PREVALENCE OF ODONTOGENIC RELATED MAXILLARY SINUS PATHOLOGY IN PATIENTS OF TEMPLE UNIVERSITY KORNBERG SCHOOL OF DENTISTRY

A Dissertation
Submitted to
the Temple University Graduate Board

In Partial Fulfillment
of the Requirements for the Degree
MASTER OF SCIENCE

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May, 2016

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ABSTRACT

Objectives: Cone beam computerized tomography use is becoming more common in preparation for surgical planning and treatment diagnosis by clinicians. The scanning result gives clinicians a more accurate understanding of each patients' anatomy, which aids in designing better treatment plan, avoidance of vital anatomy, etc. Modern treatments involving extraction of teeth has become more sophisticated due to advent of dental implant treatment. Along with the procedure, more sophisticated treatment techniques involving manipulation of sinus has flourished. Traditional periapical and panoramic radiograph are not as adapt at identifying sinus pathologies. As patients age, proximity of sinus floor and apex of teeth may become closely related where possibility of one affecting another is observed. This study aims to study the prevalence of odontogenic related pathologies in relation to maxillary sinus in the population who had CBCT images taken at Temple University Kornberg School of Dentistry. The study also looks in detail the relationship of such pathology in relation to teeth status, age, gender, and ethnicity.

Methods: 821 CBCT scans completed at Temple University Kornberg School of Dentistry Department of Oral Maxillofacial Radiology from January 1st, 2009 to July 31, 2013 were evaluated with iCAT computer imaging software. Patients under 18, no posterior dentition, or complete edentulous were excluded from the study. A total of four hundred fourty four (444) CBCT scans were included in the study. Patients with odontogenic related maxillary sinus pathology were selected and teeth status, age, gender and ethnicity recorded. Individual scans had sinus pathology identified and examined for

proximity and relationship to respective tooth/teeth. Each individual tooth's status were also recorded. Chi-square test was conducted to verify validity

Results: After reviewing 680 scans, only 444 were included in the study due to exclusions. Scans were subdivided by age (18-35: 77, 36-53: 113, 54-71: 188, 72> : 46), gender (280 male and 164 female), ethnicity (African American 86, Asian 45, Caucasian 291, Hispanic 22), tooth status (caries, 26, crown 87, healthy 31, impacted 11, root canal 88, restoration 58), tooth position (3^{rd} molar 9, 2^{nd} molar 86, 1^{st} molar 138, 2^{nd} premolar 20, 1^{st} premolar 6, canine 3). Overall 63.06% of scans were classified as healthy, and 36.04% were classified as presenting odontogenic related maxillary sinus pathology.

None of the parameters showed significant predilection to odontogenic related pathology, however, 1^{st} molar has the highest risk of exhibiting pathology in the maxillary sinus with 2^{nd} molar second. The pathology incidence rates are slightly higher in male patients 41% vs 34%. Age is not a significant factor as all age groups demonstrates similar incidence rate except 72> group. Dentition status showed root canal and crown being the most commonly associated with pathology at 29% each. In Caucasian population, crown and root canal was most commonly related. African American was restoration and healthy teeth. Asian population had the most link with large restorations.

Conclusions: Maxillary 1st and 2^{nd} molar are the most commonly involved tooth with maxillary sinus pathologies. Caucasian population had the most odontogenic related pathologies. In general, crown and root canal are associated with a significant number of pathologies found in the sinus and should be evaluated prior to any surgical evaluation prior to any sinus manipulative surgery or odontogenic treatment.

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CHAPTER 1

INTRODUCTION

Cone Beam Computerized tomography (CBCT) was first developed by Arai, et al. in Japan and Mozzo, et al. in Italy (de Vos, 2009). CBCT offered significant advantages over traditional x-ray imaging in that it offered a true three dimensional model for assessment of patient's anatomy with relative representation of densities. With the advent of CBCT, surgeons are able to evaluate cases without performing surgeries and problem shooting on the fly. Clinicians are able to treatment plan and better communicate with patients about the projected needs of treatment. Common uses include but not limited to dental implants, orthodontic growth evaluation, maxillofacial trauma, and other related needs. With modern technology improvements, CBCT has become more accessible and more advantageous to utilize. With increase in routine CBCT use, incidental findings that were previously unable to be visualized on two dimensional radiographs are now discovered. (Lofthag-Hansen et al 2007)

CBCT produces a three dimensional model based on Hounsfield scale derived from medical CT. A linear scale from -1000 (air) (Hounsfield 1973) to 0 (water), then anything denser than water is given a positive value. Osseous structure ranges from +700 cancellous bone to +3000 cortical bone. Soft tissue can range from +100 - +300 (De Vos 2008). With such mechanism, the dental anatomy can be visualized by the contrasting gray scales indicating each important structure. (Mah, P. 2010)

De Vos in 2009 published a systematic review of CBCT imaging used in oral and maxillofacial region. 86 studies were identified with 41% for maxillofacial surgery, 16% for orthodontics, 13% for dental implants, 5% for endodontics, 3% for periodontics, 1% for general dentistry, 1% forensic dentistry, and 1% for otolaryngology.

Dento-alveolar	25	29% (Table 5)
Maxillofacial surgery	35	41% (Table 5)
Orthodontics	14	16% (Table 5)
Implantology	11	13% (Table 5)
Endodontics[21,87,121,153]	4	5%
Periodontics[68,69,117]	3	3%
General dentistry[177]	1	1%
Forensic dentistry[179]	1	1%
Otolaryngology[22]	1	1%
Total	**86**	**110%**

Table 1: CBCT imaging of oral and maxillofacial region: a systematic review of literature (De Vos 2009)

Dental CBCT has significantly and drastically changed the dental field and has greatly benefitted clinicians and patients (Scarfe 2006). CBCT in orthodontics can identify dental structure abnormalities, teeth position, dental alveolar relationships, skeletal discrepancies, craniofacial problems, treatment planning etc according to the American Academy of Oral and Maxillofacial Radiology 2013's position paper. Further, it can be used to identify teeth integrity, anatomical structural relationships, surgical planning, etc (Miracle 2009). Limited view CBCT scan can also benefit endodontics by increasing resolution to assist in identifying teeth morphology, accessory canals, relationship of tooth apex to vital structure, presence of lesion, etc (Patel 2007).

The American Academy of Oral Maxillofacial Radiology published a position paper on CBCT diagnostics for dental implants which pointed out the posterior maxillae often pneumatizes in an inferior direction post tooth loss. Subsequent bone remodeling can cause a lack of osseous structure for future implant treatment. Often post acquiring of CBCT image, radiologists will review CBCT scans for areas of interest and other anatomical abnormalities. Sinus pathology is often discovered while examining CBCT images (White 2008).

The maxillary sinus is first developed in the second to third month from conception. The growth of sinus space increases with eruption of permanent teeth (Testori 2009). Subsequent expansion often initiates post tooth loss in the posterior segments. The sinus membrane is lined by the Schneiderian membrane which is composed of pseudo-stratified columnar ciliated epithelium. Normal thickness of membrane is between 0.13mm to 0.5mm (Lim 2003). In presence of pathologies, CBCT imaging can assist in discovering pathologies when often they do not have any symptoms. Often, patient can exhibit minimal mucosal thickening as part of a normal variant, or physiological sinus cycle, ENT consultation is advised when membrane thickening of more than 3-4mm are noted (Testori 2009).

4 major categories of possible pathologies have been identified: inflammation, cyst, neoplasms, and antroliths and foreign bodies. Inflammatory changes are the most ubiquitous (Beaumont, 2005). It is further subdivided into acute, chronic rhinosinusitis or allergic sinusitis. Etiologies are thought to be from either odontogenic or non-odontogenic stimulus. The proximity of Schneiderian membrane can be irritated by

periapical damages, periapical pathologies, periodontitis, dental trauma, or iatrogenic causes. Management often consists of both sinus and related tooth (Mehra 2004).

