PREVALENCE OF MAXILLARY SINUS PATHOLOGY IN PATIENTS OF THE MISCH INTERNATIONAL IMPLANT INSTITUTE

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ABSTRACT

With the continuous evolution of sinus augmentation procedures in the field of implant dentistry it is imperative to have a comprehensive understanding of the maxillary sinus area. Both lateral wall and crestal approach sinus augmentation procedures have proven to be extremely successful for guided bone regeneration in the maxillary sinus. However, complications stemming from augmentation procedures are related to the presence of pre-existing maxillary sinus pathologies. The purpose of this study was to expand upon the current knowledge base in regards to the prevalence of maxillary sinus pathologies in patients presenting to an implant dentistry practice. To this end, computerized tomography (CT) scans of patients presenting to the Misch International Implant Institute (MIII) were analyzed for the existence of maxillary sinus pathology.

Scans of 275 patients presenting to the MIII for maxillary sinus augmentation were evaluated by up-to three different examiners, all of whom were calibrated to the study design and well versed in the use of software to analyze CT scans. Age and gender were also evaluated to see if they had any relationship on the incidence of pathology. Scans were classified into one of five categories based upon the type of sinus pathology detected. The categories of sinus findings were: healthy, mucosal thickening > 5mm, polypoidal mucosal thickening, partial opacification and/or air fluid level, and complete opacification.

Overall, 54.9% of scans were classified as healthy, and 45.1% of scans were classified as exhibiting sinus pathology. Men were more likely to exhibit pathology

compared to females ($p<0.01$). However, age did not appear to have any relation on the prevalence of sinus pathology.

The prevalence of sinus pathology reported in this study appears to be within the range shown in previous medical and dental literature. However, due to the different populations studied in the literature and the varying definitions of what constitutes pathology, there is no consensus as to the exact prevalence of sinus pathology. Therefore, it may be more important for the dentist who is evaluating a CT scan prior to maxillary sinus augmentation to understand which patients will benefit from referral to another specialist (such as an otolaryngologist) for evaluation and co-management. It is proposed that based on the findings of this study, 45.1% of patients would require further consultation prior to proceeding with maxillary sinus augmentation surgery.

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INTRODUCTION

The prevalence of tooth loss in the adult population of the United States is a staggering figure. According to data from the National Health and Nutrition Examination Survey (NHANES III), approximately 30% of adults in the United States population have a full dentition (which is defined as the presence of all teeth other than 3rd molars). Therefore, approximately 70% of adults in the United States are missing one or more permanent tooth. It was also found that partial edentulism was much more common in the maxilla compared to the mandible, and that the most commonly missing teeth were first and second molars.[1]

Posterior maxillary tooth loss poses a unique challenge compared to any other area of the mouth. The pneumatization of the maxillary sinus which is seen after tooth extraction can compromise the volume of bone available for placement of dental implants. The development of the maxillary sinus has been well documented. In short, the maxillary sinus is the largest of the 4 paranasal sinuses, the others being the ethmoid, frontal and sphenoid. Its growth is continuous with age, being only the approximate size of a pea in a newborn. The presence of teeth in the maxillary posterior region restricts the growth of the sinus inferiorly. However, the loss of teeth can lead to the pneumatization of the sinus in an inferior direction.[2] A recently published study showed that of more than 500 posterior maxillary implants that were placed over a 4 year period, 54% required sinus augmentation procedures to facilitate placement of a dental implant.[3]

With the work of Tatum in the 1970s and the first publication of the modified Caldwell-Luc approach by Boyne and James, sinus augmentation was introduced to the field of implant dentistry. The alternative to the modified Caldwell-Luc (lateral wall) approach are the so-called 'internal' sinus floor elevation techniques. This approach was prominently brought to attention by the publication of Summers in 1994 describing the bone added osteotome sinus floor elevation technique.[2] The survival rates of implants placed into areas that have undergone sinus augmentation either by a lateral wall or internal approach are shown to be as high as for those implants placed in native bone. A study by Del Fabbro found a 96.9% implant survival rate when >5mm of residual bone height was present and implants were placed using an osteotome approach.[4] Another study by Pjetursson found a 98.3% survival rate for implants placed in bone regenerated using a lateral wall approach when using rough surfaced implants and a membrane over the lateral window.[5] Therefore, the augmentation of the maxillary sinus can be viewed as a predictable and highly successful technique for guided bone regeneration.

However, one must still consider the possible complications related to sinus augmentation procedures. In particular, it is widely accepted that perforation of the maxillary sinus membrane is undesirable, and is to be avoided when performing any sinus manipulation surgery. This has been particularly emphasized when surgical procedures involve the placement of bone graft material in the space previously occupied by the elevated membrane. It has been hypothesized that entry of graft material in the sinus proper can serve as a nidus for infection itself, or seal off the ostium and foster an environment for the development of a sinus infection.[2] Studies also show that sinus

membrane perforations can lead to decreased implant survival rates and decreased bone formation after augmentation. A recent study by Cho-Lee found that the 5-year implant survival rate dropped from 97.6% to 81% when implants were placed into perforated sinuses or those that later developed sinusitis, as compared to cases with no complications.[6] Studies have also shown that the risk of developing post-operative sinusitis is related to the presence of pre-existing sinus pathology.[7,8,9]

There are four general categories of maxillary sinus pathology that have been described in the literature: 1) inflammatory lesions, 2) cystic conditions, 3) neoplasms and 4) antroliths and foreign bodies. Inflammatory lesions may be derived from both odontogenic and non-odontogenic sources. Odontogenic sinusitis results from lesions involving the apices of teeth which are in close proximity to the maxillary sinus (such as periapical granulomas and radicular cysts). They can also develop from perforations of the membrane during extraction of teeth or the presence of foreign bodies (such as gutta-percha, root tips or restorative dentistry materials). Often times, odontogenic sinusitis will result in a characteristic 'halo-appearance' in the sinus membrane adjacent to a localized area of periapical mucositis. In other cases, a more generalized thickening of the sinus membrane may occur adjacent to the offending teeth. Non-odontogenic sinusitis usually falls into one of two broad categories: acute rhinosinusitis and chronic rhinosinusitis. Acute rhinosinusitis is often due to a viral infection from the upper respiratory tract that spreads from the nasal cavity to involve one of the paranasal sinuses. The patency of the osteomeatal complex may become compromised as a result of this inflammatory process. There is often an alteration in the production of mucous in the

