ผลของการมีพยาธิสภาพของฟันต่อการหนาตัวของเยื่อบุผิวและถุงน้ำในโพรงอากาศขากรรไกรบน

นางสาว ศิริกาญจน์ โพธิคุณ

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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THE EFFECT OF DENTAL DISEASES ON MUCOSAL THICKENING AND MUCOSAL CYSTS OF THE MAXILLARY SINUS

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for the Degree of Master of Science Program in Periodontics

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ศิริกาญจน์ โพธิคุณ: ผลของการมีพยาธิสภาพของฟันต่อการหนาตัวของเยื่อบุผิวและถุงน้ำในโพรงอากาศขากรรไกรบน (THE EFFECT OF DENTAL DISEASES ON MUCOSAL THICKENING AND MUCOSAL CYSTS OF THE MAXILLARY SINUS) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: ผศ.ทญ.ดร. กนกวรรณ นิสภกุลธร, 54 หน้า.

ที่มาและความสำคัญ การหนาตัวของเยื่อบุผิวและถุงน้ำในโพรงอากาศขากรรไกรบนเป็นความผิดปกติที่พบได้บ่อยโดยไม่แสดงอาการทางคลินิก การศึกษานี้มีวัตถุประสงค์เพื่อศึกษาถึงความสัมพันธ์ของการมีพยาธิสภาพของฟันต่อการหนาตัวของเยื่อบุผิวและถุงน้ำในโพรงอากาศขากรรไกรบน

วัสดุและวิธีการ ทำการศึกษาในภาพถ่ายรังสีส่วนตัดอาศัยคอมพิวเตอร์จำนวนทั้งสิ้น 250 ภาพในผู้ป่วยที่ถ่ายภาพรังสีเพื่อใช้สำหรับการวางแผนการรักษาทางทันตกรรม ทำการบันทึกพยาธิสภาพของฟันคือ ระดับการสูญเสียกระดูกจากรอยโรคปริทันต์ การมีรอยโรคปลายรากฟันและการมีวัสดุอุดคลองรากฟัน พร้อมทั้งบันทึกการพบการหนาตัวของเยื่อบุผิวและถุงน้ำในโพรงอากาศขากรรไกรบน และทำการวิเคราะห์เชิงสถิติโดยการทดสอบไคสแควร์ และการวิเคราะห์การถดถอยโลจิสติก เพื่อทราบถึงอิทธิพลของพยาธิสภาพของฟันต่อความผิดปกติของเยื่อบุโพรงอากาศขากรรไกรบน

ผลการศึกษา พบความชุกของการมีการหนาตัวของเยื่อบุผิวคิดเป็นร้อยละ 42 และความชุกของการเกิดถุงน้ำคิดเป็นร้อยละ16.4 ของกลุ่มตัวอย่าง โดยพบความชุกของความผิดปกติของเยื่อบุโพรงอากาศขากรรไกรบนทั้ง 2 ชนิดในเพศชายมากกว่าเพศหญิง โดยที่การสูญเสียกระดูกจากรอยโรคปริทันต์เป็นปัจจัยที่มีความสัมพันธ์ต่อการหนาตัวของเยื่อบุผิวในโพรงอากาศขากรรไกรบนอย่างมีนัยสำคัญทางสถิติ ในขณะที่ไม่พบความสัมพันธ์ระหว่างการมีรอยโรคปลายรากฟันและการมีวัสดุอุดคลองรากฟันต่อการหนาตัวของเยื่อบุผิวในโพรงอากาศขากรรไกรบน นอกจากนี้การสูญเสียกระดูกจากรอยโรคปริทันต์ระดับรุนแรงเป็นปัจจัยเพียงปัจจัยเดียวที่มีอิทธิพลและเพิ่มความเสี่ยงในการหนาตัวของเยื่อบุผิวในโพรงอากาศขากรรไกรบนได้มากกว่าการไม่พบการสูญเสียกระดูกจากรอยโรคปริทันต์ถึง 3 เท่า ในขณะที่ไม่พบความสัมพันธ์ระหว่างการมีพยาธิสภาพของฟันใดๆต่อการเกิดถุงน้ำในโพรงอากาศขากรรไกรบน

สรุป การสูญเสียกระดูกจากรอยโรคปริทันต์ระดับรุนแรงมีความสัมพันธ์ต่อการหนาตัวของเยื่อบุผิวในโพรงอากาศขากรรไกรบนอย่างมีนัยสำคัญทางสถิติ แต่ไม่พบว่าการมีพยาธิสภาพของฟันมีความสัมพันธ์ต่อเกิดถุงน้ำในโพรงอากาศขากรรไกรบน

ภาควิชา ปริทันตวิทยา ลายมือชื่อนิสิต ศิริกาญจน์ โพธิคุณ

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SIRIKARN PHOTHIKHUN: THE EFFECT OF DENTAL DISEASES ON MUCOSAL THICKENING AND MUCOSAL CYSTS OF THE MAXILLARY SINUS. THESIS ADVISOR: ASST. PROF. KANOKWAN NISAPAKULTORN, PhD., 54 pp.

Background: Mucosal thickening and mucosal cysts of the maxillary sinus are commonly observed among asymptomatic subjects. The role of dental diseases on these abnormalities was unclear. The aim of this study is to determine the relationship between dental diseases and mucosal thickening/ mucosal cysts of the maxillary sinus.

Methods: The computed tomographic (CT) images of 250 consecutive subjects who underwent CT scans for dental treatment purposes were studied. Dental findings including periodontal bone loss, periapical lesions, and root canal fillings were assessed. The presence of mucosal thickening and mucosal cyst of the maxillary sinus was recorded. Logistic regression analysis was used to determine the influence of dental findings on these sinus mucosal abnormalities.

Results: The prevalence of mucosal thickening was 42% and of mucosal cysts was16.4% of subjects, both being more frequent in males than in females. Periodontal bone loss was significantly associated with mucosal thickening whereas periapical lesions and root canal fillings were not. Presence of severe periodontal bone loss increased risk of mucosal thickening by 3 folds (OR=3.02, $P<0.001$). There was no association between dental findings and mucosal cysts.

Conclusions: Severe periodontal bone loss was significantly associated with mucosal thickening of the maxillary sinus. Mucosal cysts were not associated with any dental findings.

Department : Periodontology Student's Signature ศิริกาญจน์ โพธิกุล

Field of Study : Periodontics Advisor's Signature N. Kaha

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CHAPTER I

INTRODUCTION

Background and significance

Maxillary posterior teeth are among the teeth with the highest incidence of periodontal bone loss and tooth loss (Hirschfeld and Wasserman, 1978). Limited amount of residual bone due to pneumatization of the maxillary sinus after tooth extraction in this area may complicate dental implant therapy. Maxillary sinus augmentation has become the treatment of choice when dealing with the insufficient bone below the maxillary sinus. It is a predictable and safe technique and has limited effects on sinus physiology (Timmenga et al., 2003). Pathology of the maxillary sinus including mucosal abnormalities may preclude sinus augmentation procedure. Therefore, proper preoperative evaluation of the patient scheduled to undergo a sinus augmentation is expected to minimize post-operative adverse events (Beaumont et al., 2005).

Mucosal thickening and mucosal cysts are common mucosal abnormalities of the maxillary sinus. They are often detected by various radiographs in asymptomatic subjects. The prevalence of the mucosal thickening ranged from 8-29% whereas that of

the mucosal cysts ranged from 2-36%. The cause of these abnormalities is not well understood. The close proximity between the root apices of maxillary posterior teeth and the maxillary sinus floor may allow the spread of dental infection/ inflammation to the sinus mucosa via direct contact or through the anastomoses between the blood and lymph vessels around this region. Several studies suggested that dental diseases such as periodontal and periapical diseases might be the cause of mucosal thickening (Engstrom et al., 1988; Falk et al., 1986; Nenzen and Welander, 1967; Vallo et al., 2010), but the role of dental diseases on mucosal cysts was unclear. Some studies found that the presence of mucosal cysts was odontogenic causes (Casamassimo and Lilly, 1980; Mathew et al., 2009; Vallo et al., 2010), while other studies observed no any association between dental diseases and mucosal cysts (Kanagalingam et al., 2009; Soikkonen and Ainamo, 1995; Vallo et al., 2010).

The clinical significance of these sinus mucosal abnormalities is unknown. Mucosal thickening and mucosal cysts of the maxillary sinus in asymptomatic patients generally do not require any treatment. However, it may become clinically important when they cause obstruction of the maxillary sinus outflow tract (Bhattacharyya, 2000). The opening of the maxillary ostium is located high up in the sinus medial wall. If thick sinus mucosa or large mucosal cysts the ostium during sinus lift procedure, the risk of ostium obstruction and sinusitis may be increased (Carmeli et al., 2011).

Although the relationships between dental causes and mucosal abnormalities had long been studied, most of them included limited number of subjects or used conventional radiographic techniques to evaluate sinus pathology. Conventional radiographic techniques often used were periapical and panoramic films. Periapical radiographs provide very limited observed area and are of little diagnostic value for sinus evaluation (Ruprecht and Lam, 2008). Panoramic radiographs are often used as a preliminary diagnostic radiograph. Although it provides an overview of the sinus floor and its relationship with the tooth roots, superimposed images often obscure or distort the anatomy of the maxillary sinus. Computed tomography (CT) is considered the gold standard for sinus evaluation (Chong and Fan, 1998; Mafee et al., 2006). The use of CT scans to evaluate maxillary sinus and dental parameters in a large number of subjects should clarify the relationship between dental diseases and sinus mucosal abnormalities.