Non-odontogenic causes can be from viral, bacterial, fungal, and allergy sources. Rhinosinusitis was classified based on duration of symptoms such as acute (less than 4 weeks), subacute (4-12 weeks), or chronic (greater than 12 weeks) (Chan 2009). Acute form is typical of viral or bacterial infection of upper respiratory tract. Chronic sinusitis consist of mainly anaerobic bacteria. Fungal infection is rarely found but cases of eosinophilic fungal rhinosinusitis were reported. Allergic sinusitis is a form of allergy induced inflammatory change of sinus membrane. Polyp formation may be noted and it is usually multiple, smooth, rounded and radiopaque on the walls of maxillary sinus. Commonly located high up near the ostium and are easily noted. Fungal sinusitis is more rare, often caused by aspergillosis, mucormycosis, or histoplasmosis. It may appear as a mild thicknening to complete opacification depending on severity.

Cystic lesion are further divided into pseudocysts, retention cyst, primary maxillary sinus mucocele, and post-operative maxillary cyst. Most commonly being pseudocysts (Gardner 1984). They are depicted radiographically as smooth homogenous, dome-shaped, round to ovoid and well defined radiopacities. Retention cysts differ in presence of epithelial lining and are very small. Mucocele often involve entire sinus and are opacified. It may cause destruction of mucosal lining. Maxillary cyst are well defined, radiolucent, and usually spherical.

Malignant tumors of the sinus are usually squamous cell carcinomas or adenocarcinomas. Radiographic appearance includes radiopaque masses, complete

opacification, or bony wall destruction. Antroliths and foreign objects usually comprise of retained roots.

A typical presentation of maxillary sinus under CBCT can be seen from axial, coronal, or sagittal view. However, the Schneiderian membrane being surrounded by cortical bone is usually not visualized on the CBCT. Only when there is evidence of pathology will a thicker than normal or exotic shape be pronounced enough for CBCT resolution to pick up the anomaly. While the majority of sinus pathologies are benign, early diagnosis of neoplasms are essential and can often determine the prognosis of treatment. (Manji 2013)

It is noted that sinusitis has been reported as patient's chief complaint when visiting a dentist's office. Periapical x-rays and panoramic xrays sometimes are unable to assist in visualizing sinus pathologies, especially when it is mucosal thickening. CBCT is required to determine involvement with sinus. With success of dental implant treatment in dentistry, it has rapidly come a preferred treatment to missing teeth. Along with it, many adjunctive treatment such as guided bone regeneration, sinus augmentation (vertical approach and lateral approach), etc can be affected by presence of sinus pathologies with tooth extractions (Seong 2013). Without careful evaluation and clear imaging to visualize treatment area, failure or infection may be the unwanted outcome.

This study focuses primarily on the odontogenic related maxillary sinus pathologies in patients of Temple University Kornberg School of. The study aims to evaluate the relationship of such pathology in relation to teeth status, age, gender, and ethnicity.

CHAPTER 2

MATERIALS AND METHODS

The study was conducted via retrospective evaluation of CBCT scans taken from January 1st, 2009 to July 31, 2013. The study received Temple University Office for Human Subjects Protections Institutional Review Board approval prior to initiating. Eight hundred and twenty-one (821) scans were screened initially. Patients that are 18 and younger, poor resolution CT scan, absence of sinus, no posterior dentition or complete edentulous were excluded from the data. A total of 444 scans were complied. Subjects had gender, age, ethnicity, dentition relating to sinus, and presence of sinus pathology were included in the study. All CT scans were taken with i-CAT machine (Imaging Science International, Inc. Hatfield, PA, USA) with flat panel image detector. Images were acquired with the following setting: 120 kvp, 5 mA, and a voxel size of 0.3 mm, with an exposure time of 8.9 seconds. Fourteen (14) bits gray scales and 8.9 seconds scan time. 327 total slices for one CBCT volume is noted.

CBCT scans were reviewed using i-CAT software. All images had panoramic view module examined with axial slices for posterior segments to review proximity of dentition and communication with sinus pathology. All scans were reviewed with 2 other temple residents to verify presence of pathology and relation to odontogenic sources.

The mean age of population group 18-90 was 53.44 yrs old. Gender spread was 280 male and 164 female. Ethnicity included 86 African Americans, 45 Asian, 291 Caucasian, and 22 Hispanic. Of the teeth involved with pathologies, they are divided into

categories of healthy, caries, crown, root canal, impacted, and restoration. In regards to tooth positions teeth found to be related to pathologies were categorized into, 3rd molar, 2nd molar, 1st molar, 2nd premolar, 1st premolar, and canine.

Data were recorded and statistical analysis completed with Microsoft Excel spreadsheet. Association patterns of covariate were checked with chi-square test. The validity of logistic regression model were evaluated with lack of fit test and likelihood test. 95% confidence intervals of pathology incidence rates were calculated with normal approximation under binomial distribution assumption.

Patient ID	Age	Sex	Ethnicity	Right Pathology	Left Pathology	Maxillary Dentition	Affected Teeth	Tooth #
26327	69	M	C	1	1	CD		
63852	50	F	AA	1B	3B	PE		
124947	47	F	C	1B/2	1B	PE		
134904	48	F	AA	1	1	CD	restoration	14
143455	48	F	C	1B	1B	CD	restoration	2
149792	62	F	C	1B	1B	PE		
154712	51	F	C	2	2	PE		
155540	47	M	C	1B	3B	CD		
155631	63	M	C	2	3B	PE		
156828	66	F	C	1	1	PE		
157410	51	F	C	1	1	PE		
157534	54	M	C	1B	1B	PE	crown	3
157610	46	F	Asian	1B	1B	PE		
160762	35	F	C	2	2	PE	PAR, endo	14
163260	21	M	H	1	1	CD		
163765	66	F	C	1	1B	PI		
164176	66	F	C	1/3A?	1	PE		
165974	72	F	C	1	1	CD		
3162012	23	F	AA	1B	1B	CD		
0000016	76	M	AA	2	2	PE		
00132973	35	M	Asian	2	1	CD		
00133368	57	M	C	1	1	PE		
0059960	66	M	C	3A	2	CD	parl - endo	3
0070917	64	M	C	3B	3C	PE		
0077056	18	M	C		1B	CD	impacted molar	1, 16
0079368	60	F	AA	1	3A	CD		
0081396	77	M	AA	5	2	PE		
0084473	73	F	AA	1B	1B	PE		
0084837	59	M	C	1	1	PE		
0091313	32	F	AA	1	1	PE		
0091623	64	F	C	1B	1B	PE		