sinus as well as a diminished mucociliary transport. This results in the common radiographic appearance of acute rhinosinusitis, which is manifested as the presence of an air-fluid level. It is usually consistent with clinical findings of nasal congestion, purulent discharge, as well as pain and tenderness of the face. Chronic rhinosinusitis is considered as a progression of disease from the acute to chronic stage. Most literature describes chronic rhinosinusitis as sinusitis persisting for greater than 6 weeks. It has been stated that the microbiological flora shifts to favor more anaerobic species as compared to acute rhinosinusitis. Radiographically, chronic rhinosinusitis does not present with an air-fluid level, but rather with a thickening of the sinus mucosa. Total opacification of the maxillary sinus may also be seen, as well as sclerotic changes to the walls of the sinus which appear to the observer as an increased density of these walls. The preceding description of acute and chronic rhinosinusitis has explained the initiation of the condition as a result of a bacterial infection; however, these conditions may also arise as a result of an allergen in the upper respiratory tract or a fungal species. In allergic sinusitis, 15-60% of cases may develop into a chronic rhinosinusitis. From a radiographic standpoint, the anatomy of the sinus membrane can be greatly altered and can result in the formation of polyps. These polyps can originate on any of the walls of the maxillary sinus and are well-delineated, smooth, dome-shaped thickenings of the Schniderian membrane. In more extreme cases, complete blockage of the osteomeatal complex may be observed coincident with displacement or obliteration of the walls of the sinus. Complete opacification of the sinus may also be observed. Fungal infections (eosinophilic fungal rhinosinusitis) of the maxillary sinus are an extremely dangerous condition and require referral and specialized management. Radiographically their

appearance can range from mild thickening to complete opacification of the maxillary sinus.[2]

After inflammatory conditions, cystic lesions are the next most common category of maxillary sinus pathology. Mucous retention cysts are the most common cystic lesion and are differentiated into two different categories – pseudocysts and retention cysts. Pseudocysts are much more common and their name is derived from the fact that these cysts have no epithelial lining and hence are not actually cysts. Rather, they develop from an accumulation of fluid between the periosteum and the Schniderian membrane, which results in a smooth, dome-shaped lesion in the sinus. In almost all cases, they are found located on the floor of the maxillary sinus. In contrast, retention cysts can be found in a number of different locations including along the floor, lateral or medial walls or within polyps, and do possess an epithelial lining. These cysts develop from blockage of seromucous glands located in the connective tissue underlying the sinus membrane resulting in dilation of the ducts and the development of a cyst surrounded by respiratory or cuboidal epithelium. Retention cysts are rarely seen radiographically and even with computerized tomography (CT) imaging are not often seen. When they are viewable on a CT scan, they resemble small pseudocysts. The other major category of cystic lesions after mucous retention cysts are mucoceles. Mucoceles can also be further subdivided into primary and secondary varieties. Primary mucoceles arise from obstruction of the ostium by growth of fibrous connective tissue. As a result of this impaired clearance through the osteomeatal complex, herniation of the sinus membrane through the peripheral walls is observed, as well as the presence of mucin within the cyst. In the

early stages of the lesion the radiographic appearance is one of complete opacification of the sinus. As the cyst enlarges, thinning of the adjacent walls and perforation of the cyst through these walls can be observed. Eventual destruction of surrounding walls can be observed without treatment. Secondary mucoceles are also referred to as surgical ciliated cysts or postoperative maxillary sinus mucoceles. They develop as a result of trauma, or post-operatively following surgery involving the maxillary sinus area. Remnants of sinus epithelium and mucosa can become entrapped leading to the development of these mucoceles. Reports of this condition in Western populations are extremely rare, although they are reported more frequently in Japanese populations.[2]

Neoplasms of the maxillary sinus are usually either squamous cell carcinomas or adenocarcinomas. Depending on the specific wall of the sinus that the tumor involves, the signs and symptoms of the neoplasm will differ. Tumors involving the maxillary sinus can present with a wide range of radiographic appearances, including total sinus opacification, loss of bony walls and radiopaque masses of soft tissue. One well known characteristic which is suggestive of a neoplasm is the loss of the posterior wall of the maxillary sinus as viewed on a panoramic radiograph. Antroliths of the maxillary sinus are calcified masses that can originate from a nidus of either an endogenous or exogenous source. The source can vary from being a retained root tip or a piece of a fractured dental instrument to a nidus of mucous or bone. They appear on a CT scan as either solitary or multiple radiopaque masses which are found between the periosteum and sinus membrane; however, the sinus walls remain intact.[2]

As early as the late 1980s, the use of advanced imaging techniques such as magnetic resonance imaging (MRI) and CT have been utilized to visualize abnormalities associated with the paranasal sinuses.[10,11,12,13] These early studies demonstrated that the imaging techniques of MRI and CT were more sensitive and provided more detailed information than plain films. More recently, cone-beam computerized tomography (CBCT) scans have become very popular in dentistry as they have significantly less radiation exposure for patients compared to traditional CT scans.[14] It has been said that CT scans provide more information regarding soft tissue (as they provide higher contrast images), while CT scans are better suited for hard tissues such as bone. However, both CBCT and CT scans are widely utilized for analysis of the maxillary sinuses by dentists.[15]

One of the key features of CT imaging is that various anatomical structures can be differentiated one from another based upon their relative densities. When talking about medical grade CT scans, water is classified as the center of the scale and is assigned a value of 0 Hounsfield Units (HU). Any tissue or structure which is denser than water is given a positive value; and conversely, a negative value is assigned when the density is less than water. Therefore, air is assigned a value of -1000 HU whereas bone can range anywhere from <150 to 1250 HU.[16] In translating these numerical values to what is seen on a CT scan, spaces occupied with air appear completely radiolucent (black). In contrast, bone will appear radiopaque (white). The denser the bone, the more radiopaque it will appear. Areas of tissue will appear as varying shades of grey.

When describing a maxillary sinus that demonstrates no areas of mucosal thickening, one would see the maxillary sinus as a large black cavity (because it is filled with air) which is surrounded by bony walls which appear radiopaque. In cases where no mucosal thickening is present, the Schniderian membrane cannot be demarcated easily as a space between the air in the cavity and surrounding bone (Figure 1). However, when there is some evidence of mucosal thickening, one will see the appearance of a grey mass representing the thickened tissue or fluid (Figure 2). This area of thickened tissue or fluid will appear grey because its density is somewhere between that of air (black) and bone (white).

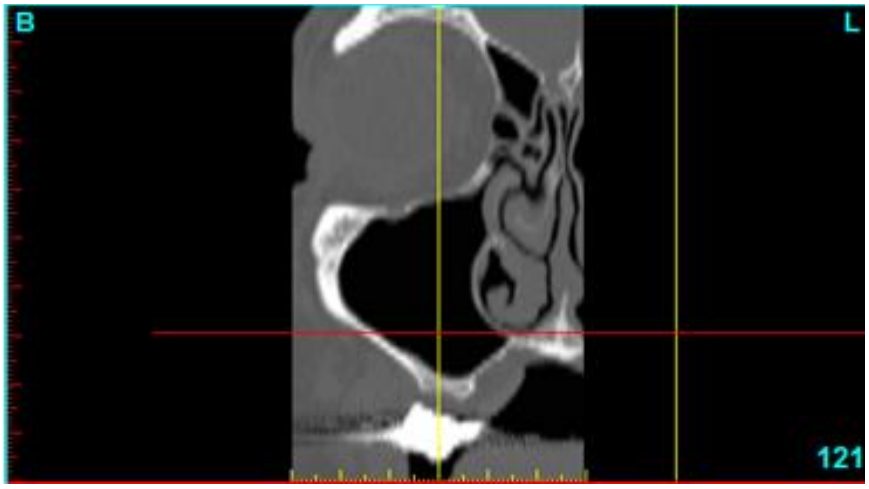

Figure 1. Sagittal view of a CT scan demonstrating no mucosal thickening.