The demand for dental implants and sinus augmentation surgery is increasing. Therefore, it becomes important for dentists to be familiar with the maxillary sinus diseases and abnormalities and to understand the relationship between dental diseases and sinus mucosal abnormalities. It is the aim of this study to investigate the relationship between dental findings including periodontal bone loss, periapical lesions,

and root canal fillings and the presence of mucosal thickening/mucosal cysts of the maxillary sinus, using dental CT scans.

Objectives

1. To determine the association between dental diseases and mucosal thickening of the maxillary sinus.
2. To determine the association between dental diseases and mucosal cysts of the maxillary sinus.

Hypothesis

1. Dental diseases are associated with mucosal thickening of the maxillary sinus.
2. Dental diseases are not associated with mucosal cysts of the maxillary sinus.

Field of Research

Retrospective study.

Limitation of Research

We do not have clinical examination or questionnaire regarding the sinus condition. Only CT scans are retrospectively examined. Therefore, the presence of sinus mucosal abnormalities and clinical symptoms cannot be correlated.

Application and Expectation of Research

This is the first study that evaluated the association between dental diseases and mucosal abnormalities of the maxillary sinus in a large number of subjects using dental CT radiographs. This study will provide more information regarding the role of dental diseases on the etiology of sinus mucosal thickening and maxillary mucosal cysts. Recognition of this relationship will have an impact on the clinical management of patients, especially those who plan for sinus augmentation procedure.

CHAPTER II

LITERATURE REVIEW

Mucosal thickening of the maxillary sinus

The maxillary sinuses are the largest of the paranasal sinuses. The sinus is internally lined with a thin mucosa of pseudostratified, cliliated, columnar epithelium. The ciliated epithelium has a transport function for fluids like pus and mucus towards the internal ostium (Stammberger, 1986). The thickness of normal sinus mucosa is ranged between 0.8-1 mm (Misch et al., 2008; van den Bergh et al., 2000). In response to irritating stimuli, the sinus mucosa becomes inflamed and thickened (Soikkonen and Ainamo, 1995).

Mucosal thickening is a common mucosal change of the maxillary sinus. The radiographic appearance of mucosal thickening is the grayish thickening of the lining of the sinus. It is usually observed in subjects with sinusitis. Sinusitis is an inflammation of the mucosa lining the paranasal sinuses (Brook, 2009). The diagnosis is based on clinical signs and symptoms including preceding upper respiratory tract infection, facial pain or pressure, fever, nasal congestion, nasal discharge, purulence or discolored

postnasal drainage. However, a large number of subjects have mucosal thickening in the absence of any clinical symptoms.

The prevalence of mucosal thickening of the maxillary sinus from several radiographic investigations ranged from 8-29% (Havas et al., 1988; Iwabuchi et al., 1997; Soikkonen and Ainamo, 1995; Vallo et al., 2010). Soikkonen and Ainamo reported mucosal thickening of maxillary sinuses in 8% of 289 elderly subjects (76-86 years old) using panoramic radiographs. Vallo et al. also examined panoramic radiographs of 5021 subjects participated in the Finnish National Health Examination Survey. They found that the prevalence of mucosal thickening was 12% (Vallo et al., 2010). Havas et al. prospectively studied the CT image of 666 subjects who underwent the scan for cranial diseases (Havas et al., 1988). Patients with clinical suspicion of sinus disease were excluded from the study. They showed that 15% of subjects had mucosal thickening of the maxillary sinus. Using magnetic resonance imaging (MRI), Iwabushi et al. reported that 29% of 257 subjects who had MRI taken for cranial diseases and lacked of nasal or sinus symptoms showed mucosal thickening of the maxillary sinus (Iwabuchi et al., 1997). The more sensitive radiographic techniques such as CT and MRI, the higher prevalence of mucosal thickening was found.

Table 1. Prevalence of mucosal thickening of the maxillary sinus.

Study	Radiograph	Number of subjects (N)	Radiographic purposes	Prevalence (%)
Soikkonen and Ainamo, 1995	Panoramic	289	Dental examination	8
Vallo et al., 2010	Panoramic	5021	Dental examination	12
Havas et al., 1988	CT	666	Scanning for cranial diseases	14.6
Iwabuchi et al., 1997	MRI	257	Scanning for cranial diseases	28.8

Mucosal cysts of the maxillary sinus

Cysts of the maxillary sinus may be broadly classified into 3 groups: mucoceles, retention cysts, and pseudocysts (Gardner, 1984; Shear and Speight, 2007). A sinus mucocele is a true cyst, lined by epithelium and containing mucinous secretions that accumulated within a blocked or obstructed sinus cavity. When normal sinus drainage is blocked or with the progressive dilatation of an obstructed gland, these mucoceles can distend to fill the sinus. The mucocele is an expansive and destructive lesion. Often, they are seen radiographically to have expanded or herniated into adjacent structures. The bone of the sinus is generally remodeled from the process of inflammation, which may cause thickening and expansion, in turn leading to thinning of

the sinus wall. This radiographic appearance may be difficult to distinguish from a malignant lesion.

A retention cyst or a mucous retention cyst is an epithelial-lined cyst caused by mucous retention from blockage of the ducts of the small mucous gland in the antral mucosa. Most retention cysts are small and are not evident clinically or radiographically. However, a large retention cyst may appear as a dome-shape radiopacity and is indistinguishable from a pseudocyst. A pseudocyst is caused by accumulation of exudates that lift the sinus mucosa and form the dome-shape radiopacity on the floor of the sinus. These lesions differ from true cysts as they are not lined by epithelium. Antral pseudocysts are a common finding in dental practice and are commonly seen in the panoramic radiographs. They are generally asymptomatic, harmless, and require no treatment. Many researchers did not differentiate retention cysts and pseudocysts. They used these terms synonymously to describe the dome-shape radiopacity with sharp demarcation of lateral borders arising from the antral wall (Ruprecht and Lam, 2008; Shear and Speight, 2007). Together they are often referred to as mucosal cysts, mucosal antral cysts, or maxillary mucosal cysts.

The reported prevalence of mucosal cysts ranged from 2-36% (Beaumont et al., 2005; Bhattacharyya, 2000; Carter et al., 1998; Casamassimo and Lilly, 1980; Gordts et

al., 1996; Harar et al., 2007; Kanagalingam et al., 2009; MacDonald-Jankowski, 1993, 1994; Mardinger et al., 2007; Mathew et al., 2009; Rodrigues et al., 2009; Ruprecht et al., 1986; Soikkonen and Ainamo, 1995; Vallo et al., 2010). The wide range of the prevalence may be due to different radiographic techniques and subject characteristics.

Panoramic radiograph of patients presented for routine dental examination showed the prevalence of mucosal cyst 2-14% (Carter et al., 1998; Casamassimo and Lilly, 1980; MacDonald-Jankowski, 1993, 1994; Rodrigues et al., 2009; Ruprecht et al., 1986; Vallo et al., 2010). In the elderly subjects, the mucosal cyst was occasionally seen at 2% to 5% on panoramic radiographs (Mathew et al., 2009; Soikkonen and Ainamo, 1995). There were 2 studies undergone CT scanning of the paranasal sinuses for possible chronic sinus diseases in 410-500 subjects (Bhattacharyya, 2000; Harar et al., 2007). They identified 12-22% of subjects had mucosal cysts with the mean cyst size of 14-16 mm. Most cysts were located on the floor of the antrum. Another prospective case series identified at least one mucosal cyst in 36% of 257 asymptomatic patients who underwent CT scans for ophthalmic reasons (Kanagalingam et al., 2009). On MRI imaging, Gordts et al. reported that 21% of subjects who had MRI taken for cranial disease showed mucosal cysts (Gordts et al., 1996). Prevalence of mucosal cyst in 45-109 patients scheduled for sinus lift procedures was range from 7-29% of subjects (Beaumont et al., 2005; Mardinger et al., 2007).

Table 2. Prevalence of maxillary mucosal cysts.

Study	Radiograph	Number of subjects (N)	Radiographic purposes	Prevalence (%)
Casamassimo and Lilly, 1980	Panoramic	4,546	Dental examination	1.6
Ruprecht et al., 1986	Panoramic	1,685	Dental examination	2.6
MacDonald-Jankowski, 1993	Panoramic	1,000	Dental examination	5.2
MacDonald-Jankowski, 1994	Panoramic	1,000	Dental examination	14
Soikkonen and Ainamo, 1995	Panoramic	289	Dental examination	5
Carter et al., 1998	Panoramic	1,175	Dental examination	9.7
Mathew et al., 2009	Panoramic	97	Dental examination	2
Rodrigues et al., 2009	Panoramic	6,293	Dental examination	3.2
Vallo et al., 2010	Panoramic	5021	Dental examination	7
Bhattacharyya, 2000	CT	410	Scanning for chronic sinus diseases	12.4
Harar et al., 2007	CT	500	Scanning for chronic sinus diseases	22
Kanagalingam et al., 2009	CT	257	Scanning for ophthalmic reasons	35.6
Gordts et al., 1996	MRI	Not shown	Scanning for cranial diseases	21
Beaumont et al., 2005	CT	45	Scanning for sinus lift	29
Mardinger et al., 2007	CT	109	Scanning for sinus lift	7.3

Radiographic techniques for maxillary sinus evaluation

Several radiographic techniques are used to evaluate the sinus pathology. Different radiographic techniques provide varying degree of information and are partly contribute to a wide range of the prevalence of sinus abnormalities reported in the literature. Conventional radiograph such as a periapical film is of limited value because the observed area is small and inadequate (Misch et al., 2008). Cysts and inflammation of the membrane can sometimes be seen in association with the apex of the tooth. However, it does not allow precise measurements and evaluation of pathologic conditions of the maxillary sinus due to distortions caused by the projection. Panoramic radiograph is often used as a preliminary diagnostic radiograph. It provides an overview of the sinus floor and its relationship with the tooth roots, the presence of pneumatization, and the presence of foreign bodies inside the sinus. However, it is not the standard radiograph used to evaluate the maxillary sinus for abnormalities or pathologic conditions. Superimposed images will often obscure or distort the anatomy of the maxillary sinus. An occipitomental sinus radiograph, also called the Waters' view, which is effective to evaluate the frontal view of orbits and maxillary sinuses. This radiograph permits direct comparison between right and left sides. Nevertheless, the Waters' view has its limit in the diagnosis of sinus diseases when compared with CT (Konen et al., 2000).