Table 2: Examples of data collection

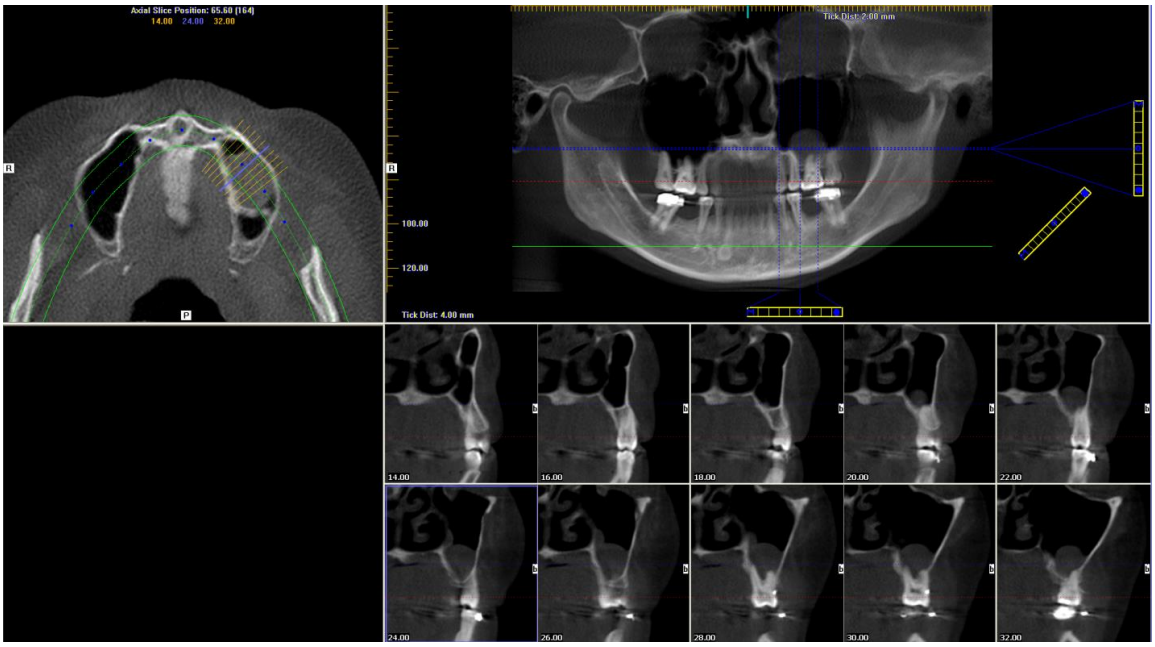

Figure 1: iCAT computer imaging screenshot. Axial (upper left), Panoramic (upper right), sectional view (bottom) demonstrating sinus polyp connecting with apex of tooth #13,14,15 with previous restorations.

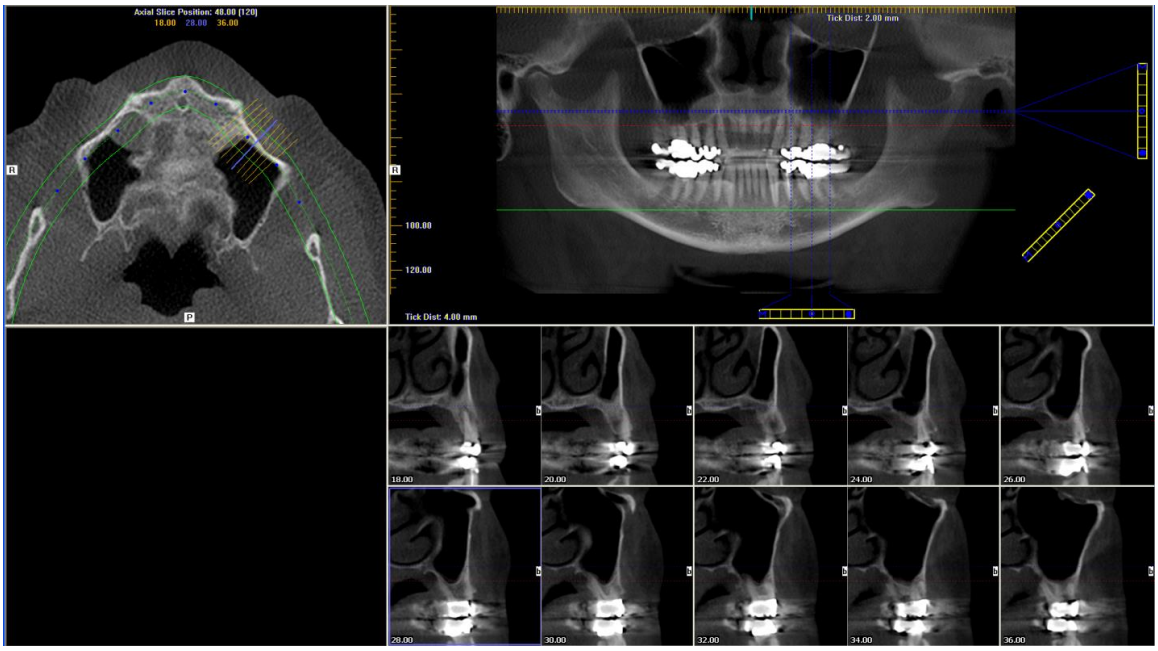

Figure 2: iCAT computer imaging screenshot. Axial (upper left), Panoramic (upper right), sectional view (bottom) demonstrating mucosal thickening in proximity with apex of teeth #14,15 previous treated with dental crown.

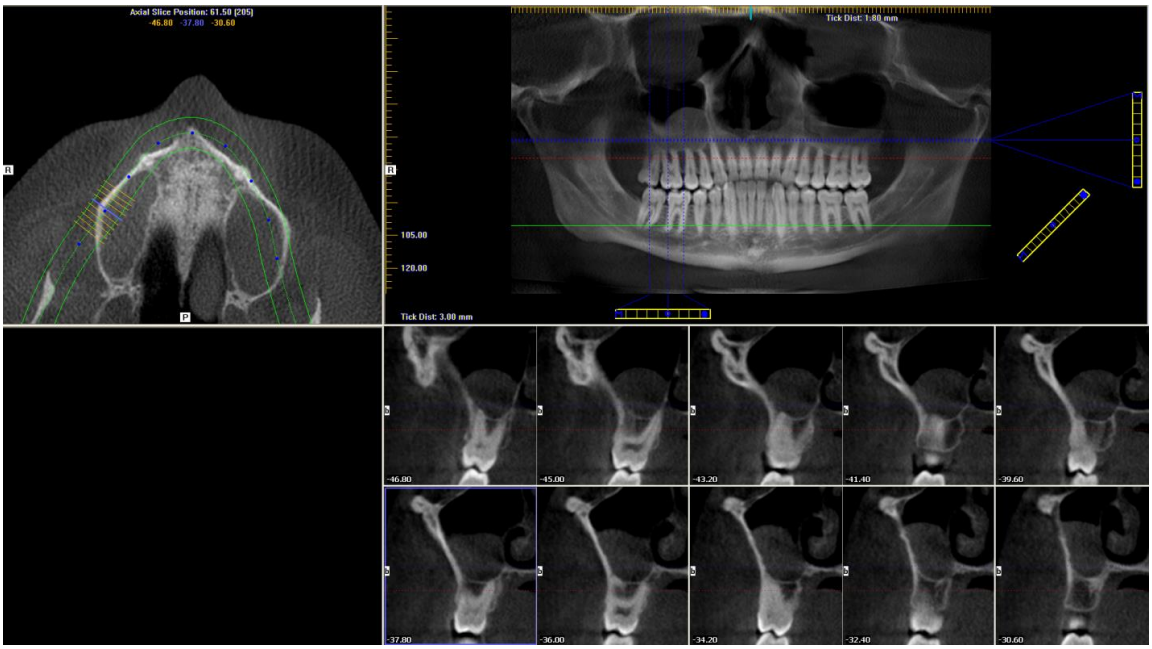

Figure 3: iCAT computer imaging screenshot. Axial (upper left), Panoramic (upper right), sectional view (bottom) demonstrating sinus opacification connecting with apex of healthy teeth #1, 2, 3.