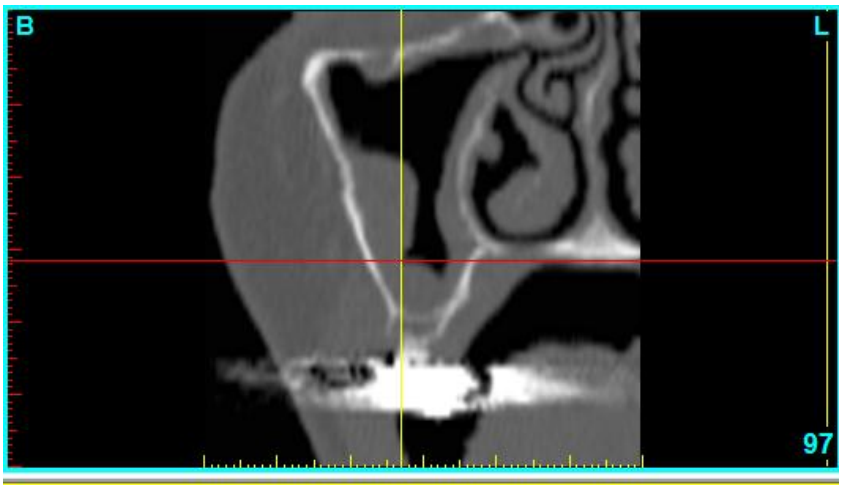

Figure 2. Sagittal view of a CT scan demonstrating mucosal thickening.

The purpose of this study was to determine the prevalence of maxillary sinus pathology in patients of the Misch International Implant Institute (MIII). Variables such as age and gender were also studied to see if they had any influence on the results.

CHAPTER 2

METHODS AND MATERIALS

During the course of this investigation, 275 scans (either CT or CBCT) were analyzed retrospectively. All of the patients were selected at random from the database of patients presenting to the MIII for maxillary sinus augmentation. The scans were taken during the course of initial treatment planning. Information regarding the patients' gender and age were recorded when available. All patients had agreed to the use of their records for presentation and research purposes. In many cases, patients were referred from other dentists to the MIII and therefore had scans taken prior to becoming patients of the institute. Therefore, the scans were taken from a wide number of different CT or CBCT scanning machines, and no attempt was made to accommodate for this. All that was required was for the scans to be available in a DICOM (digital imaging and communication in medicine) format which was then converted for use with the SimPlant Pro treatment planning software (Materialise, Glen Burnie MD).

The Simplant Pro treatment planning software allowed for the visualization of the scans in 3 different views: axial, sagittal, and panoramic. All scans were viewed by up-to 3 different examiners. All examiners (2 periodontal residents – Drs. Aleem Manji and Joanie Faucher, and 1 prosthodontist – Dr. Randolph R. Resnik) were well versed in the utilization of CT scans for implant treatment planning. First the scans were reviewed independently by Dr. Manji and Dr. Faucher. If there was a disagreement between the two in terms of the findings, Dr. Resnik cast the deciding vote. If there was not an

agreement between at least 2 of the reviewers the scan was eliminated from consideration. Furthermore, all reviewers had complete access to all features of the software including the ability to change the color/contrast, zoom images and access all views available in the scans.

The mean age of the patients at the time of scan was 54.8 (range 13-91), and there were 115 males and 160 females included in the study. The patients were also categorized based on age into one of 3 groups : <30, 30-59, and $\geq$ 60. There were 16 aged <30, 112 aged 30-59 and 92 aged $\geq$ 60. Age data was only available for 220 patients, as this information was missing from some of the scans reviewed.

Patients were assigned to one of five different categories according to the level and pattern of sinus inflammation: healthy, mucosal thickening ($\geq$ 5mm), polypoidal mucosal thickening, partial opacification and/or air/fluid level or complete opacification. All 3 examiners were calibrated as to the 5 different categories and representative examples were discussed. Patients who were categorized as healthy had anywhere from 0 to 5mm of mucosal thickening (Figure 3). When the mucosal thickening was polypoidal in nature (as is the case when pseudocysts or nasal polyps are present) it was categorized as polypoidal mucosal thickening (Figure 4). The next category included mucosal thickening which displayed areas of partial opacification, or if an air/fluid level was apparent (Figure 5). The final category of complete opacification was noted when the sinus cavity was completely occupied with a grey or white appearance as opposed to the normal black appearance (Figure 6).