Currently, computed tomography (CT) is considered the gold standard for sinus diagnosis and treatment planning due to the ability to provide multiple sections through the sinuses at different planes and allow visualization of bone and soft tissue (Chong and Fan, 1998; Mafee et al., 2006). The addition of reformatted images of axial, panoramic, cross-sectional, and 3D images provide comprehensive evaluation of the entire sinus cavity. CT has been possible to find 30% more periapical lesions and 4 times more mucosal thickening than intraoral radiography (Lofthag-Hansen et al., 2007). Magnetic resonance imaging (MRI) provides good contrast between the different soft tissues of the body compared with other medical imaging techniques such as CT. MRI is generally reserved for the evaluation of any complications of local sinus inflammation. For purposes of tumor detection and suspected intracranial disease, MRI is generally superior (Mafee et al., 2006). However, CT is usually more widely available, faster, and less expensive than MRI for diagnosis of sinus diseases.

Dental diseases and mucosal thickening of the maxillary sinus

Sinusitis is the major cause of the sinus mucosal thickening in symptomatic subjects. However, the cause of mucosal thickening in asymptomatic subjects is unclear. Several studies suggested the dental causes. The close proximity between the roots of maxillary posterior teeth and the sinus floor as well as the anastomoses between

the blood and lymph vessels in this region may allow the spread of periodontal and periapical inflammation to the maxillary sinus causing thickening of sinus mucosa.

Studies suggested that periodontal diseases were associated with sinus mucosal thickening. Falk et al. studied 21 patients who had advanced periodontal disease and mucosal thickening of the maxillary sinus in a total of 36 maxillary posterior sextants (Falk et al., 1986). Periapical and panoramic radiographs were used in this study. Following 15-20 months after periodontal therapy, which included extraction of hopeless teeth, plaque control, root planing, and periodontal surgery, the sinus mucosa was normalized in 28 of the 36 sextants and markedly improved in 6 sextants. Similarly, Engstrom et al. evaluated the thickness of sinus mucosa in 13 patients with advanced periodontitis using periapical radiographs (Engstrom et al., 1988). Before initial periodontal treatment by plaque control and root planning, 79% of the posterior sextants showed sinus mucosal thickening. They observed mucosal thickening in 17% of sextants at 12 months post treatment that demonstrated significant reduction of the thickness of sinus mucosa. These studies suggested that periodontal diseases may cause maxillary mucosal thickening and proper periodontal therapy could lead to reduction of mucosal thickness.

Abrahams and Glassberg performed a case-control study comparing computed tomographic images of 84 periodontitis subjects with 84 age, sex-matched control subjects who were referred for head or neck CT scans (Abrahams and Glassberg, 1996). They found that the prevalence of sinus diseases, including complete opacification, air-fluid levels, and sinus mucosal thickening, was two folds higher in the periodontitis subjects than in the control subjects. However, the nature and severity of periodontitis in the study group and periodontal conditions of the control group were not clearly identified.

The effect of periodontal inflammation on maxillary sinus mucosa was also demonstrated histologically (Moskow, 1992). Moskow examined 20 blocks of human jaw and found that 17 out of 20 jaws had moderate to severe periodontal bone loss and 19 specimens also had sinus mucosal thickening. He concluded that there was a possible relationship between periodontitis and pathologic changes resulting in thickening of sinus mucosa. However, the nature of these specimens and clinical data regarding periodontal and maxillary sinus status were unknown.

Studies on the association between periapical diseases and mucosal thickening are limited. Nenzen & Welander performed a study on 14 patients with periapical lesions (Nenzen and Welander, 1967). Fourteen patients had local sinus mucosal

thickening. Seven of these 14 cases received conventional endodontic treatment and all seven cases showed regression of the mucosal thickness. The control group who did not receive endodontic treatment showed regression in only one case. This study demonstrated that proper treatment of periapical lesions resulted in reduction of sinus mucosal thickness. Recently, Vallo et al. determined the relationship between dental diseases and mucosal abnormalities of the maxillary sinus using panoramic radiographs (Vallo et al., 2010). The study sample consisted of 5021 participants in a nationally representative Health Examination Survey. They found that periodontal bone loss and periapical lesions were significantly associated with mucosal thickening.

Dental diseases and mucosal cysts of the maxillary sinus

The etiology of mucosal cyst has yet to be definitely determined. The possible causes of mucosal cysts included sinusitis, allergies, seasonal variations, and dental causes (Ruprecht and Lam, 2008). The relationship between mucosal cysts and dental diseases has been controversial. Casamassimo and Lilly examined 4,546 patients and found mucosal cysts in 73 subjects (Casamassimo and Lilly, 1980). Almost half of those with mucosal cysts reported an allergy of some types and about one half of the patients had identifiable periodontal disease. A trend toward a larger cyst with increasing severity of periodontal diseases was noted. On the other hand, endodontic treated-

teeth appeared to play a minor role in the etiology of mucosal cyst. This study suggested that periapical factor might not be as important as periodontal factor in sinus problem. Using panoramic radiographs, Mathew et al. found mucosal cysts in 2% of subjects with dentate upper jaws while they found no cyst in edentulous subjects (Mathew et al., 2009). They suggested that the presence of mucosal cyst was odontogenic causes. In contrast, Soikonen and Ainamo showed that the prevalence of mucosal cysts was 5% both in subjects with a dentate upper jaw and in those with an edentulous upper jaw (Soikkonen and Ainamo, 1995). Therefore, they suggested that the maxillary mucosal cyst was non-odontogenic causes. Kanagalingam et al. prospectively examined CT images from 257 patients undergoing scans of the orbits for ophthalmic reasons (Kanagalingam et al., 2009). Patients responded to a questionnaire prior to scanning inquiring about nasal complaints, treatment for nasal disorders, previous nasal injury, allergy, asthma, recent upper respiratory tract infection, and dental diseases of the upper jaw. They found no association between the presence of cysts and subjective or objective evidence of any sinus or dental diseases. They concluded that mucosal cysts was prevalent in non-rhinitic patients and did not reflect sinus or dental diseases.

Clinical significance of mucosal thickening and mucosal cysts

The clinical significance of sinus mucosal thickening in asymptomatic subjects is unclear. Rak et al. suggested that mucosal thickening of up to 3 mm is commonly seen in asymptomatic patients and may be lack of clinical significance (Rak et al., 1991). Savolainen et al. proposed that the thickness of the mucosal membrane over 6 mm should be considered a pathological change (Savolainen et al., 1997). It is unknown whether sinus mucosal thickening represents subclinical sinusitis and predisposes the subject to future clinical problems.

Mucosal cysts rarely cause any symptoms. Occasional reports of a sensation of nasal stuffiness, facial fullness, paresthesia, pain or soreness on palpation have generally been associated with large lesions, those attached to the infraorbital nerve, or mucosal cysts in locations that obstructed the sinus ostium (Rhodus, 1990). Most mucosal cysts spontaneously regressed or showed no significant change in size over the long term (Wang et al., 2007).

Mucosal thickening and mucosal cysts of the maxillary sinus in asymptomatic patients generally do not require any treatment. However, they may become clinically important when they cause obstruction of the maxillary sinus outflow tract

(Bhattacharyya, 2000). If the sinus ostium is blocked by the sinus mucosal thickening or mucosal cyst, infection may be encountered (Harar et al., 2007). The risk of ostium obstruction and sinusitis may be increased when sinus augmentation was performed at sinuses with thick mucosa or large mucosal cysts (Carmeli et al., 2011; Stammberger, 1986).

The indications for sinus augmentation in patients with mucosal cysts and mucosal thickening are not clearly defined in the literature. Ziccardi and Betts stated that mucoceles of the maxillary sinus was a relative contraindication for sinus augmentation (Ziccardi and Betts, 1999). However, the term mucoceles was used for what they defined as mucosal cysts. They suggest that the cyst should be removed or aspirated prior to sinus augmentation. Recently, case reports showed that bone augmentation may be performed at sinuses with mucosal thickening and mucosal cysts. Tozum et al. reported a case of sinus augmentation surgery performed at sinus with chronic inflammation and 7 mm thick sinus mucosa (Tozum et al., 2009). The patient had no clinical diagnosis of acute sinusitis. The treatment included sinus augmentation and implant placement which was successful after 3 year of follow-up. Mardinger et al. reported sinus augmentation in the presence of mucosal cysts in 8 patients (Mardinger et al., 2007). Complications were found in 2 patients: one had sinus membrane perforation, and one had acute sinusitis. After the mean follow-up of 20 months, all

patients showed successful healing with well-functioning implants. Kara et al. reported 2 cases of sinus augmentation in the presence of mucosal cysts (Kara et al., 2010). A complication was observed in one patient who had fluid drainage at the incision line. The problem was resolved by medical therapy. The dental implants were successful after 7-10 months follow-up. More studies are needed to determine the long term success of the dental treatment.

