TINNITUS AND TEMPOROMANDIBULAR JOINT DISORDER SUBTYPES

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ABSTRACT

Tinnitus And Temporomandibular Joint Disorder Subtypes

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OBJECTIVE: The purpose of this study was to assess the prevalence of tinnitus within a TMD population and to determine an association between the presence of tinnitus and type of TMD diagnoses.

METHODS: A secondary data analysis was performed using data from 'Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) baseline (Validation project) study and follow up (Impact project) study. Self-reported questionnaires for reporting tinnitus and medical history and gold standard diagnoses after clinical examination were used. Log-binomial regression was used to compute risk ratios for tinnitus by TMD subtype and adjusted for patient characteristics. All statistical analysis was performed using SAS 9.3 software (SAS Institute), and a two-sided significance level of 0.05 to determined statistical significance ($p<0.05$).

RESULTS: At baseline, 614 subjects met required criteria for TMD diagnosis. Prevalence of tinnitus within sample was 41% (253 of 614). Approximately 80% of TMD subjects received a MPD diagnosis. Tinnitus frequency in the MPD group was 48% (238/495) while subjects without MPD diagnosis the rate of tinnitus was 13% (15 of 119). Using log-binomial regression analysis, the risk ratio for tinnitus was calculated. The relative risk for tinnitus by number of sites

painful to palpation by TMD diagnosis for MPD, DD and DJD groups was 1.03 (95% CI: 0.97, 1.10; p=0.28), 1.24 (95% CI: 1.05, 1.46; p = .0086) and 1.20 (95% CI: 1.01, 1.43; p = .033), respectively, when adjusted for age, gender, study site and somatization. Among the population, 207 subjects received a TMD diagnosis also reported headaches. The adjusted risk ratio for tinnitus among subjects with TMD diagnosis and headache was 4.52 (95% CI: 1.67, 12.19; p = .0002) higher than in subjects with only TMD diagnosis (RR=3.8) or only headaches (RR=1.4) Similarly, the adjusted risk ratio for tinnitus among subjects with an MPD diagnosis and headaches was 3.59 (95%CI: 1.82, 7.06) higher than in subjects with only MPD diagnosis (RR=3.02) and only headaches (RR= 1.75)

CONCLUSION: These findings suggest higher rate of tinnitus among subjects with MPD than other forms of TMD. Moreover, the risk for tinnitus is six times higher if subject has TMD diagnosis and headache and three times higher in myofascial group with headaches.

DEDICATIONS

I dedicate my thesis to my Mother and my Brother.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my advisors Dr. Edmond L. Truelove, Dr. Lloyd A.Mancl and Dr. Peggy Lee for giving me the opportunity to be a part of their team and this project and for their encouragement to learn and to provide meaningful results. Their knowledge and suggestions were fundamental throughout this work.

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CHAPTER 1

INTRODUCTION

1.1 RESEARCH OBJECTIVES

The main objective of this study is to assess the prevalence of tinnitus in patients with temporomandibular jaw disorder and to analyze if prevalence of tinnitus varies among temporomandibular jaw disorder subtypes. The study also focuses on identifying potential risk factors among this population that contribute to tinnitus. After extensive literature review, the study aims to provide an insight to one of the various theories discussed in relation to tinnitus in temporomandibular joint disorders. This study hypothesizes that subjects with myofascial pain type TMD diagnosis are more likely to report tinnitus than Disk displacement type TMD or DJD/arthralgia type TMD. Clinically, this study examines the potential value of screening for TMD and MPD in patients with tinnitus of unknown etiology.

1.2 PROBLEM DESCRIPTION

Although there is vast literature available related to the clinical problem of tinnitus, little is known about the relationship of this condition in patients who suffer from both tinnitus and Temporomandibular disorders. Moreover, in the past, research exploring the relationship between TMD and tinnitus has focused on TMD as whole and rarely TMD subtypes. Of the several theories proposed about the relationship of tinnitus and TMD, most of them are confined to association between the tinnitus and TMD as whole but not the subtypes. Our study aims to provide a better understanding of the association between tinnitus and TMD, its subtypes and other patient reported factors.