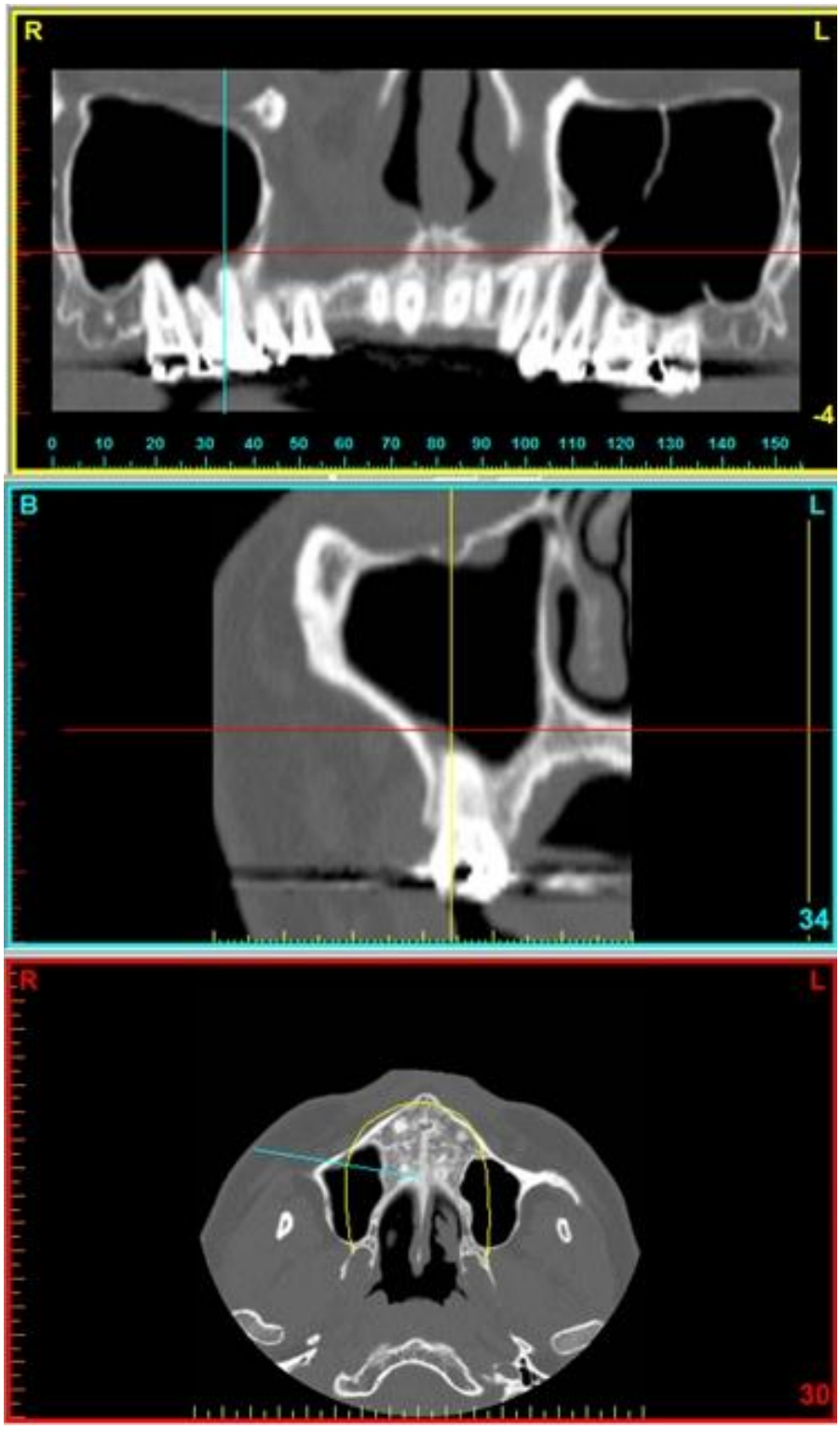

Figure 3. Panoramic (top), sagittal (middle) and axial (bottom) views of a patient categorized as healthy.

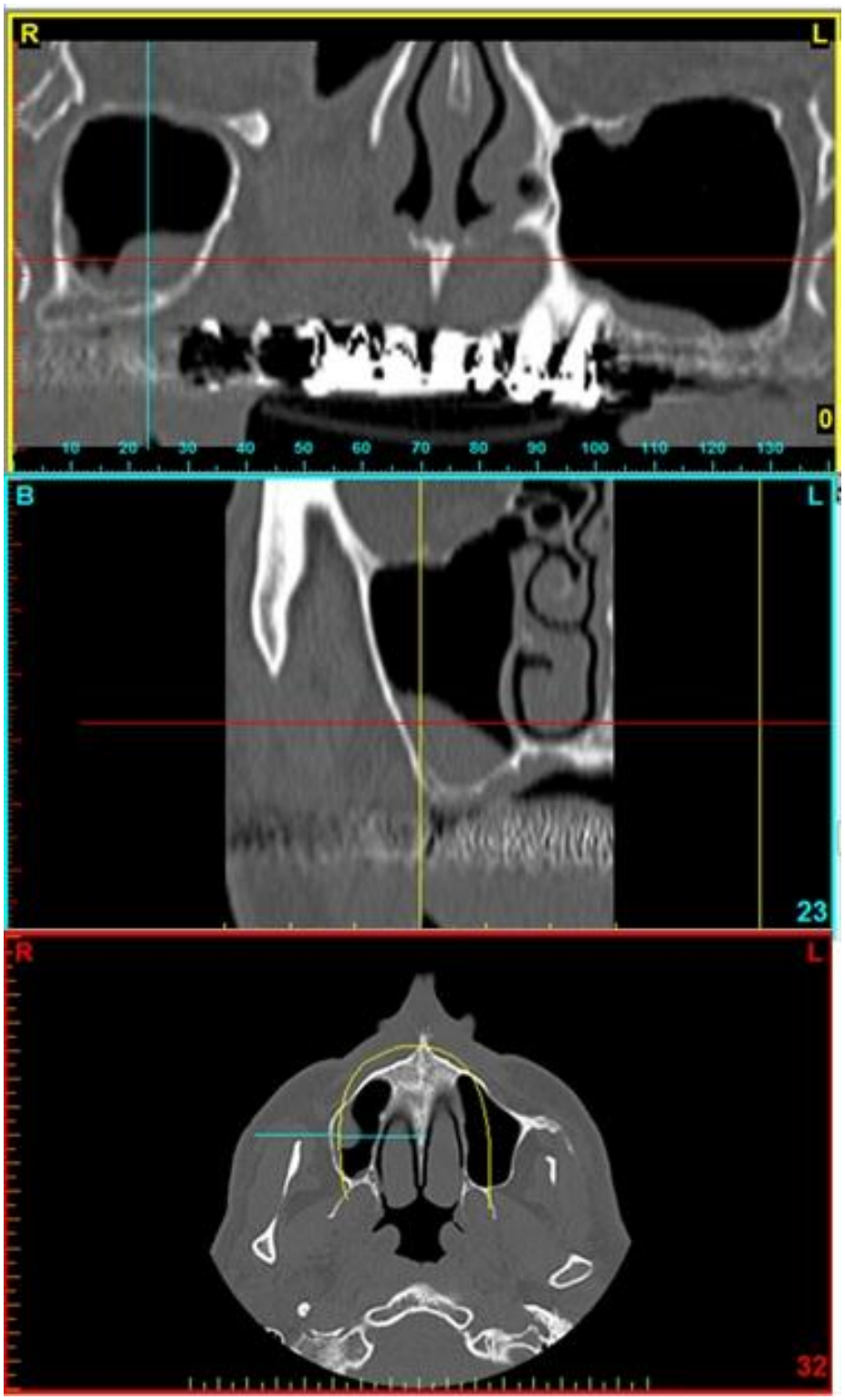

Figure 4. Panoramic (top), sagittal (middle) and axial (bottom) views of a patient categorized as mucosal thickening > 5mm.