Studies on the relationship between sinus mucosal abnormalities and dental diseases were mostly based on small number of subjects and conventional radiographs such as periapical and panoramic films. At present, the CT scan is considered the gold standard for sinus evaluation. The CT images provide more accurate information for sinus and dental diagnosis than the conventional radiographs. Therefore, it is the aim of this study to determine the relationship between dental diseases including periodontal and periapical diseases and the presence of mucosal thickening and mucosal cysts of the maxillary sinus using dental CT scans. This study will provide more information regarding the role of dental diseases on sinus mucosal abnormalities. Recognition of this relationship will have an impact on the clinical management of patients, particularly those planning for the sinus augmentation.

CHAPTER III

MATERIALS AND METHODS

Study samples

The study protocol was approved by the ethics committee of the Faculty of Dentistry, Chulalongkorn University. The CT images of 250 consecutive subjects who underwent dental CT scans at the Department of Radiology, Faculty of Dentistry, Chulalongkorn University, between January to July 2009, were retrospectively examined. These subjects received CT scans for dental treatment purposes, mostly for dental implant planning. The patient's head was in the neutral position with the occlusal plane parallel to the floor. The subjects who had edentulous upper jaws were excluded. The CT images were acquired using a dental CT unit (CB MercuRay, Hitachi, Tokyo, Japan) using P-mode (15 cm diameter field of view (FOV), and 0.29 mm image resolution) and standard parameters (120 kVp, 15 mA, 9.6 sec). Data were reformatted with a dental-reformatting CT program (Lucion v.1.2, Cybermed Inc., Seoul, South Korea) to display panoramic and cross-sectional views of the maxilla for evaluation of dental diseases (periodontal and periapical diseases) and mucosal abnormalities of the maxillary sinus.

Dental CT program

Dental CT program used transverse images of the jaw to reformat series of panoramic and cross-sectional views. For making such those kind of images, the reconstructed curve was plotted parallel along the maxilla arch on the selected transverse images around the middle level of alveolar process of maxillary first molar tooth. After that panoramic and cross-sectional views were shown up automatically. For making proper panoramic view, additional option of 10 mm thickness (ray-sum) was used. Two-mm slice interval was also done for series of cross-sectional image. All images were constructed and evaluated by one examiner who tested for calibration and reproducibility from the pilot study.

Assessment of periodontal bone loss, periapical lesions, and root canal fillings

All maxillary posterior teeth located below the maxillary sinus were examined. Embedded teeth were excluded. The amount of periodontal bone loss was classified as followed: <25% = normal-mild, 25-50% of = moderate, and >50% = severe bone loss, respectively. Using a panoramic view, the bone loss on the mesial and distal side of the tooth was assessed. The periodontal bone loss was classified as severe when at least one tooth below that sinus had bone loss >50%. The periodontal bone loss was

classified as moderate when at least one tooth below that sinus had bone loss 25-50%. The periodontal bone loss was classified as normal-mild when all teeth below the sinus had bone loss <25%. The assessment of periodontal bone loss was shown in Figure 1.

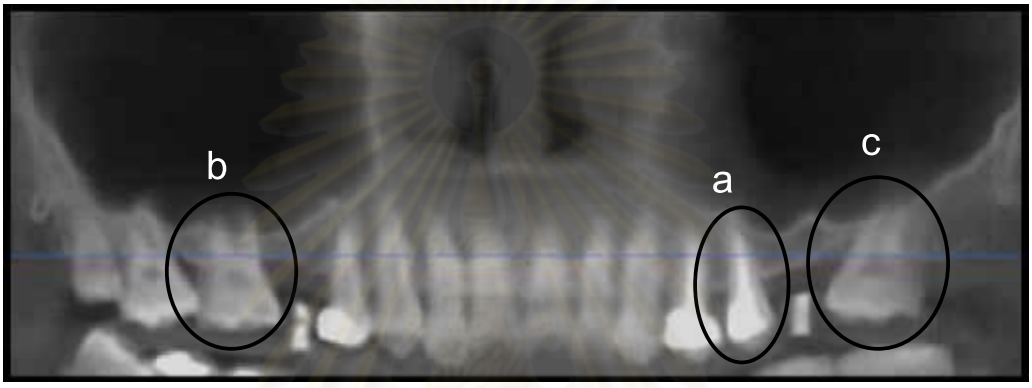

Figure 1. Panoramic view showing the assessment of periodontal bone loss: (a) normal-mild, (b) moderate, and (c) severe periodontal bone loss.

The presence or absence of periapical lesions was determined from the panoramic and cross-sectional views. The periapical lesion was recorded when a widened periodontal ligament space was seen or when the lamina dura was invisible, diffuse, or had an irregular appearance, or when there was a radiolucency indicating bone destruction around the root apex. The periapical lesion was considered "presence" when at least one tooth below that sinus had a periapical lesion. The assessment of periapical lesions was shown in Figure 2.

The presence or absence of root canal fillings was determined from the panoramic view. The root canal filling was recorded when a radiopaque material was seen within the root canal. The root canal filling was considered “presence” when at least one tooth below that sinus had a root canal filling. The assessment of root canal fillings was shown in Figure 3.

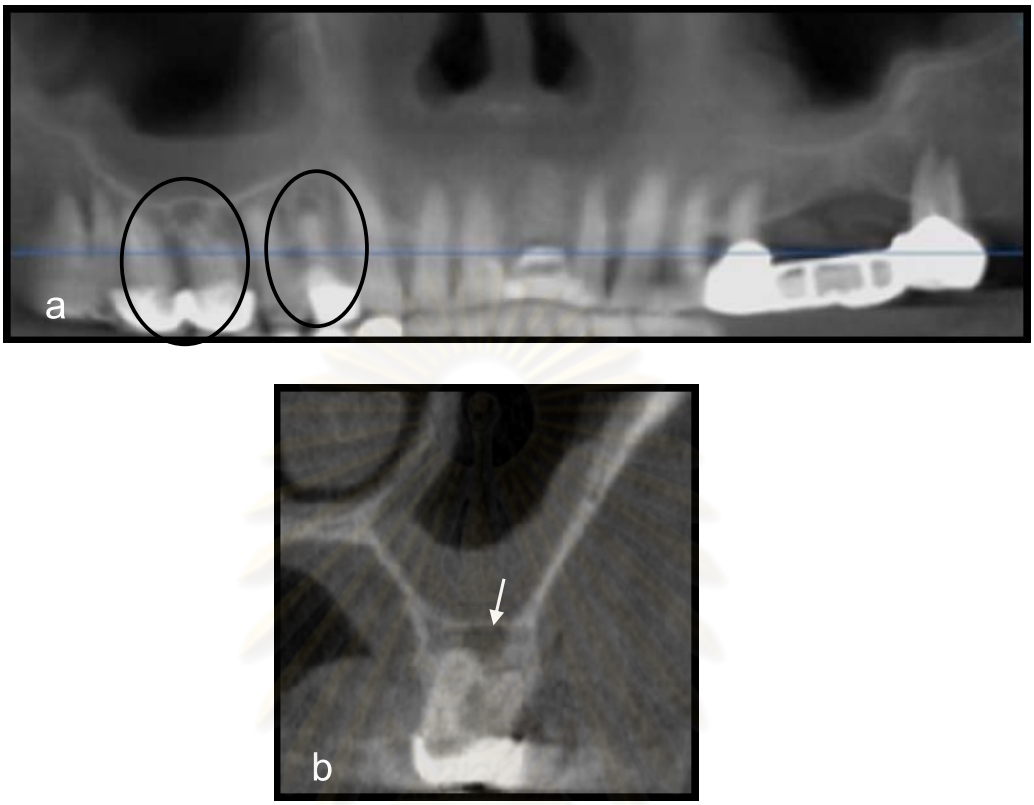

Figure 2. (a) Panoramic, and (b) cross-sectional views showing the presence of periapical lesions.

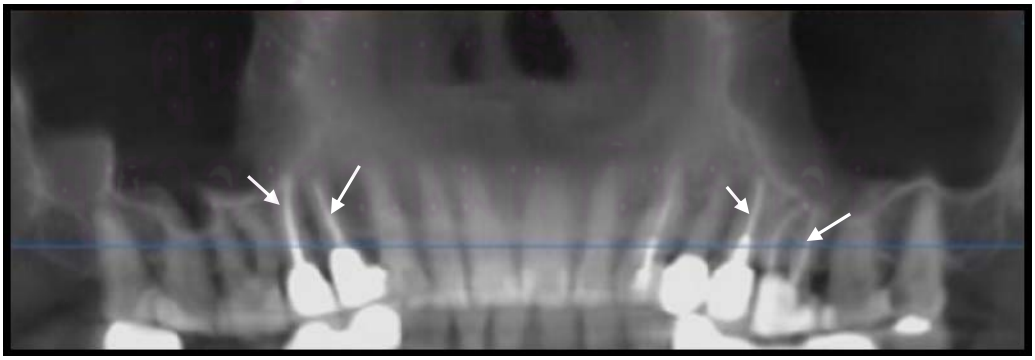

Figure 3. Panoramic view showing the presence of root canal fillings.

