 (0.4)	1 (0.4)	0.08
	Incomplete filling	7 (2.7)	4 (1.5)	3 (1.1)	3 (1.1)	2 (0.7)	
	Periodontic status of neighboring teeth						
	Healthy	51 (19.5)	11 (4.2)	9 (3.4)	6 (2.3)	2 (0.7)	0.056
	Periodontally involved	106 (40.5)	17 (6.5)	29 (11.1)	18 (6.9)	13 (5.0)	
	Shape of sinus inferior border						
	Round	87 (33.2)	12 (4.6)	20 (7.6)	12(4.6)	6 (2.3)	
	Flat	31 (11.8)	7 (2.7)	7 (2.7)	4(1.5)	2 (0.7)	0.625
	Irregular	39 (14.9)	9 (3.4)	11 (4.2)	8 (3.1)	7 (2.7)	
	Total	157 (59.9)	28 (10.6)	38 (14.5)	24 (9.1)	15 (5.6)	

Table 3. Associations between sinus membrane thickness (SMT) and complications.

	Thickness	≤2 mm *n* (%)	2–5 mm *n* (%)	5–10 mm *n* (%)	10–15 mm *n* (%)	>15 mm *n* (%)	*P*
Complications	**Intraoperative complication** Membrane perforation	14 (82)	2 (12)	0	1 (6)	0	0.27
	Postoperative complications	4 (67)	1 (17)	1 (17)	0	0	
	Infection	1	0	1	0	0	
	Wound dehiscence	1	1	0	0	0	0.935
	Swelling	1	0	0	0	0	
	Hematoma	1	0	0	0	0	
	Preprosthetic complication Osseointegration failure	3	0	0	0	0	1.000
	Implant-related complications	1 (33)	0	1 (33)	0	1 (33)	
	Implant mucositis	1	0	0	0	1	0.179
	Peri-implantitis	0	0	1	0	0	
	Total	22 (76)	3 (10)	2 (7)	1 (3)	1 (3)	

국문요약

상악동 점막 비후의 형태, 원인 인자와 치과 임플란트 합병증에 미치는 영향에 관한 후향적 연구

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상악 후방의 무치악 부위는 악골의 다른 부위에 비하여 임플란트 식립에 불리한 조건을 갖는다. 특히 발치 후 상악동의 함기화로 인해 잔존골의 높이가 적절하지 못한 경우 임플란트 수복시 상악동 골 이식술을 동반하게 된다. 다양한 요인들이 상악동 골 이식술의 결과에 영향을 미칠 수 있다. 상악동 점막 비후는 상악동의 병리적 상태를 나타내거나 잠재적 합병증의 지표가 될 수 있으나, 상악동 골이식술과 임플란트 식립에 대한 점막 비후의 영향은 여전히 불분명하다. 본 연구의 목적은 상악동 점막의 형태, 점막 비후에 영향을 줄 수 있는 잠재적인 요인, 점막 비후와 임플란트 식립시 합병증 사이의 상관관계를 후향적으로 연구하는 것이다.

2009년 1월부터 2013년 12월까지 연세대학교 치과병원 치주과를 내원한 환자들 중에서 측방 접근법을 이용한 상악동 골이식술을 시행한 227명, 262개의 상악동을 연구 대상으로 하였다. 환자들의 평균 나이는 46.3세였다. 상악동 점막 비후는 콘빔 전산화 단층 촬영상의 시상 단면에 따라 형태와 두께가 분류되었다. 점막 비후와 환자의 나이, 성별, 인접 치아의 근관치료 상태 및 치주 상태, 상악동 하부 경계의 형태 등의 여러 인자들 사이의 상관관계를 분석하였다. 또한 점막 비후와 상악동 골이식술 합병증 간의 연관성이 조사 되었다.

연구 결과, 상악동 점막 비후의 크기는 2mm 이하가 가장 많았고(60%), 2mm가 넘는 비후에서 점막의 형태는 불규칙한 형태가 가장 많았다. 조사된 여러 인자들과 점막 비후 간에 통계적으로 유의한 상관관계는 관찰되지 않았다. 또한 상악동 점막 두께는 상악동 막 천공이나 수술 후 합병증과 유의한 상관관계가 없었다.

본 연구에서 상악동 점막 비후는 환자의 나이, 성별, 인접 치아의 근관치료 상태 및 치주 상태, 상악동 하부 경계의 형태 등의 인자들과 상관관계가 없었다. 또한 상악동 점막 비후의 정도가 상악동 골이식술의 위험인자 혹은 잠재적 임플란트 실패의 징후가 될 수 없는 것으로 나타났다.

핵심되는 말: 상악동, 점막 비후, 치과 임플란트, 병인