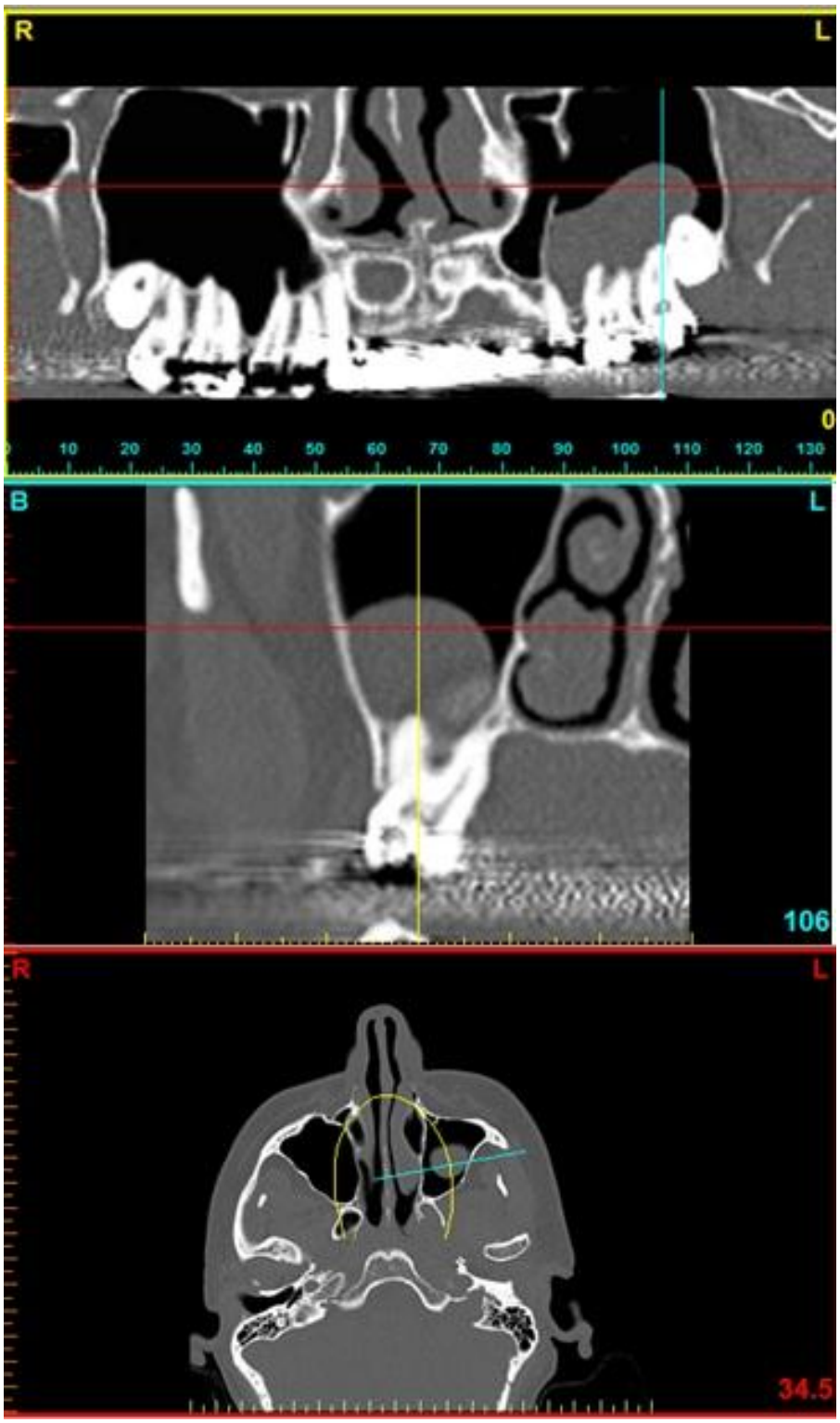

Figure 5. Panoramic (top), sagittal (middle) and axial (bottom) views of a patient with polypoidal mucosal thickening.

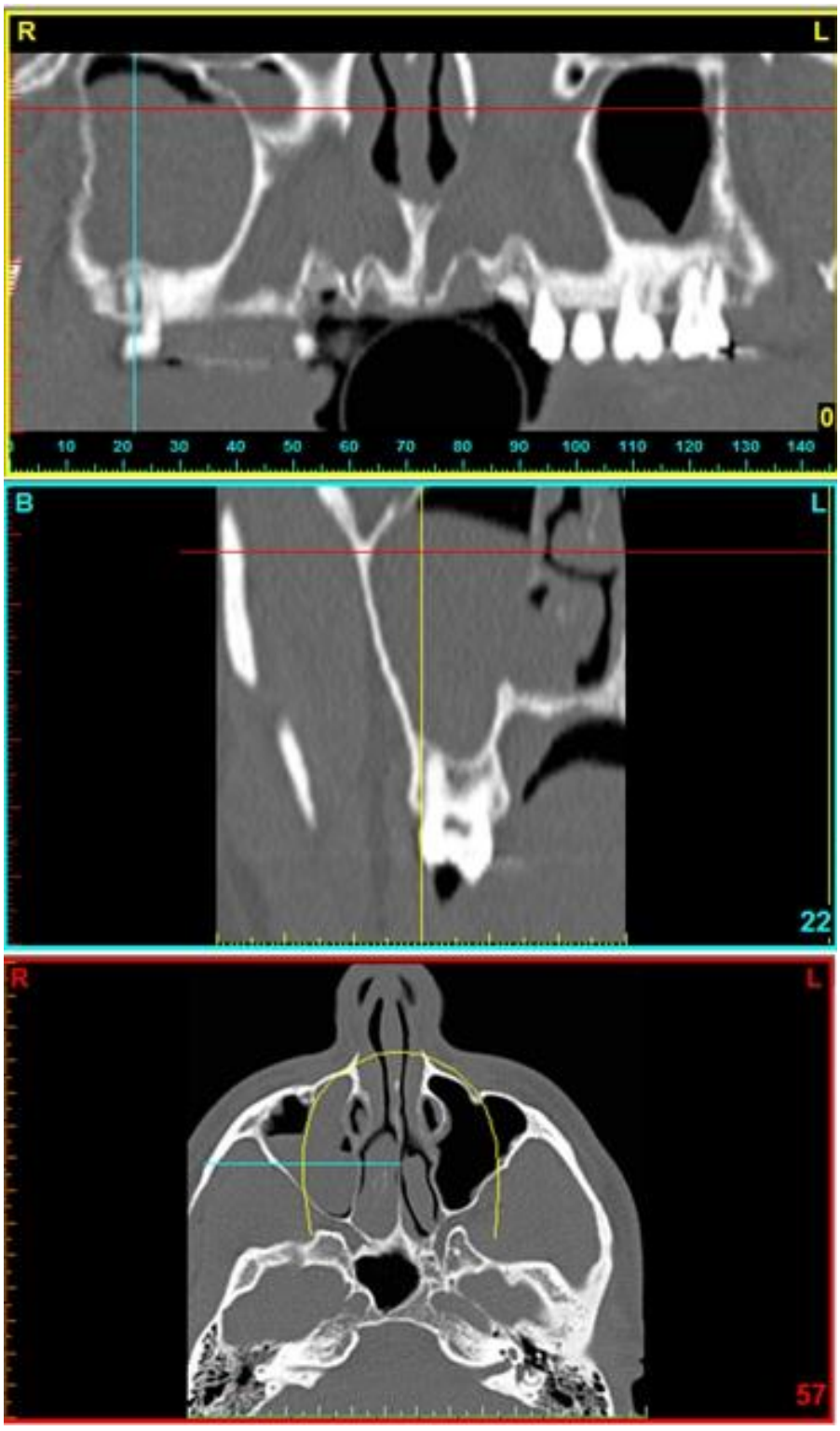

Figure 6. Panoramic (top), sagittal (middle) and axial (bottom) views of a patient categorized as partial opacification and/or air/fluid.