Assessment of mucosal thickening

From the cross-sectional view, the presence or absence of mucosal thickening at the floor of the maxillary sinus was recorded. For each sinus, the mucosal thickening was considered presence when the thickness of the sinus mucosa was ≥1 mm (Figure 4). When mucosal thickening was presented, the thickness of sinus mucosa was measured in millimeter from the floor of sinus to the highest border of mucosal thickening of that sinus. For each subject, the mucosal thickening was considered presence when a least one sinus had mucosal thickening.

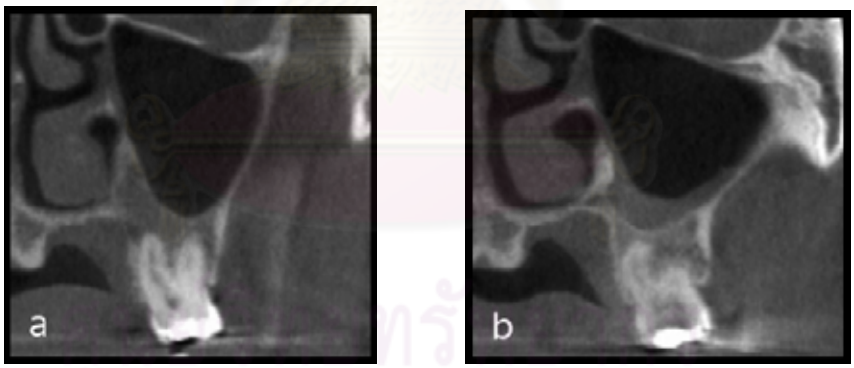

Figure 4. Cross-sectional view showing (a) normal sinus mucosa, and (b) mucosal thickening.

Assessment of mucosal cysts

The mucosal cyst was assessed from the panoramic and cross-sectional views (Figure 5). The diagnosis was based on the following radiographic characteristics: 1) a homogeneous dome-shaped opacity within the maxillary sinus with sharp demarcation of lateral borders; 2) absence of bony erosion; 3) absence of communication with a tooth root; 4) a smooth, spherical outline at the free border of the cyst (Kanagalingam et al., 2009). The size of mucosal cysts was measured in millimeters from the floor of sinus to the highest border of the cysts. Only mucosal cysts located on the floor of the maxillary sinus was included in this analysis. For each subject, a mucosal cyst was considered presence when at least one sinus had a mucosal cyst.

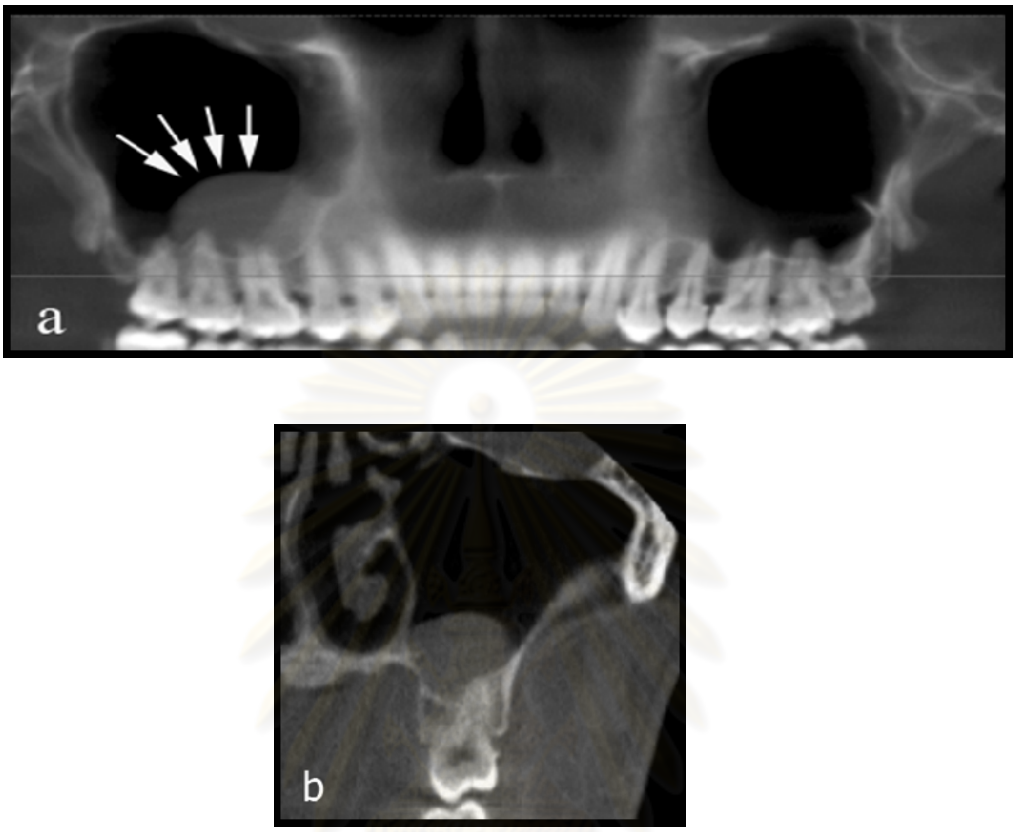

Figure 5. (a) Panoramic, and (b) cross-sectional views showing the presence of maxillary mucosal cysts.

Statistical analysis

A commercially available statistical software (SPSS version 17.0; SPSS Inc., Chicago, IL, USA) was used to analyze the data. The descriptive analysis of data was presented as frequency, mean ± SD, and range. The correlation between occurrence of sinus mucosal abnormalities (mucosal thickening and mucosal cysts) was evaluated according to sex and presence of dental findings (periodontal bone loss, periapical lesions, and root canal fillings) with Chi-square test. The influence of dental diseases findings on sinus mucosal abnormalities was analyzed using bivariate logistic regression analysis. The data were shown as the odds ratios (OR) with 95% confidence intervals (CI). Statistical differences with a *P*-value <0.05 were considered significant.

CHAPTER IV

RESULTS

The CT images of 250 subjects (500 maxillary sinuses) were examined. There were 110 (44%) males and 140 (56%) females, with an average age of 46.1 years (range 13-74, SD ± 14.3). Prevalence of maxillary sinus abnormalities of this study group was shown in Table 3. Mucosal thickening was found in 42% of subjects and maxillary mucosal cysts was detected in 16.4% of subjects.

Table 3. Prevalence of maxillary sinus abnormalities (N=250).

Sinus abnormalities	n (%) of subjects
Mucosal thickening	105 (42)
Mucosal cysts	41 (16.4)

The prevalence of maxillary sinus abnormalities in relation to sex of the subjects was shown in Table 4. We observed significantly higher prevalence of maxillary mucosal thickening (50.9% vs. 35%) and maxillary mucosal cysts (24.5% vs. 10%) among male than female.

Table 4. Prevalence of maxillary sinus abnormalities according to sex.

	Subjects (N)	Prevalence of mucosal thickening n (%)	Prevalence of mucosal cysts n (%)
Sex			
Male	110	56 (50.9)	27 (24.5)
Female	140	49 (35.0)	14 (10.0)
P-Value[†]		0.011[*]	0.002[*]

[†]Chi-square test.

[*]Statistically significant: $P<0.05$.

We examined the prevalence of mucosal thickening and mucosal cysts within each age group. We found that the prevalence of mucosal thickening was higher among older subjects. The highest prevalence was observed in subjects of age 60-69 years old (Figure 6). In contrast, the prevalence of mucosal cysts was higher among younger subjects. The highest prevalence was observed in subjects of age 20-39 years old (Figure 7).

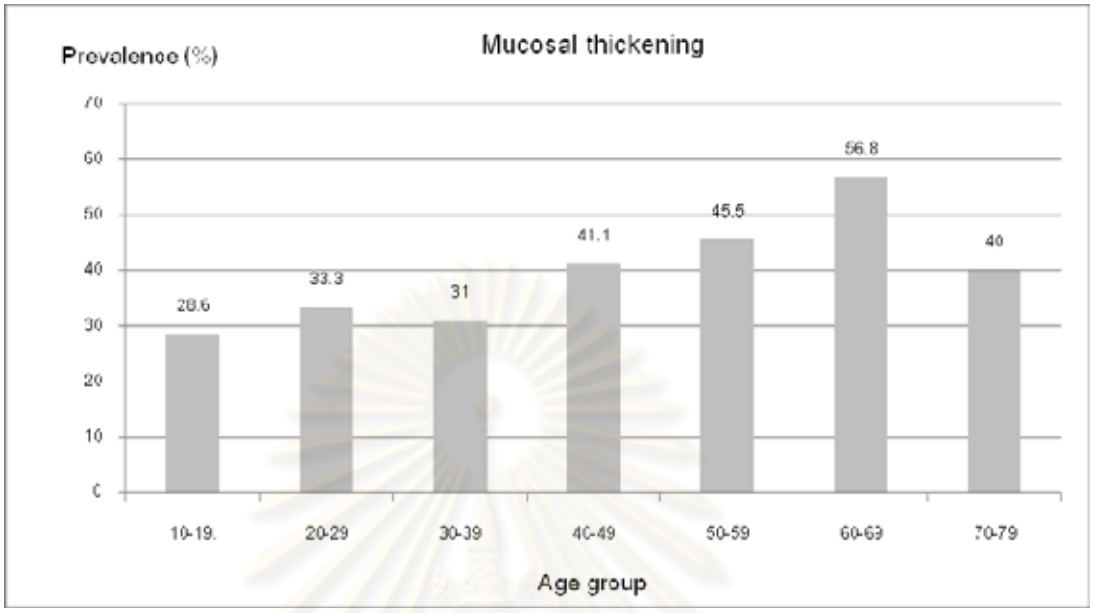

Figure 6. Prevalence of mucosal thickening within each age group.