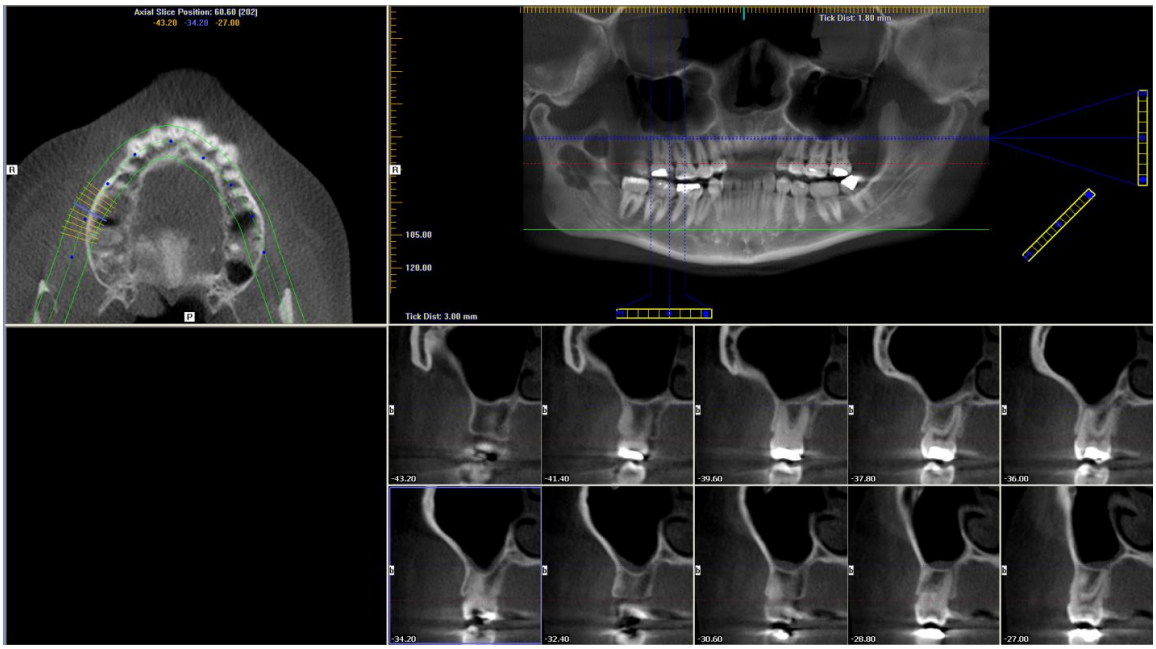

Figure 4: iCAT computer imaging screenshot. Axial (upper left), Panoramic (upper right), sectional view (bottom) demonstrating mucosal thickening connecting with apex of tooth #2, 3 with previous restorations.

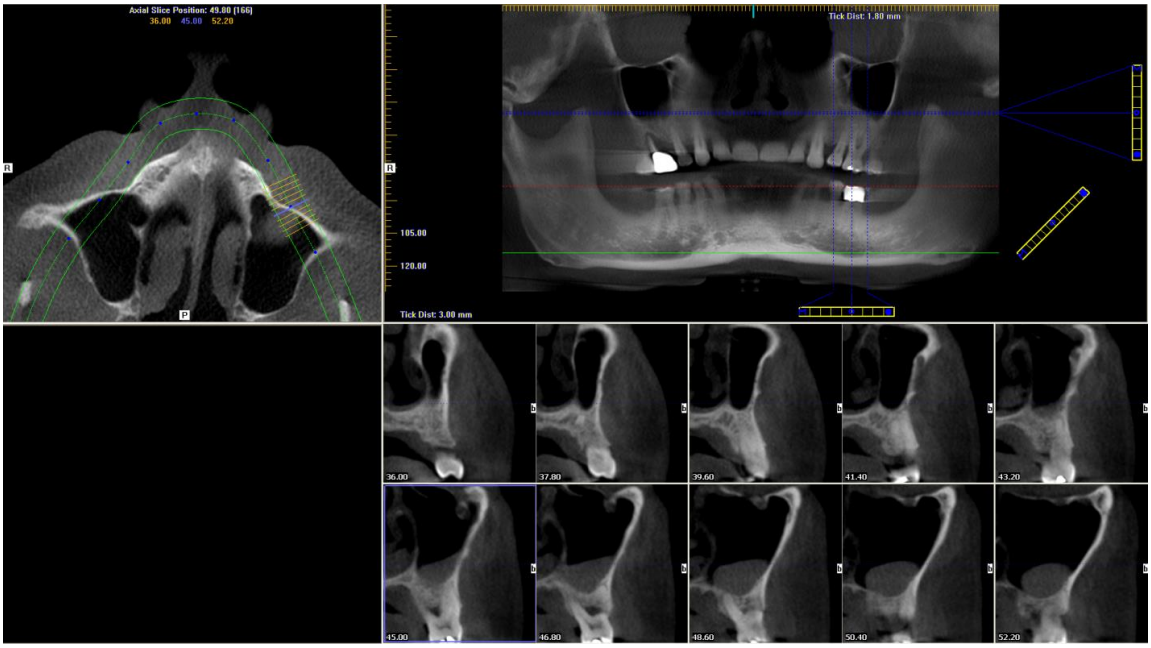

Figure 5: iCAT computer imaging screenshot. Axial (upper left), Panoramic (upper right), sectional view (bottom) demonstrating pseudocysts connecting with apex of tooth #13,14,15.

CHAPTER 3

RESULTS

Of the 444 studies evaluated, 280 patients are healthy and 164 had some form of odontogenic related sinus pathology which equates to 36.93% of sinus had odontogenic related pathology. The figure below illustrates based on total of 444 patients, how many patients had pathologies and which type affected the most. For patients who had multiple causes, only the most common tooth condition was recorded.

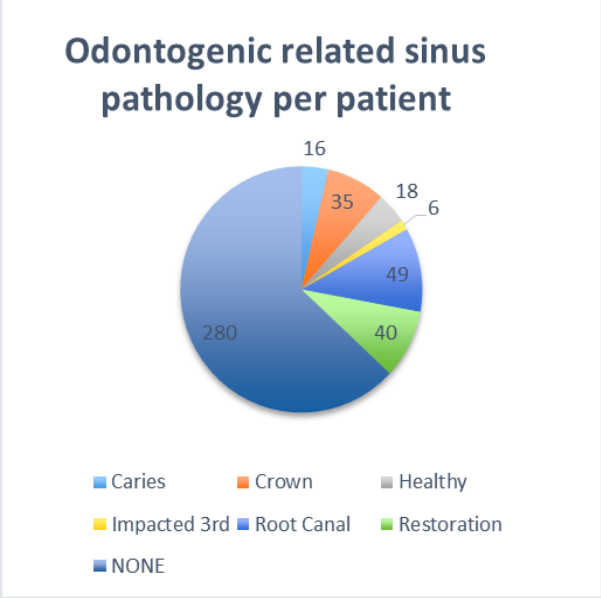

Figure 6: Odontogenic related sinus pathology per patient number in study population

patient	# of patients
Caries	16
Crown	35
Healthy	18
Impacted 3rd	6
Root Canal	49
Restoration	40
NONE	280
Total:	444

Table3: Odontogenic related sinus pathology per patient number in study population

A closer tabulation looking at individual tooth # and its status in relationship to pathology reveals that crowns and root canals were most commonly involved with sinus pathology.

	Healthy	Caries	Restoration	Root Canal	Crown	impacted
# teeth	31	26	58	88	87	11
Percentage	10.299	8.637874	19.2691	29.23588	28.90365	3.654485

Table4: Individual tooth status in association with sinus pathology

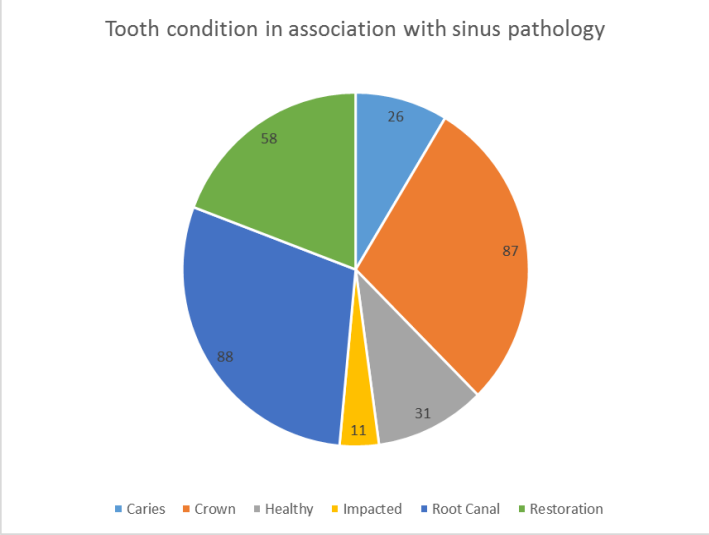

Figure7: Individual tooth status in association with sinus pathology

Of the teeth involved with sinuses, a total of 262 teeth were recorded. 1st molars had the most involvement at 138. 2nd molar at 86. Canine at 3, 1st premolar at 6, 2nd premolar at 20, and 3rd molar at 9. 1st molars are involved in more than half of the identified odontogenic related sinus pathologies.