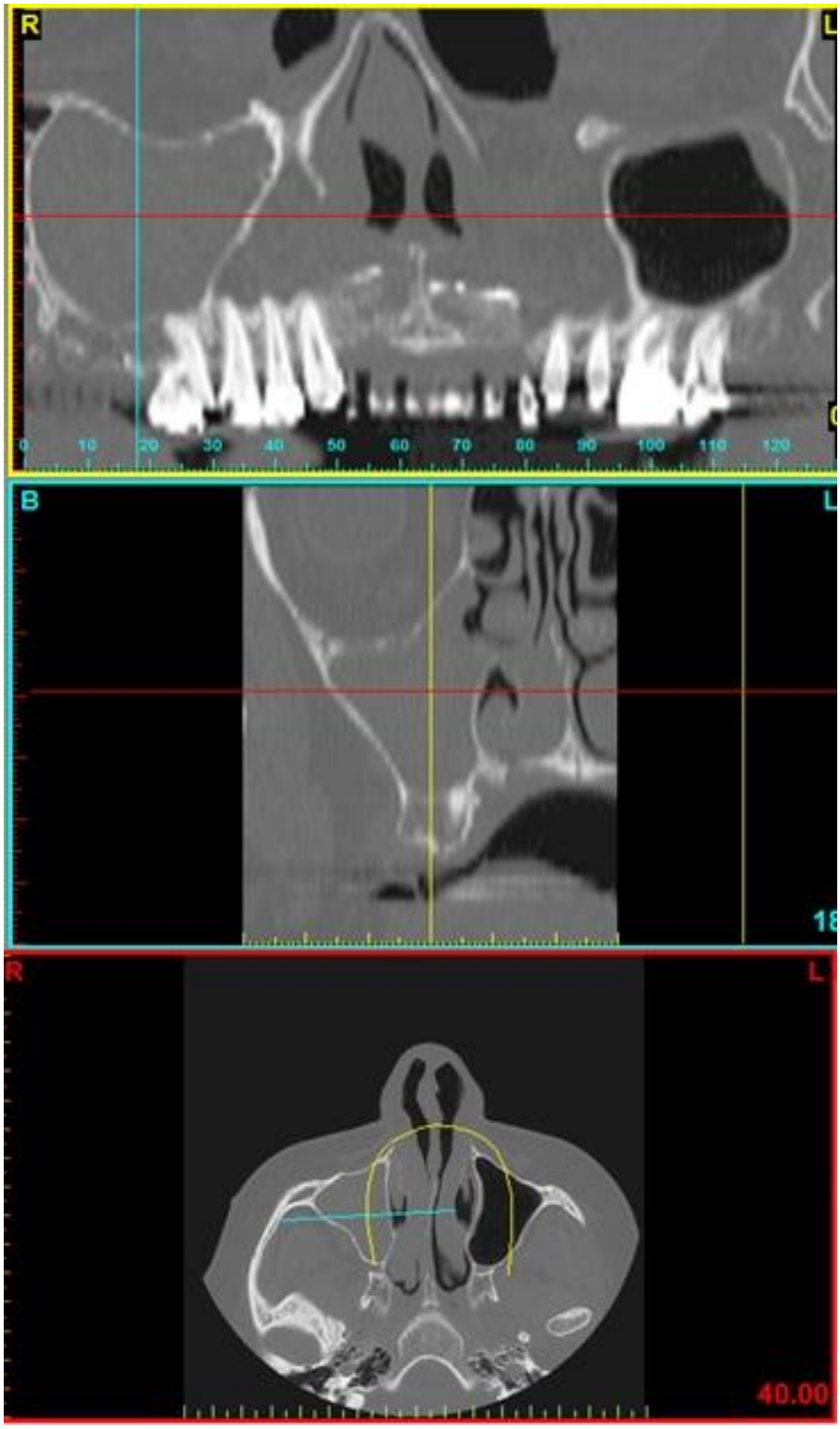

Figure 7. Panoramic (top), sagittal (middle) and axial (bottom) views of a patient with a completely opacified sinus.

Statistical calculations were performed using the Mann-Whitney U Test for non-parametric data to determine differences between groups, and subsequent p-values were generated.

CHAPTER 3

RESULTS

Of the 275 CBCT scans which were reviewed, 151 patients were categorized as healthy and the remaining 124 exhibited some evidence of maxillary sinus pathology (Figure 8). This translated to a prevalence of maxillary sinus pathology of 45.1% in the population studied, with the remaining 54.9% not significant for any finding of maxillary sinus pathology.

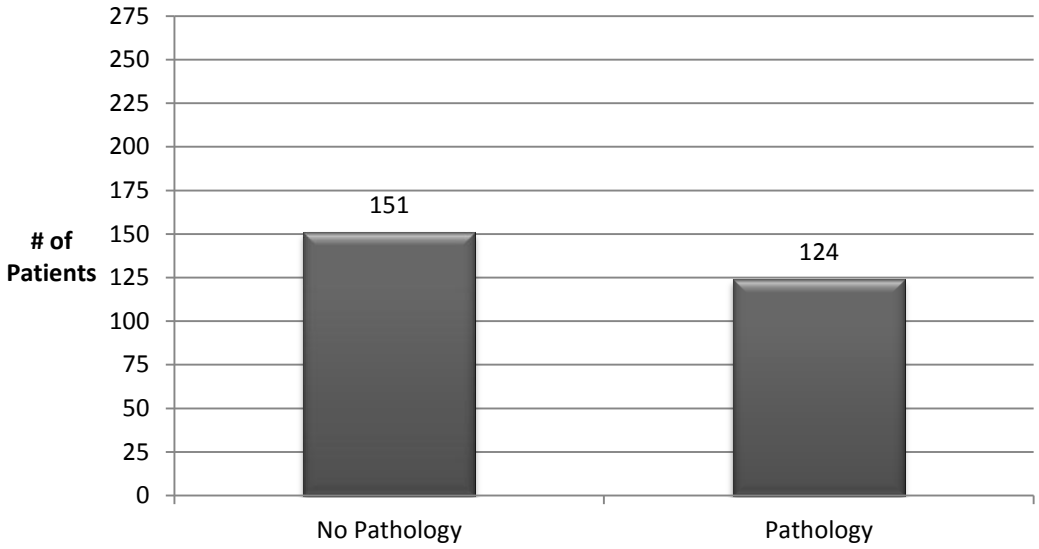

Figure 8. Number of patients exhibiting no pathology and pathology respectively.