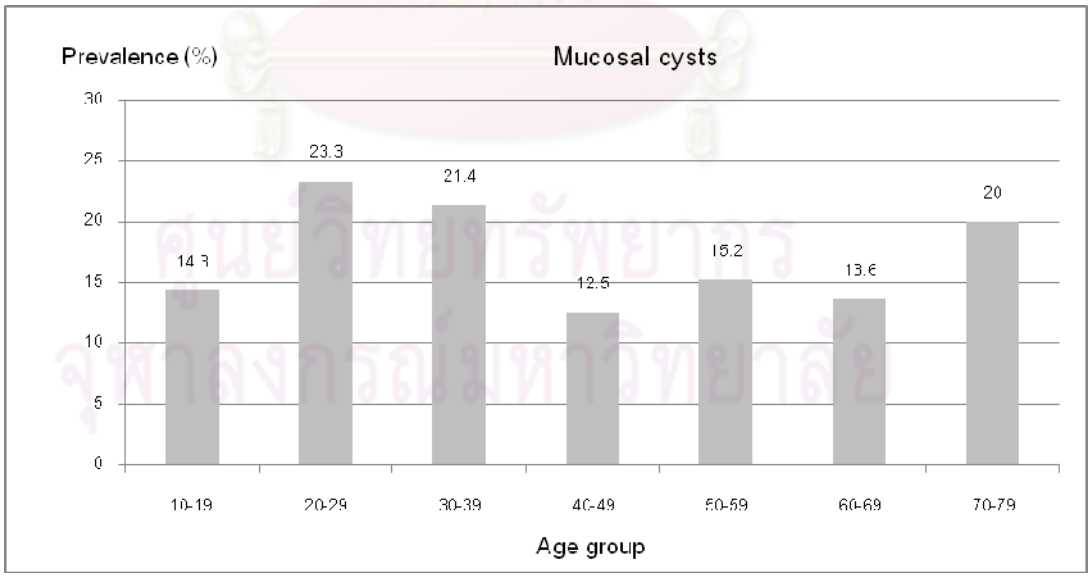

Figure 7. Prevalence of mucosal cysts within each age group.

The thickness of sinus mucosa and the size of mucosal cysts were measured. When mucosal thickening was presented, the mean height of sinus mucosa was 5.0±3.9 mm. The mean height of mucosal cysts was 14.4±6.4 mm. The distribution of mucosal thickening and mucosal cysts by thickness was shown in Table 5. Most sinus presented mucosal thickening (66%) had the thickness of 5 mm or less. The majority of mucosal cysts (62%) had the size of 15 mm or less.

Table 5. The distribution of mucosal thickening in sinus presented ≥1 mm of sinus mucosa and mucosal cysts by thickness.

Mucosal thickness (mm)	Mucosal thickening N (%)	Mucosal cysts N (%)
1.1-5.0	96 (65.8)	0
5.1-10.0	37 (25.3)	18 (36.0)
10.1-15.0	7 (4.8)	13 (26.0)
15.1-20.0	4 (2.7)	9 (18.0)
20.1-25.0	2 (1.4)	6 (12.0)
25.1-30.0	0	4 (8.0)

Prevalence of dental findings of this study group was shown in Table 6. The prevalence of mild, moderate, and severe periodontal bone loss was 28.6%, 51.2%, and 20.2%, respectively. Periapical lesions were observed in 7.8% of sinuses, whereas root canal fillings were found in 21.2% of sinuses.

Table 6. Prevalence of dental findings (N=500).

Dental findings	n (%) of sinuses
Periodontal bone loss	
Normal-mild	143 (28.6)
Moderate	256 (51.2)
Severe	101 (20.2)
Periapical lesions	39 (7.8)
Root canal fillings	106 (21.2)

The relationship between maxillary sinus abnormalities and dental findings was presented in Table 7. Data analysis revealed that mucosal thickening was significantly associated with periodontal bone loss ($P<0.001$), but not for periapical lesions and root canal fillings. Mucosal cysts were not associated with any dental findings.

Table 7. Association between dental findings and maxillary sinus abnormalities (N=500).

Dental findings	Mucosal thickening		Mucosal cysts	
	Presence n (%)	Absence n (%)	Presence n (%)	Absence n (%)
Periodontal bone loss				
Normal-mild	33 (23.1)	110 (76.9)	15 (10.5)	128 (89.5)
Moderate	65 (25.4)	191 (74.6)	23 (9.0)	233 (91.0)
Severe	48 (47.5)	53 (52.5)	12 (9.2)	89 (88.1)
P-Value[†]	<0.001[*]		0.695	
Periapical lesions				
Absence	132 (28.6)	329 (71.4)	47 (10.2)	414 (89.8)
Presence	14 (35.9)	25 (64.1)	3 (7.7)	36 (92.3)
P-Value[†]	0.439		0.785	
Root canal fillings				
Absence	108 (27.4)	286 (72.6)	39 (9.9)	355 (90.1)
Presence	38 (35.8)	68 (64.2)	11 (10.4)	95 (89.6)
P-Value[†]	0.115		1.000	

[†]Chi-square test.

[*]Statistically significant: $P<0.05$.

Using logistic regression analysis, we found that the presence of severe periodontal bone loss significantly increased the risk of having mucosal thickening with OR of 3.02. Presence of moderate periodontal bone loss, periapical lesions, and root canal fillings did not increase the risk of having mucosal thickening. On the other hand, presence of periodontal bone loss, periapical lesions, and root canal fillings did not increase the risk for mucosal cysts (Table 8).

Table 8. Odds ratios (OR) and 95% confidence intervals (95% CI) for the risk of mucosal thickening and mucosal cysts (N=500).

Dental findings	Mucosal thickening		Mucosal cysts	
	OR (95% CI)	*P*-Value[†]	OR (95% CI)	*P*-Value[†]
Periodontal bone loss				
Moderate	1.13 (0.70-1.83)	0.607	0.84 (0.42-1.67)	0.624
Severe	3.02 (1.74-5.24)	<0.001[*]	1.15 (0.51-2.58)	0.733
Periapical lesions	1.40 (0.70-2.77)	0.340	0.73 (0.22-2.48)	0.618
Root canal fillings	1.48 (0.94-2.33)	0.091	1.05 (0.52-2.14)	0.884

[†]Bivariate logistic regression analysis.

[*]Statistically significant: $P<0.05$.

CHAPTER V

DISCUSSION AND CONCLUSION

We examined the CT scans of dental patients and found a relatively high prevalence of maxillary sinus mucosal abnormalities among these subjects. In this study, the prevalence of mucosal thickening was 42%. This was higher than previous reports. It had been shown that the prevalence of mucosal thickening was 8-12%, 15% and 29% as assessed by panoramic, CT, and MRI images, respectively. It appeared that the higher prevalence of mucosal thickening was observed when the more sensitive radiographic technique such as CT and MRI were used. In addition, the criterion for mucosal thickening was different among studies. The normal thickness of Schneiderian membrane was 0.8-1 mm (Misch et al., 2008; van den Bergh et al., 2000). In our study, the mucosal thickening was recorded when the thickness of the sinus mucosa was more than 1 mm. Vallo et al. recored the presence of mucosal thickening when there was a 3-6 mm thick noncorticated radiopaque band following the bony wall of the maxillary sinus (Vallo et al., 2010). Soikkonen and Ainamo recorded the mucosal thckening when there was diffuse radiopacities along the margins of the sinus without well-defined rounded outlines (Soikkonen and Ainamo, 1995). Both studies used panoramic radiographs which did not allow accurate measurements of sinus mucsoal thickness. Other studies

did not clearly define the identification method of mucosal thickening (Havas et al., 1988; Iwabuchi et al., 1997).

We found that the prevalence of mucosal cysts was 16.4%. This was within the range of previous reports (2-36%) (Beaumont et al., 2005; Bhattacharyya, 2000; Carter et al., 1998; Casamassimo and Lilly, 1980; Gordts et al., 1996; Harar et al., 2007; Kanagalingam et al., 2009; MacDonald-Jankowski, 1993; MacDonald-Jankowski, 1994; Mardinger et al., 2007; Mathew et al., 2009; Rodrigues et al., 2009; Ruprecht et al., 1986; Soikkonen and Ainamo, 1995; Vallo et al., 2010). The computerized techniques including CT and MRI tend to give higher prevalence than the conventional techniques such as panoramic and periapical films. Our findings indicate that the mucosal abnormalities of the maxillary sinus are common among patients who underwent dental treatments. Therefore, proper radiographic investigations are recommended prior to sinus augmentation surgery for dental implant therapy.

The prevalence of sinus mucosal abnormalities according to age and sex was investigated. We found that the prevalence of mucosal thickening was higher in men and older age groups. Vallo et al. reported similar findings (Vallo et al., 2010). Iwabuchi et al. also found that subjects older than 50 years had a higher frequency of mucosal thickening than those younger than 50 years (Iwabuchi et al., 1997). The maxillary sinus

of elderly may expose to irritations over lifetime, thus the rate of mucosal thickening was increased. We showed the predominance of mucosal cysts in men and in younger subjects. The highest prevalence was observed in third and fourth decades. Ruprecht and Lam reported that the mucosal cysts occurrence was higher among men than women, at a ratio of 2:1 (Ruprecht and Lam, 2008). Studies by Casamassimo and Lilly as well as MacDonald-Jankowski showed that mucosal cysts were predominant in the third decade of life (Casamassimo and Lilly, 1980; MacDonald-Jankowski, 1993; MacDonald-Jankowski, 1994). Vallo et al. reported the mucosal cysts were twice as frequent in men as in women and were most often seen in younger age groups (Vallo et al., 2010). Carter et al. found the prevalence of mucosal cysts was higher in men, but was independent of age (Carter et al., 1998). However, Havas et al. found no relationship between age group and prevalence of both mucosal thickening and mucosal cysts (Havas et al., 1988).