Maxilla	3rd molar	2nd molar	1st molar	2nd premolar	1st premolar	Canine
Right	5	39	83	9	4	2
Left	4	47	55	11	2	1
Total	9 (3.4%)	86 (32.8%)	138 (52.6%)	20 (7.6%)	6 (2.3%)	3 (1.1%)

Table 5: Teeth number with number of affected sinus pathologies on right and left

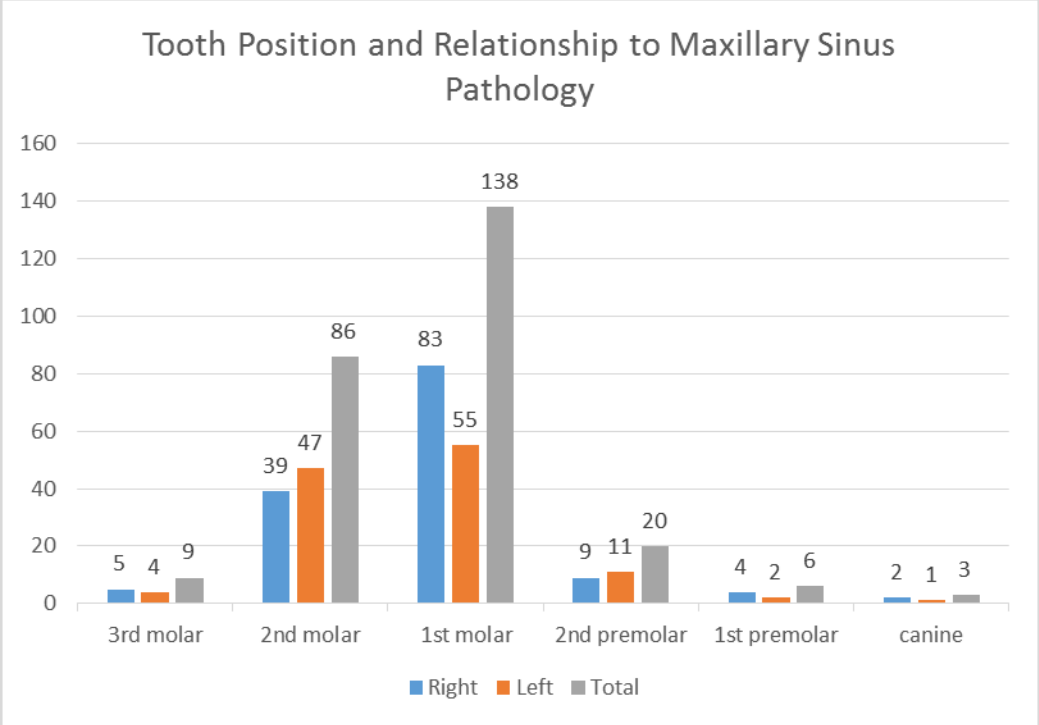

Figure 8: Tooth position and relationship to Maxillary Sinus Pathology

Of the teeth related to sinus pathology, a total of 301 teeth were recorded. Teeth involving two or treatment were recorded individually, eg. Tooth with both root canal and crown were tabulated twice. The majority of tooth treatment related to the sinus are root canal and crown treatment. Restorations occupied 19.2%. Nonrestored caries were less related than compared to healthy teeth.

	Healthy	Caries	Restoration	Root Canal	Crown	impacted
# teeth	31 (10.3%)	26 (8.6%)	58 (19.2%)	88 (29.2%)	87 (28.9%)	11 (3.6%)

Table 6: Tooth status in association with sinus pathology

When comparing sex predilection, 80 of 196 males had odontogenic related sinus pathology while the female population has 84 out of 248. 33.9% of female has odontogenic related pathology and males are slightly higher at 40.8% with pathology.

	Pathology	Healthy
Female	84	164
Male	80	116

Table7: Sex relation to odontogenic related sinus pathology

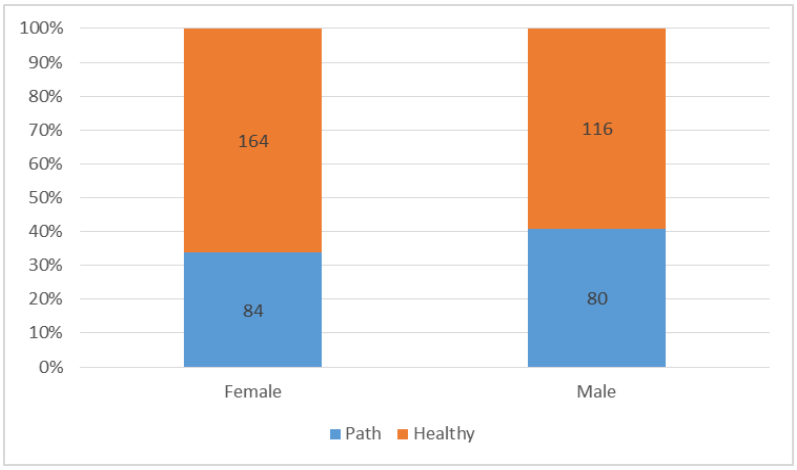

Figure 9: Sex relation to odontogenic related sinus pathology

A chi-square test was conducted for the sex predilection to see if there were any relationship. Following the chi-square test formula,

$$X^2 = \Sigma \frac{(\text{Observed frequency} - \text{Expected frequency})^2}{\text{Expected frequency}}$$

Figure 10: chi-square test example

Actual	Male	Female	grand total
Pathology	80	84	164
Healthy	116	164	280
total	196	248	444
Expected	Male	Female	grand total
Pathology	72.3964	91.6036	164
Healthy	123.6036	156.3964	280
total	196	248	444

Table 8: chi square test data for sex predilection

The Chi-Square test gave us a p value of 0.132 which is much larger than the 0.05 value we were hoping to attain. Therefore, the null hypothesis is accepted and the relationship may just be a result of chance alone.

In terms of race, the percentage of population with odontogenic related sinus pathology ranges from 18.2% for Hispanics, 27.9% for African American, 35.6% for Asian to 41.2% for Caucasian.

	African American	Asian	Caucasian	Hispanic
Pathology	24	16	120	4
Healthy	62	29	171	18

Table 9: Odontogenic related sinus pathology in relationship to race

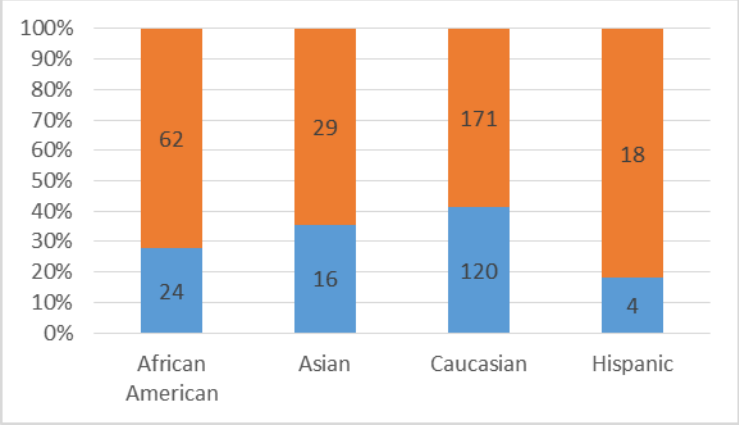

Figure 11: Odontogenic related sinus pathology in relationship to race

A similar chi square test was performed.