When categorizing the results in terms of gender, 64 males and 60 females presented with evidence of sinus pathology. This translated to 55.6% of males and

37.5% of females studied. There was a statistically significant difference in comparing the incidence sinus pathology between males and females ($p<0.01$) (Figure 9).

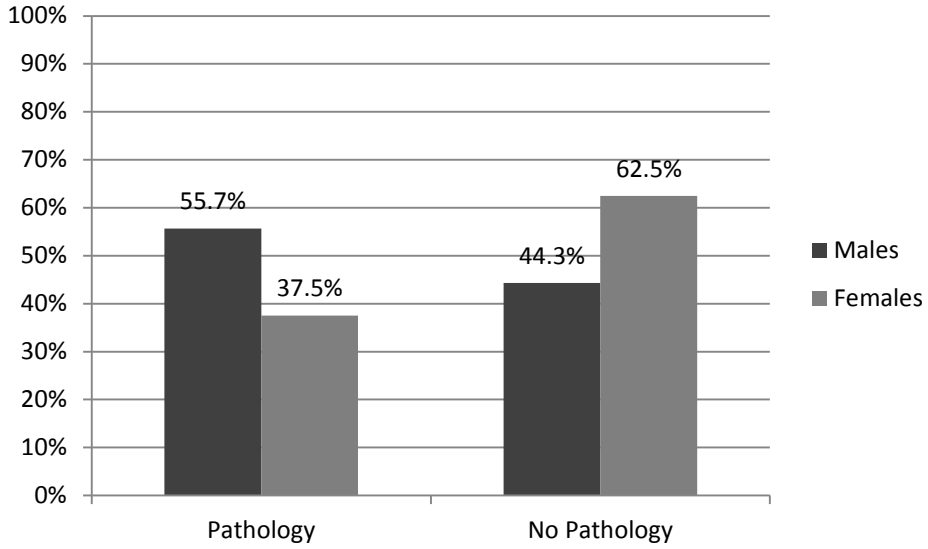

Figure 9. Prevalence of sinus pathology based on gender.

Out of the 151 patients who presented with evidence of sinus pathology, there were 70 cases of mucosal thickening (≥ 5mm), 35 cases of polypoidal thickening, 11 cases partial opacification and/or air/fluid level and 8 cases of complete opacification. This translated to 56.5%, 28.2%, 8.9% and 6.5% respectively for the 4 categories. (Figure 10)

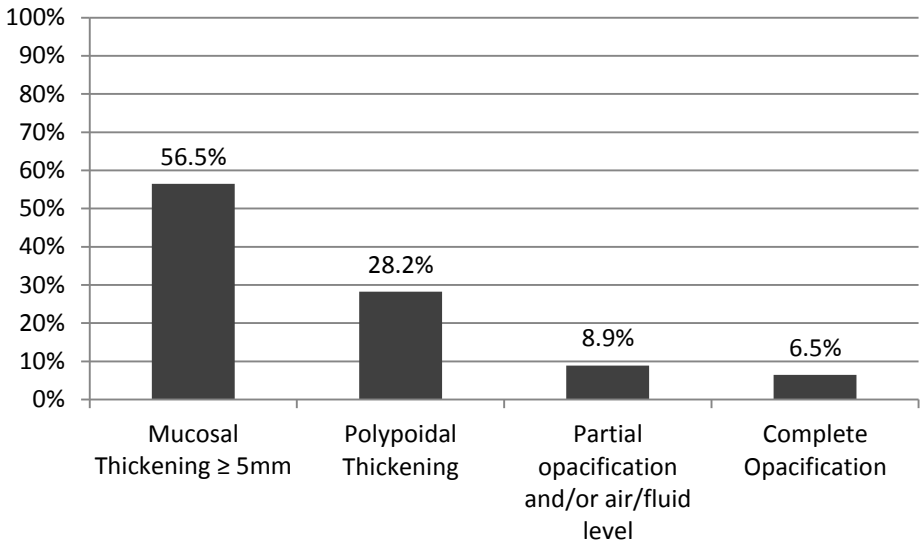

Figure 10. Percentage of each category of pathology of all cases exhibiting pathology.

When categorizing the results in terms of age, the prevalence of sinus pathology were 38%, 48% and 48% for the groups <30, 30-59 and $\geq$ 60 respectively. There was no statistically significant difference between any of the age categories in terms of the incidence of sinus pathology (Figure 11).

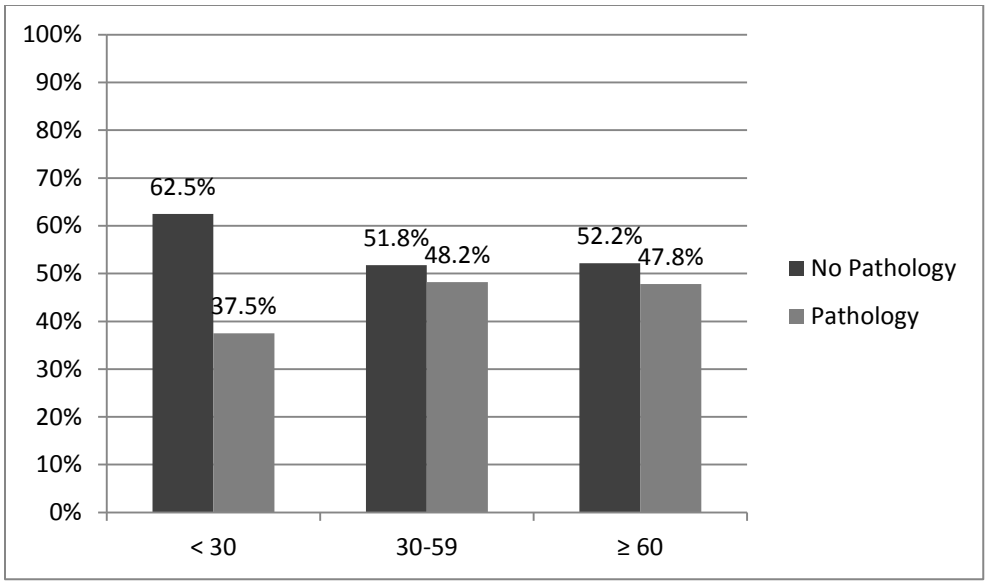

Figure 11. Prevalence of sinus pathology and health by age group

CHAPTER 4

DISCUSSION

The overall prevalence of 45.1% of cases showing some evidence of sinus pathology is consistent with other reports in the literature. However, in order to put this number into perspective and how it differs from other studies, it is important to have an understanding of the history of imaging of the paranasal sinuses in both the medical and dental literature.