Infections and mucosal irritations are the potential causes of mucosal thickening of the maxillary sinus. Previous studies suggested that infection and inflammation of dental origins might be the cause of mucosal thickening (Engstrom et al., 1988; Falk et al., 1986; Moskow, 1992; Nenzen and Welander, 1967). However, most of these studies had limitations from a small sample size or using conventional radiographic techniques that did not allow accurate assessment of dental and sinus pathology. In this study,

computed tomography was used to evaluate dental and maxillary sinus findings. The CT scans provide three-dimension visualization of the tooth and the sinus, thus avoiding the superimposition of the anatomic structure, which may conceal the pathology (Lofthag-Hansen et al., 2007).

We showed that periodontal bone loss was associated with mucosal thickening of the maxillary sinus. Regression analysis showed that severe periodontal bone loss (loss $\geq$ 50% of bone support) increased the risk of mucosal thickening by 3 folds. However, presence of moderate periodontal bone loss did not increase the risk of mucosal thickening. Previous studies, using panoramic and periapical radiographs, found thickening of sinus mucosa in advanced periodontitis cases (Engstrom et al., 1988; Falk et al., 1986). The thick of sinus mucosa turned to normal level after successful periodontal treatment. Vallo et al. examined 5021 panoramic radiographs (Vallo et al., 2010). They found that mucosal thickening was associated with periodontal pathology including horizontal bone loss (extend to middle third of the root), vertical infrabony pockets (extend to middle to apical third of the root), and furcation lesions. The risk of mucosal thickening, using edentulous subjects as a reference group, was 3.1, 6.3, and 4.4 respectively. The results from our study and those of Vallo et al. suggested that the risk of mucosal thickening was related to the level of periodontal bone loss. Increased risk of mucosal thickening was only observed when bone loss was

more than half of the bone support. Severe periodontal bone loss is a characteristic of severe periodontitis. It has been shown that the level of pathogenic bacteria and bacterial products as well as inflammatory cytokines increased significantly at sites with severe periodontitis (Feng and Weinberg, 2006). These products may spread to the sinus mucosa through direct diffusion thorough porous maxillary bone, or through bloods and lymph vessels causing thickening of sinus mucosa.

We found that periapical lesions and root canal fillings were not associated with mucosal thickening of the maxillary sinus. On the contrary, Nenzen and Welander reported case series showing that local thickening of the sinus mucosa above teeth with periapical lesions was resolved after successful root canal treatment (Nenzen and Welander, 1967). Vallo et al. also showed that periapical lesions significantly increased the risk of mucosal thickening with ORs of 3.7, but root canal fillings did not (Vallo et al., 2010). In this study, the number of sinuses that had periapical lesions and mucosal thickening was rather small (Table 6). The smaller sample size in our study (N=250), as compared to that of Vallo et al. (N=4655) may account for this difference. In addition, it should be noted that one or more dental findings might be observed in a sinus. It was possible that the effect of severe periodontal bone loss was strong and overwhelmed the effect of other dental findings.

The etiology of mucosal cyst of the maxillary sinus remains unclear. Some authors suggested that the mucosal cyst had odontogenic causes. Casamassimo and Lily found that about one half of the patients who had mucosal cysts also had periodontal disease (Casamassimo and Lilly, 1980). In addition, there was a trend toward larger cysts with increasingly severe periodontal diseases. McDonald and Newton reported a case involving the endodontic retreatment of a maxillary molar associated with a sinus radiopacity similar to a mucosal cyst (MacDonald and Newton, 1993). They found disappearance of sinus pathology 6 days after root canal debridement. Vallo et al., found that the presence of periapical lesions and vertical infrabony pockets slightly increased that risk of mucosal cysts (Vallo et al., 2010). Moreover, Mathew et al. examined panoramic radiographs of elderly subjects. They found that the prevalence of mucosal cysts was 2% in subjects with a dentate upper jaw, whereas no mucosal cysts were found in edentulous subjects (Mathew et al., 2009). Therefore, they suggested that mucosal cysts may have an odontogenic cause.

In this study, we did not observe any association between mucosal cysts and dental findings that included periodontal bone loss, periapical lesions, and root canal fillings. Kanagalingam et al. also found no association between the presence of mucosal cysts and self-reported dental root problems (Kanagalingam et al., 2009). MacDonald-Jankowski showed that the mucosal cyst was not significantly associated

with the presence of periapical lesions (MacDonald-Jankowski, 1994). Soikonen and Ainamo also reported that the prevalence of mucosal cysts in subjects with a dentate and edentulous upper jaw was similar and mucosal cysts were not related to the odontogenic cause (Soikkonen and Ainamo, 1995).

Mucosal thickening and mucosal cysts of the maxillary sinus are commonly seen in asymptomatic subjects. The clinical significance of these sinus abnormalities is unknown. In this study, we found that the average mucosal thickness at sinuses with mucosal thickening was 5 mm. Mucosal thickening of >10 mm was uncommon (8.9%). Savolainen et al. graded the sinus mucosa of less than 6 mm in thickness as normal mucosa and those of over 6 mm as mucosal pathology (Savolainen et al., 1997). Rak et al. suggested that mucosal thickening of up to 3 mm was common and may be lack of clinical significance (Rak et al., 1991). The average size of mucosal cysts in this study was 14 mm which was similar to previous reports (Bhattacharyya, 2000; Harar et al., 2007). They identified the mean cysts size of 14-16 mm from CT Scanning. Mucosal cysts are generally self-limiting condition. Most mucosal cysts spontaneously regress or show no significant change in size over the long term (Wang et al., 2007). Therefore, no treatment is necessary unless a significant expansion is evident radiographically or is associated with symptoms, such as headache, facial pain, nasal obstruciton (Gardner, 1984).

Mucosal thickening and mucosal cysts may become clinically important when they cause obstruction of the maxillary sinus outflow tract. Obstruction of the ostium is believed to be a critical step in the development of sinusitis (Stammberger, 1986). Carmeli et al. assessed the correlation between maxillary sinus mucosal thickening and sinus outflow obstruction from CT images (Carmeli et al., 2011). They found that the risk of sinus obstruction increased as the thickness of sinus mucosa increases. The prevalence of sinus obstruction was 11.1%, 36.2%, and 74.3% when the mucosal thickness was <5 mm, 5-10mm, and >10 mm, respectively. The mucosal thickening of round appearance on the sinus floor, which is likely to be mucosal cysts, was associated with low risk of sinus obstruction. They also defined the possibility that thick sinus mucosa or large mucosal cysts may reach the ostium during sinus augmentation. Some studies suggested to remove or aspirate these mucosal abnormalities prior to sinus lift procedure (Ziccardi and Betts, 1999). In spite of this, several recent case reports showed that sinus augmentation may be performed at sinuses with mucosal thickening and mucosal cysts with low complications (Kara et al., 2010; Mardinger et al., 2007; Tozum et al., 2009).

This study has some limitations. There was no sinus examination or questionnaire regarding the subject's sinus conditions. Therefore, the prevalence of sinus diseases in these subjects was unknown. We also did not have the clinical data of the patient's

periodontal and periapical conditions. Nonetheless, the amount of periodontal bone loss is considered a significant feature of periodontitis and is well-related to the clinical attachment loss (Reddy, 1997).

In conclusion, our study showed that mucosal thickening and mucosal cysts of the maxillary sinus are common among dental patients. Severe periodontal bone loss significantly increased the risk of mucosal thickening, whereas mucosal cyst was not associated with any dental findings. CT scans to assess sinus pathology are recommended prior to sinus augmentation. In addition, clinicians should evaluate the periodontal condition of the patients and provide proper treatment prior to sinus augmentation surgery.

REFERENCES

Abrahams, J.J., and Glassberg, R.M. 1996. Dental disease: a frequently unrecognized cause of maxillary sinus abnormalities? Am J Roentgenol. 166:1219-1223.

Beaumont, C., Zafiropoulos, G.G., Rohmann, K., and Tatakis, D.N. 2005. Prevalence of maxillary sinus disease and abnormalities in patients scheduled for sinus lift procedures. J Periodontol. 76:461-467.

Bhattacharyya, N. 2000. Do maxillary sinus retention cysts reflect obstructive sinus phenomena? Arch Otolaryngol Head Neck Surg. 126:1369-1371.

Brook, I. 2009. Sinusitis. Periodontol 2000. 49;126-139.

Carmeli, G., Artzi, Z., Kozlovsky, A., Segev, Y., and Landsberg, R. 2011. Antral computerized tomography pre-operative evaluation: relationship between mucosal thickening and maxillary sinus function. Clin Oral Implants Res. 22:78-82.

Carter, L.C., Calamel, A., Haller, A., and Aguirre, A. 1998. Seasonal variation in maxillary antral pseudocysts in a general clinic population. Dentomaxillofac Radiol. 27:22-24.

Casamassimo, P.S., and Lilly, G.E. 1980. Mucosal cysts of the maxillary sinus: a clinical and radiographic study. Oral Surg Oral Med Oral Pathol. 50:282-286.