Actual	African American	Asian	Caucasian	Hispanic
Pathology	24	16	120	4
Healthy	62	29	171	18

Expected	African American	Asian	Caucasian	Hispanic	Sum of all
Pathology	31.76577	16.62162	107.4865	8.126126	164
Healthy	54.23423	28.37838	183.5135	13.87387	280
Sum of race	86	45	291	22	444

Table 10: Chi square data for race relationship to pathology

The p value was recorded ad 0.0338. We therefore rejected the hypothesis and conclude that race may have a possible link to observation of odontogenic pathology.

An attempt to break down in detail of the related tooth status with pathology by race showed different causal factors. In the African American population group, a total of

39 teeth were involved with sinus pathologies. Categorical break down showed 39 total teeth with a relatively even distribution of each type of tooth status.

AA	# of teeth
Caries	4
Crown	6
Healthy	8
Impacted	7
Root Canal	6
Restoration	8
Total	39

Table 11: African American tooth status in relationship to sinus pathology

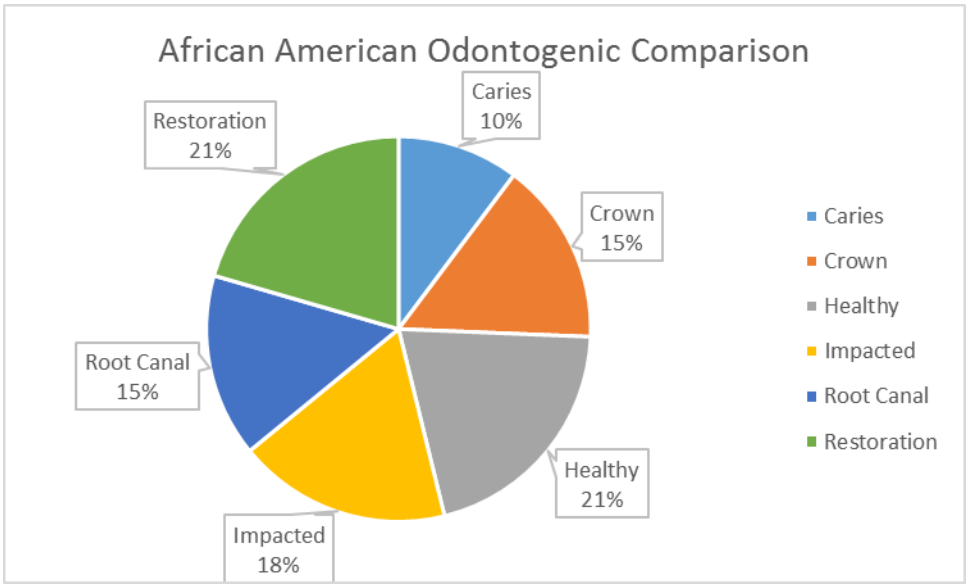

Figure 12: African American tooth status in relationship to sinus pathology

In the group of African Americans, healthy teeth and teeth with restorations has the highest percentage of relating to sinus pathology.

In the Asian population, a total of 25 teeth were recorded. In the documented teeth status involved with sinus pathology, restoration was 36% as most likely to relate to sinus pathology and crown treatment second.

Asian	# of teeth
Caries	2
Crown	6
Healthy	3
Impacted	1
Root Canal	4
Restoration	9
Total	25

Table 12: Asian American tooth status in relationship to sinus pathology

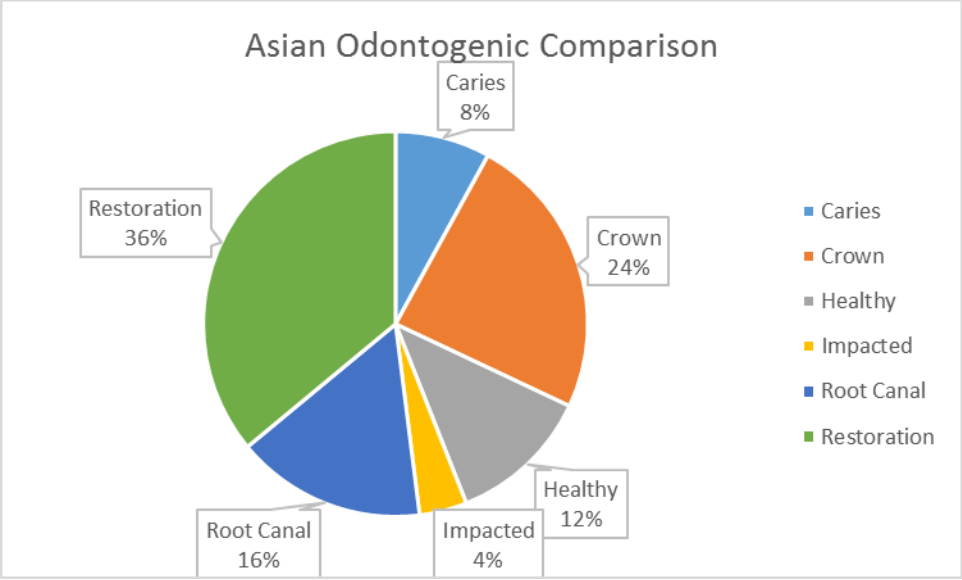

Figure 13: Asian American tooth status in relationship to sinus pathology

In Caucasian population, out of the 224 detected teeth, crown and root canal were of highest percentage relating to sinus pathology. 69 crowns and 69 root canal each occupying 31% of total teeth involved.

Caucasian	# of teeth
Caries	19
Crown	69
Healthy	22
Impacted	4
Root Canal	69
Restoration	41
Total	224

Table 13: Caucasian tooth status in relationship to sinus pathology

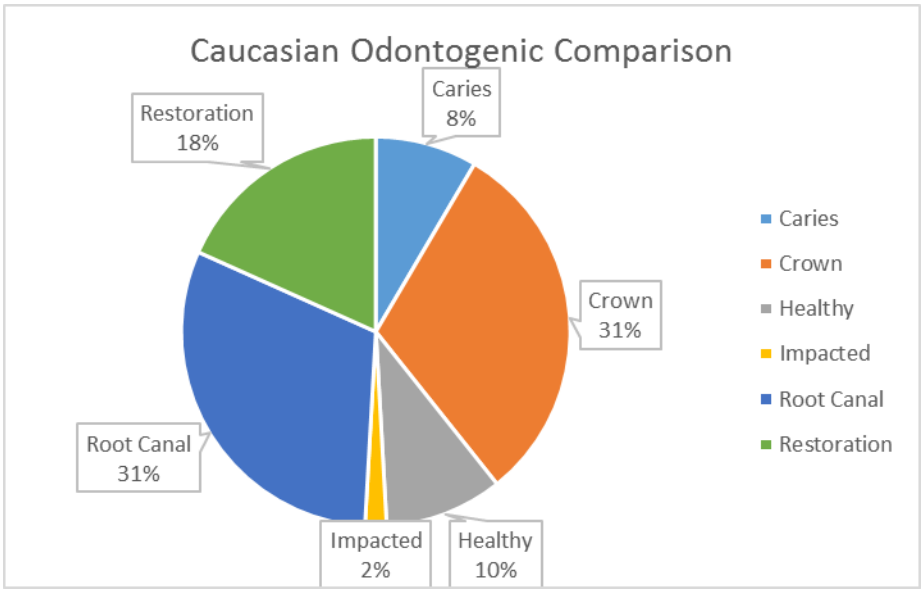

Figure 14: Caucasian tooth status in relationship to sinus pathology

In the Hispanic population, the teeth that were involved with sinus pathology calculated to only 4. 1 caries, 1 crown and 2 restoration were noted.