A study by Havas in 1988 investigated the prevalence of radiographic abnormalities of the paranasal sinuses in 666 asymptomatic patients. They found radiographic abnormalities in of 42% of scans, with 28.4% and 24.8% respectively within the ethmoid and maxillary sinuses. The authors also mentioned in their discussion that mucosal thickening was the most common finding but that there may be a range of mucosal thickening that can be considered normal and not evidence of pathology.[17]

Moser in 1991 examined the use of MRI imaging to determine the prevalence of paranasal sinus pathology in patients who did not present with symptoms indicative of sinus pathology. The categories of pathology included mucoperiosteal thickening, retention cysts or polyps, air-fluid levels and complete opacification. Of the 263 images studied, 24.7% demonstrated abnormalities in the paranasal sinuses. The authors mentioned in their discussion that it was important to differentiate between 'normal changes' such as asymptomatic retention cysts or slightly thickened sinus mucosa from true pathology. They stated that the 24.7% prevalence demonstrated changes that would be interpreted as abnormalities in symptomatic patients.[18]

A study by Rak in 1991 investigated mucosal thickening in the paranasal sinuses as a finding in patients undergoing MRI imaging. They concluded that mucosal thickening ≤ 3mm lacked clinical significance, and that mucosal thickening of 1-2mm in the ethmoidal sinus was found in 63% of patients who were asymptomatic.[19] Taken together, the studies by Moser Havas and Rak provided a foundation for future study of paranasal sinus pathology. Namely, that a large segment of the population may exhibit pathologic changes of the paranasal sinuses, and that an even larger number of patients exhibit findings of the paranasal sinuses that are not considered pathologic or significant.

` A study by Tarp in 2000 investigated the prevalence of sinus pathology based on evaluation with MRI in patients presenting for intracranial neurological pathology. According to their study, 31.7% of patients exhibited pathology according to MRI imaging. It is important to note that similar to this study, mucosal thickening ≤ 5mm was not considered pathology and was scored as normal. They found no correlation between positive findings of sinus pathology and either age or gender.[20]

Studies published in the dental literature have also investigated the prevalence of paranasal sinus pathology, but obviously they have focused mostly on the maxillary sinus. A study by Beaumont in 2005 studied 45 consecutively treated patients scheduled to undergo maxillary sinus augmentation and who were referred to an otolaryngologist for consultation. After evaluation, 18 were diagnosed with sinus diseases and/or abnormalities for a prevalence of 40%. The categories of disease and/or abnormalities included chronic sinusitis, sinus cysts, nasal septum deviation and ostium stenosis.[21] A study by Cha in 2007 examined 500 CBCT scans and found that 18.2% of incidental findings related to the "airway". The findings of the airway category included sinusitis,

sinus polyps, retention cysts, obstructed sinus, septum deviation, and thickened mucosa (> 3mm). Interestingly, 22% of patients categorized as having 'airway findings' had related symptoms or medical histories.[22]

A study by Pazera in 2011 examined the prevalence of incidental findings in the maxillary sinus of patients presenting to an orthodontic practice. They evaluated 134 CBCT scans and the mean age of the patients was 17.5 years old. The six categories of incidental findings included: acute inflammatory and/or allergic disease, chronic inflammatory and/or allergic disease, malformation and bone dysplasia, primary and secondary neoplastic disease, metabolic disease and other. Their study found a 46.8% prevalence of incidental maxillary sinus findings, and all were suspected mucosal pathologies. They categorized the mucosal pathologies into 3 different categories: flat mucosal thickening (> 1mm) (23.7%), polypoid mucosal thickening (19.4%), and signs of acute sinusitis (3.6%). No differences were found based on patient's gender.[23]

A study by Ritter in 2011 examined 1129 consecutively taken CBCT scans. They categorized maxillary sinus pathologic findings into mucosal thickening, partial opacification with liquid accumulation, total opacification and polypoidal mucosal thickening. They found a total prevalence of pathologies in the maxillary sinus of 56.3%. They found that patients > 60 years of age had more pathology compared to younger age groups, and males had more pathologies compared to females. What was not specifically mentioned was if any cut-off point for pathologic mucosal thickening was selected. As seen in other previous studies, there appears to be a level of mucosal thickening which is interpreted as non-pathological. Therefore, this may explain why this particularly study has such a high prevalence of sinus pathologies compared to others.[24]

After considering all of the aforementioned studies, it can be said that there is no consensus as to the exact prevalence of maxillary sinus pathology as measured by advanced imaging modalities. Different studies will utilize a different level for what is considered pathologic mucosal thickening, and as this appears to be the most common finding, the prevalence of sinus pathology in each study ranges significantly. Therefore, it may not be relevant for the clinician who is evaluating a CT scan for the purposes of maxillary sinus augmentation to memorize a certain number for the prevalence of sinus pathology, as depending on the study population and the definition of pathology, the number can vary a great deal. Instead, a more pragmatic approach may be to consider what percentage of cases will require further specialized consult prior to undertaking maxillary sinus augmentation and rehabilitation with dental implants. Patients in this study who were categorized as having findings indicative of sinus pathology would benefit from referral to an appropriate specialist (otolaryngologist) for each of the categories of pathology.

Significant mucosal thickening (defined in this study as > 5mm) can predispose the patient to the development of infections of highly resistant bacteria or fungi post-operatively after sinus grafting procedures. Therefore appropriate co-management of the patient can occur when these patients are recognized before any complication arises. For example, pre-operative pharmacologic protocols may need to be changed or the otolaryngologist may elect to treat the sinus surgically. As well, if a potential post-operative infection were to arise in this patient, the otolaryngologist would already be familiar with the case. Polypoidal mucosal thickening related to polyps or pseudocysts can contraindicate sinus augmentation as performing these procedures in these patients

may compromise the patency of the osteomeatal complex. Patients exhibiting partial opacification and or air/fluid levels are contraindicated for sinus grafting procedures until the symptoms have resolved. However, even once the symptoms have resolved these patients are more prone to the development of postoperative sinusitis. Consultation with an otolaryngologist as to the appropriate management of these patients (including changes to the pharmacologic protocol) can benefit the patient a great deal. The most obvious case of patients who require a referral for specialized management are the patients presenting with complete opacification of the maxillary sinus, as it is unlikely the implant surgeon will solely be the one to deal with this complication.[2]

CHAPTER 5

CONCLUSION

Overall, 45% of patients referred to the MIII for implant rehabilitation involving maxillary sinus augmentation had evidence of pathology in the maxillary sinus. There was a statistically significant relationship observed between gender and prevalence of pathology, with males being were more likely to present with pathology than females. However, no difference was observed between any age group and the prevalence of sinus pathology. Based on these findings, it is recommended that 45% of patients would benefit from consultation with an otolaryngologist prior to undergoing sinus augmentation procedures.

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