Chong, V.F., and Fan, Y.F. 1998. Comparison of CT and MRI features in sinusitis. Eur J Radiol. 29:47-54.

Engstrom, H., Chamberlain, D., Kiger, R., and Egelberg, J. 1988. Radiographic evaluation of the effect of initial periodontal therapy on thickness of the maxillary sinus mucosa. J Periodontol. 59:604-608.

Falk, H., Ericson, S., and Hugoson, A. 1986. The effects of periodontal treatment on mucous membrane thickening in the maxillary sinus. J Clin Periodontol. 13:217-222.

Feng, Z., and A. Weinberg. 2006. Role of bacteria in health and disease of periodontal tissues. Periodontol 2000. 40:50-76.

Gardner, D.G. 1984. Pseudocysts and retention cysts of the maxillary sinus. Oral Surg Oral Med Oral Pathol. 58:561-567.

Gordts, F., Clement, P.A., and Buisseret, T. 1996. Prevalence of paranasal sinus abnormalities on MRI in a non-ENT population. Acta Otorhinolaryngol Belg. 50:167-170.

Harar, R.P., Chadha, N.K., and Rogers, G. 2007. Are maxillary mucosal cysts a manifestation of inflammatory sinus disease? J Laryngol Otol. 121:751-754.

Havas, T.E., Motbey, J.A., and Gullane, P.J. 1988. Prevalence of incidental abnormalities on computed tomographic scans of the paranasal sinuses. Arch Otolaryngol Head Neck Surg. 114:856-859.

Hirschfeld, L., and Wasserman, B. 1978. A long-term survey of tooth loss in 600 treated periodontal patients. J Periodontol. 49:225-237.

Iwabuchi, Y., Hanamure, Y., Ueno, K., Fukuda, K., and Furuta, S. 1997. Clinical significance of asymptomatic sinus abnormalities on magnetic resonance imaging. Arch Otolaryngol Head Neck Surg. 123:602-604.

Kanagalingam, J., et al. 2009. Maxillary mucosal cyst is not a manifestation of rhinosinusitis: results of a prospective three-dimensional CT study of ophthalmic patients. Laryngoscope. 119:8-12.

Kara, I.M., D. Kucuk, and S. Polat. 2010. Experience of maxillary sinus floor augmentation in the presence of antral pseudocysts. J Oral Maxillofac Surg. 68:1646-1650.

Konen, E., et al. 2000. The value of the occipitomental (Waters') view in diagnosis of sinusitis: a comparative study with computed tomography. Clin Radiol. 55:856-860.

Lofthag-Hansen, S., Huumonen, S., Grondahl, K., and Grondahl, H.G. 2007. Limited cone-beam CT and intraoral radiography for the diagnosis of periapical pathology. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 103:114-119.

MacDonald-Jankowski, D.S. 1993. Mucosal antral cysts in a Chinese population. Dentomaxillofac Radiol. 22:208-210.

MacDonald-Jankowski, D.S. 1994. Mucosal antral cysts observed within a London inner-city population. Clin Radiol. 49:195-198.

MacDonald, A., and Newton, C.W. 1993. Pseudocyst of the maxillary sinus. J Endod. 19: 618-621.

Mafee, M.F., Tran, B.H., and Chapa, A.R. 2006. Imaging of rhinosinusitis and its complications: plain film, CT, and MRI. Clin Rev Allergy Immunol. 30:165-186.

Mardinger, O., Manor, I., Mijiritsky, E., and Hirshberg, A. 2007. Maxillary sinus augmentation in the presence of antral pseudocyst: a clinical approach. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 103:180-184.

Mathew, A.L., Pai, K.M., and Sholapurkar, A.A. 2009. Maxillary sinus findings in the elderly: a panoramic radiographic study. J Contemp Dent Pract. 10:E041-048.

Misch, C.E., Resnik, R.R., and Misch-Dietsh, F. 2008. Maxillary sinus anatomy, pathology, and graft surgery. In C.E. Misch (ed.), Contemporary Implant Dentistry, pp.912-922. St. Louis: Mosby.

Moskow, B.S. 1992. A histomorphologic study of the effects of periodontal inflammation on the maxillary sinus mucosa. J Periodontol. 63:674-681.

Nenzen, B., and Welander, U. 1967. The effect of conservative root canal therapy on local mucosal hyperplasia in the maxillary sinus. Odontol Revy. 18:295-302.

Rak, K.M., Newell, J.D., 2nd, Yakes, W.F., Damiano, M.A., and Luethke, J.M. 1991. Paranasal sinuses on MR images of the brain: significance of mucosal thickening. AJR Am J Roentgenol. 156:381-384.

Reddy, M.S. 1997. The use of periodontal probes and radiographs in clinical trials of diagnostic tests. Ann Periodontol. 2:113-122.

Rhodus, N.L. 1990. The prevalence and clinical significance of maxillary sinus mucous retention cysts in a general clinic population. Ear Nose Throat J. 69:82, 84, 86-87.

Rodrigues, C.D., Freire, G.F., Silva, L.B., Fonseca da Silveira, M.M., and Estrela, C. 2009. Prevalence and risk factors of mucous retention cysts in a Brazilian population. Dentomaxillofac Radiol. 38:480-483.

Ruprecht, A., Batniji, S., and el-Neweihi, E. 1986. Mucous retention cyst of the maxillary sinus. Oral Surg Oral Med Oral Pathol. 62:728-731.

Ruprecht, A., and Lam, E.W.N. 2008. Paranasal sinuses. In S.C. White, and M.J. Pharoah (eds.), Oral radiology principles and interpretation, pp. 511. St. Louis: Mosby.

Savolainen, S., Eskelin, M., Jousimies-Somer, H., and Ylikoski, J. 1997. Radiological findings in the maxillary sinuses of symptomless young men. Acta Otolaryngol Suppl. 529:153-157.

Shear, M., and Speight, P. 2007. Cysts associated with the maxillary antrum. In M. Shear, and P. Speight (eds.), Cysts of the oral and maxillofacial regions, pp. 164. Oxford: Blackwell.

Soikkonen, K., and Ainamo, A. 1995. Radiographic maxillary sinus findings in the elderly. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 80:487-491.

Stammberger, H. 1986. Endoscopic endonasal surgery--concepts in treatment of recurring rhinosinusitis. Part I. Anatomic and pathophysiologic considerations. Otolaryngol Head Neck Surg. 94:143-147.

Timmenga, N.M., et al. 2003. Effects of maxillary sinus floor elevation surgery on maxillary sinus physiology. Eur J Oral Sci. 111:189-197.

Tozum, T.F., Dursun, E., and Tulunoglu, I. 2009. Sinus floor elevation from a maxillary molar tooth extraction socket in a patient with chronic inflammation. J Periodontol. 80:521-526.

Vallo, J., Suominen-Taipale, L., Huumonen, S., Soikkonen, K., and Norblad, A. 2010. Prevalence of mucosal abnormalities of the maxillary sinus and their relationship to dental disease in panoramic radiography: results from the Health 2000 Health Examination Survey. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 109; e80-87.

van den Bergh, J.P., C.M. ten Bruggenkate, F.J. Disch, and D.B. Tuinzing. 2000. Anatomical aspects of sinus floor elevations. Clin Oral Implants Res. 11:256-265.

Wang, J.H., Jang, Y.J., and Lee, B.J. 2007. Natural course of retention cysts of the maxillary sinus: long-term follow-up results. Laryngoscope. 117:341-344.

Ziccardi, V.B., and Betts, N.J. 1999. Complications of maxillary sinus augmentation. In O.T. Jensen (ed.), The sinus bone graft, pp. 201-208. Illinois: Quintessence Publishing.

APPENDIX

Case record form

No. HN. Age : Date :

Right Sinus

Tooth	Presence	Periodontal bone loss			PA	RC	Thick	Cyst
		Nor-Mild	Mod	Severe				
#18								
#17								
#16								
#15								
#14								

Left Sinus

Tooth	Presence	Periodontal bone loss			PA	RC	Thick	Cyst
		Nor-Mild	Mod	Severe				
#24								
#25								
#26								
#27								
#28								

Nor-mild = normal-mild periodontal bone loss, Mod = moderate periodontal bone loss

PA = periapical lesions, RC = root canal fillings

Thick = mucosal thickening, Cyst = mucosal cysts

Variables

Dependent variables	1. Mucosal thickening of maxillary sinus Group 0 = Absence Group 1 = Present 2. Maxillary mucosal cysts Group 0 = Absence Group 1 = Present
Independent variables (Categorical data)	1. Periodontal bone loss Group 0 = Normal-mild Group 1 = Moderate Group 2 = Severe 2. Periapical lesions Group 0 = Absence Group 1 = Present 3. Root canal fillings Group 0 = Absence Group 1 = Present
Independent variables (Continuous data)	4. Sinus mucosal thickness (mm) 5. Size of mucosal cysts (mm)

BIOGRAPHY

Miss Sirikarn Phothikhun was born on 1st of April 1982 in Bangkok City. She graduated the elementary school education from Rajini School and high school education from Triam Udom Suksa School, Bangkok. In 2005, she earned her Doctor of Dental Surgery degree with first class honor from Chulalongkorn University. She used to serve the government as a general dentist at Sriprajan Hospital, Supanburi in year 2005. Presently, she practices in private dental clinics, Bangkok. At the same time, she attends the Master of Science Program in Periodontics, Department of Periodontology, Faculty of Dentistry, Chulalongkorn University in year 2009.