Hispanics	# of teeth
Caries	1
Crown	1
Healthy	0
Impacted	0
Root Canal	0
Restoration	2
Total	4

Table 14: Hispanic tooth status in relationship to sinus pathology

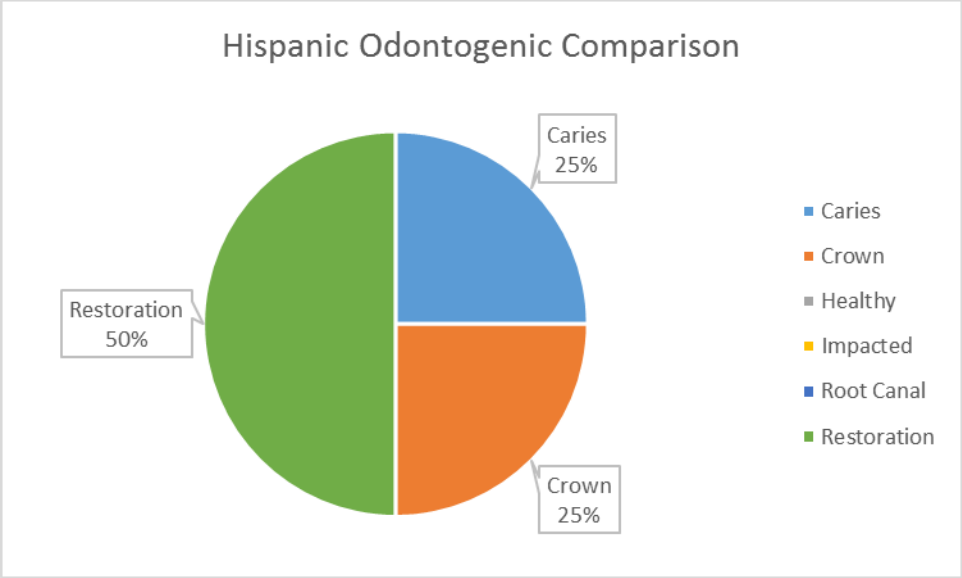

Figure 15: Hispanic tooth status in relationship to sinus pathology

Finally looking at age group relation, the age groups are categorized into 4 groups 17 years apart: 18-35, 36-53, 54-71, and 72+. With the 18-35 yr old group exhibiting 37.7% with pathology, 41.6% for 36-53 yr old, 39.9% for 54-71 yr old, and 28.3% for 72+.

	18-35 yr	36-53 yr	54-71 yr	72> yr
Pathology	29	47	75	13
Healthy	48	66	113	33

Table15: Odontogenic related sinus pathology in relationship to age group

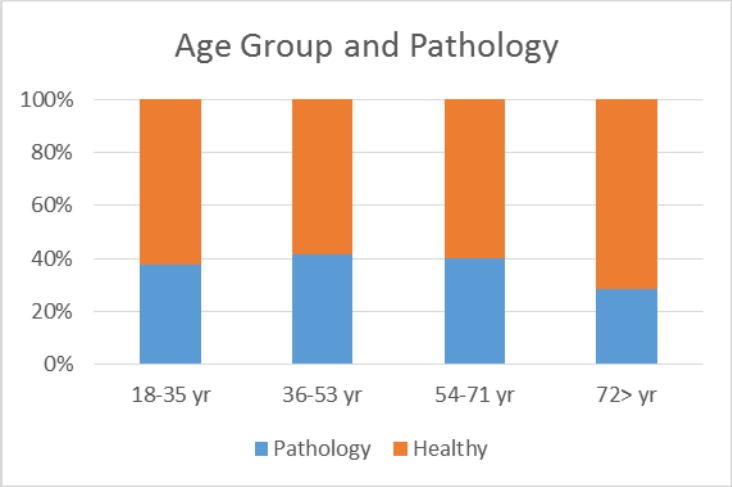

Figure16: Odontogenic related sinus pathology in relationship to age group

A chi-square test was also performed for the age group of 17 years apart.

Actual	18-35 yr	36-53 yr	54-71 yr	72> yr	
Pathology	29	47	75	13	164
Healthy	48	66	113	33	260
	77	113	188	46	424
Expected	18-35 yr	36-53 yr	54-71 yr	72> yr	
Pathology	29.78302	43.70755	72.71698	17.79245	164
Healthy	47.21698	69.29245	115.283	28.20755	260
	77	113	188	46	424

Table 16: chi square test data set for age group relationship

The p value received from the chi square test was 0.447. Which leads us to accept hypothesis and conclude that the result was most likely due to chance.

CHAPTER 4

DISCUSSION

This study is a follow up to previous studies involving Temple University Kornberg School of Dentistry's CBCT study conducted looking at types of sinus pathology found in the population at Temple University School of Dentistry Dental school. (Hsiao, 2014). In this study, we focused only on the presence of odontogenic communication with visible sinus pathologies in CBCT scans. Although it is possible to identify the type of pathology visible in each odontogenic related pathology, we chose to group all forms of non-damaging pathologies into one. Many forms of sinus pathologies are present, but the majority of the identifiable pathology in CBCT studies are non-life threatening. Referrals to ENT specialists often warrants no additional treatment. Therefore this study focuses on the relationship of odontogenic origin.

There were a total of 444 patients studied, patients who had odontogenic related pathologies were 37%. This data was taken irrespective of whether it was left or right maxillary sinus. As long as there was one identifiable pathology in sinus and in communication with tooth, the offending tooth number was recorded along with presence of pathology in whether left or right side. However, many patients had multiple status on the offending tooth. Tooth with both root canal and crown for 1st molar and restorations for second molar while both were involved with visible pathology were commonly observed. To study the distribution in detail, we counted each offending status of tooth as 1 and calculated all offending teeth in congruence to their status. If a tooth had both root

canal and crown, it will be counted twice. The total number of count was 301. In this total, teeth with crowns and root canals treatment occupied 29% for each. Roughly 60% of all odontogenic sinus pathologies had relationship to either a root canaled tooth or crown preparation. Restorations took 20% of the total with other categories such as impacted teeth 3.6%, caries 8.6%, and healthy teeth 10.2%. We thoroughly expected crown and root canal to have possible effects on sinus membrane due to the damaging nature of crown preparation. In dental literature we have reports of tooth undergoing crown preparation becoming inflamed, irritated, and/or loss of vitality leading to necrosis. (Yadav 2014). This hypersensitivity may be able to affect sinus due to close proximity. With root canal, there are many reported incidence of root canal files perforating sinus membrane thus leading to sinus infection. (Nimigean 2006) Also during root canal treatment, uses of sodium hypochlorite solution to irrigate canals are highly toxic and are a strong irritant to organic tissue (Yadav 2014). Regardless of what steps during root canal treatment actually caused the related pathology, we know for certain that there is a linked cause. While we are unable to fully visualize whether there were sinus damages from endodontic treatment, the sinus pathology often has no cortical lining between pathologies and apex of teeth. An interesting observation was noted in that we noticed an increased link of root canal treated tooth relating to sinus cyst/polyps. We did not see any cysts and polyps related to other forms of tooth treatment status (Wang, 2007). That is a topic reserved for a future study. In regards to the results of this section, we were surprised to note that there were pathologies related to healthy teeth. Teeth of virgin nature that has no radiographic visible alteration to the tooth. It is hard to discern what

lead to such pathology. One could suspect a possibility of posterior molars being the main teeth to support vertical bite stress, therefore the increased stress during occlusal function may have had some undesired effects on the epithelium of maxillary sinus due to proximity.

If we break down the type of teeth involved in sinus pathologies, a clear picture begins to appear. In a study done in 2011 using CBCT to determine odontogenic sinusitis, demonstrated in 135 instances of sinusitis, 98 cases were reported as possibly linked to odontogenic causes. In the 98 cases, 70 cases were conclusively determined to be of odontogenic source, and 28 was undetermined. Odontogenic causes for sinus pathologies can be high. They also concluded that maxillary first and second molars were 11 times more likely to be involved in maxillary sinus pathologies compared to premolars. (Maillet, 2011). This result is consistent with our findings that first molar were involved in 52.6% of the total pathologies, and second molars were involved in 32.8% of the cases. Although we did find 3 canines to be involved, but the chance is relatively low at just 1%. 1st and 2nd molars are the two largest tooth in the maxillary posterior dentition. They are in great contact with maxillary sinus. In a study by Scuderi in 1993 discussed the growth of maxillary sinuses and noted that after 9 years of age, maxillary sinus tends to grow inferiorly and posteriorly. As the human skull grows in size, it is growing in an anterior and inferior manner. While the maxillary sinus is growing inferiorly, the entire maxilla is growing anteriorly. Therefore, it is natural to expect a tandem lag behind growth of the anterior front. Therefore the premolars and canines would have less chance to be involved with maxillary sinus by the shear chance of the sinus not growing that far

anteriorly. It is also important to note that we did not find symmetrical pathologies and tooth related issues on left and right side. Though there were cases where patient had similar pathologies of both left and right side, it was few and not entirely congruent. There is observed asymmetry between size and shape of left and right maxillary sinus, and therefore it is possible to have one side of the sinus located in closer communication with the apex of dentition on respective sides. It is important to note that in the study by Lawson 2008, the sinus pathologies often limit the rate of sinus pneumatization. Sinus expansion occurs at a more rapid rate when healthy as compared to presence of pathology. Therefore, we may be able to deduce that sinus pathologies often occurs when there is little sinus floor between the inferior border of sinus and the apex of teeth, though this will require a long term prospective study to identify the validity of this claim.

Looking at the relationship of presence of pathology, we tried to look for a link between either sex predilection, race, and age group. Each had a chi square test done to improve validity of result. After tabulating the results, chi square test showed only a possible link with race. With Caucasian at 41% with pathology as highest group, Asian at 35.6%, African American at 27.9% and Hispanics at 18.2% as lowest. There are too many variations that is possible for the result of such data, therefore we will not attempt to make conclusion on this other than simply state that Caucasians were found to have highest incidence of odontogenic related pathologies. It should also be noted that Hispanics group had very few numbers compared to the other ethnic group. A larger more expansive study should be conducted to deduce the true relationship of race with incidence of pathologies. Sex and age group had no difference on the incidence of

pathology group. According to Rajendran 2014, they did not notice a clear predilection in relationship to age or sex with maxillary sinus cyst. In congruence to our study, the development of pathology probably was developed irrespective of age and sex of patient.

A detailed breakdown of tooth status effected with each individual ethnic group showed a different leading cause of pathology for different population. African American group had caries 10%, crown 15%, healthy 21%, impacted 18%, root canal 15%, and restoration 21%. Caucasian had caries 8%, crown 31%, healthy 10%, impacted 2%, root canal 31%, restoration 18%. Asian had caries 8%, crown 24%, healthy 12%, impacted 4%, root canal 16% and restoration 36%. Hispanics with only 4 teeth identified, had 2 with restoration, 1 with caries and 1 with crown. The result is interesting in that each ethnic group had different leading causes that was most associated with sinus pathology. African American had healthy and restoration as most common, while Caucasian had crown and root canal as most common. Asians are similar with crown and root canal occupying a large section but restoration was by far the largest offending factor. We are unable to explain this phenomenon other than to speculate whether the socioeconomic factor of the population group had a play in this result. The Caucasian population were more likely to receive treatment whereas the African American population were more likely to opt for the cheaper extraction treatment thus rendering a decrease of tooth that otherwise would have needed crowns and or root canal. The Asian population had a more even spread of results, but it is still hard to identify a sole cause of the dispersion of the categories.

CHAPTER 5

CONCLUSIONS

With the CBCT study, 36.9% of patients or a total of 164 patients referred or treated at Temple University Kornberg School of Dentistry had incidences of odontogenic related pathology. In these patients, the teeth related to identified sinus pathologies included caries (3.6%), crown (7.9%), impacted (1.4%), root canal (11.0%), restorations (9.0%), and healthy (4.1%). A detailed breakdown of individual teeth in association with sinus pathologies showed a different picture: caries 8.6%, crown 28.9%, impacted 3.7%, root canal 29.2%, restorations 19.3% and healthy 10.3%. Crowns and root canals were the most commonly associated tooth with maxillary sinus pathology.

Looking at sex predilections. 33.8% of male had odontogenic related pathologies and 40.8% of female had related pathologies. The statistical test of chi square showed that this result could very well be due to the selected population and is therefore insignificant. Similar to age group that was studied where patient groups were divided into 17 years group. 18-35, 36-53, 54-71, and 72+ groups. 18-35 group had 37.66%, 36-53 group had 41.6%, 54-71 had 39.9%, and 72+ had 28.3% of odontogenic related pathologies, but the numbers after chi square test showed it is also probably due to chance and is most likely not an important correlation.

Race however demonstrated a more interesting result. African American had 27.9%, Asian 35.6%, Caucasian 41.2%, and Hispanic 18.2% with pathology. The incidence showed Caucasian as most likely to exhibit odontogenic related pathologies

whereas Hispanics were the lowest group. It is determined to be a statistically significant relationship in regards to the pathology presence. However, the test population for Hispanics were relatively smaller compared to other ethnic group, it should be studied on a larger scale before making such claim. A different perspective showed the Caucasian group with most commonly crown and root canal treatment relating to sinus pathologies, while African American population were either with restoration or healthy. Asian population had the largest percentage with restorations as similar to Hispanic groups. There are many confounding factors that could be at play here so we will not attempt to identify the main cause.

It is important to note that the tooth position in relationship to maxillary sinus pathology was most prominent. 85.4% of all teeth involved with maxillary sinus pathologies were either 1st molar or 2nd molar with 1st molar dominating more than half of the offending teeth.

Further research and additional data is needed to evaluate the possible link of ethnicity with odontogenic related sinus pathologies. Based on these findings, patient with sinus proximity to first and second molars after PA x-ray evaluation should be monitored for possible sinus pathology that may interfere with sinus treatments.

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APPENDIX

IRB APPROVAL

TEMPLE UNIVERSITY
Research Administration

Research Integrity & Compliance
Student Faculty Center
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Institutional Review Board
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Certification of Approval for a Project Involving Human Subjects

Date: 03-Mar-2016

Protocol Number:	23455
PI:	SUZUKI, JON BYRON
Review Type:	EXPEDITED
Approved On:	03-Mar-2016
Approved From:	03-Mar-2016
Approved To:	02-Mar-2017
Committee:	A1
School/College:	DENTAL SCHOOL (0700)
Department:	DENTAL (07000)
Sponsor:	NO EXTERNAL SPONSOR
Project Title:	Prevalence of Odontogenic Related Maxillary sinus pathology in patient population of Temple University Kornberg School of Dentistry

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The IRB approved the protocol 23455.

If the study was approved under expedited or full board review, the approval period can be found above. Otherwise, the study was deemed exempt and does not have an IRB approval period.

If applicable to your study, you can access your IRB-approved, stamped consent document or consent script through eRA. **Open the Attachments tab and open the stamped documents by clicking the View icon next to each document**. The stamped documents are labeled as such.

Before an approval period ends, you must submit the Continuing Review form via the eRA module. Please note that though an item is submitted in eRA, it is not received in the IRB office until the principal investigator approves it. Consequently, please submit the Continuing Review form via the eRA module at least 60 days, and preferably 90 days, before the study's expiration date.

Note that all applicable Institutional approvals must also be secured before study implementation. These approvals include, but are not limited to, Medical Radiation Committee ("MRC"); Radiation Safety Committee ("RSC"); Institutional Biosafety Committee ("IBC"); and Temple University Survey Coordinating Committee ("TUSCC"). Please visit these Committees' websites for further information.

Finally, in conducting this research, you are obligated to submit modification requests for all changes to any study; reportable new information using the Reportable New Information form; and renewal and closure forms. For the complete list of investigator responsibilities, please see the Policies and Procedures, the Investigator Manual, and other requirements found on the Temple University IRB website: http://www.temple.edu/research/regaffairs/irb/index.html

Please contact the IRB at (215) 707-3390 if you have any questions