1.3 STRUCTURE OF THESIS

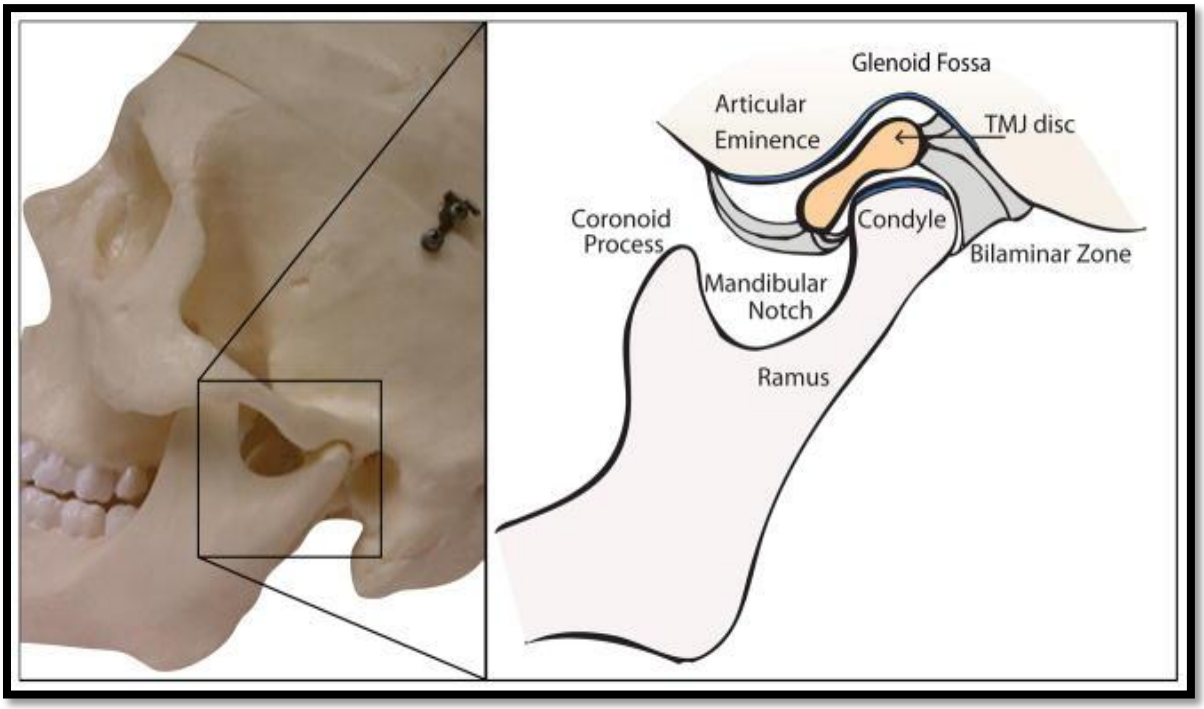
Chapter one introduces the research idea and the problem concerning. Chapter two and three will elaborate on temporomandibular joint disorders and tinnitus. These chapters will discuss key points concerning TMD and Tinnitus causes, types, signs and symptoms and management protocols. Chapter four will discuss the co-occurrence of tinnitus and TMD and the literature available so far on the association between the two. Chapter five describes the methods and methodology used to gather date performs analysis. Chapter six presents the results of this study and finally Chapter seven will discuss the conclusions and recommendations from this study.

CHAPTER TWO

TEMPOROMANDIBULAR JOINT DISORDERS

In 1934, Dr.Costen, an otolaryngologist first reported on the temporomandibular joint (TMJ). Structurally, TMJ is a ginglymoarthrodial (ginglymus= hinge joint) synovial joint that allows both forward and backward movement of the jaw as well as gliding motion (Alomar et al., 2007). Each TMJ is formed by a mandibular condyle and its corresponding temporal cavity (glenoid fossa and articular eminence), as seen in Fig 2.a. The components of TMJ are a disk that is biconcave in shape, articular surfaces of the bony structures, a fibrous capsule, synovial fluid, synovial membrane, and corresponding ligaments (Murphy et al., 2013).

Figure 1 – Temporomandibular Joint Sagittal Schematic (Int J Oral Maxillofac Implants. 2013)



2.1 DEFINITION

In the past century, knowledge relating to disorders of the temporomandibular joint was limited to testimonials and clinical estimations rather than on scientific research studied. It was only in 1975, the American Academy of Craniomandibular Disorders was founded to recommend the need for a scientific approach to temporomandibular joint disorders (TMD) (McNeill et al., 1980). According to Schiffman et al., 2014, temporomandibular disorders (TMDs) is an umbrella term for clinical conditions affecting the muscles of mastication, the temporomandibular joint (TMJ), and the related structures. Also known as temporomandibular joint dysfunction (TMJD), TMD refers to a wide range of clinical pathologies affecting the muscles of mastication and the TMJ. In 2011, the Research Diagnostic Criteria for Temporomandibular disorders (RDC/TMD) was established that included clinical examinations (under Axis I) and behavioral profile assessment (under Axis II) of patients suffering from TMD. Accordingly, TMD Axis I included myofascial pain disorder (with or without limited opening), disc displacement (with or without reduction and with or without limited opening), and arthralgia (arthritis and arthrosis). Axis II included assessment of behavioral, psychological and social factors (Dworkin et al., 2002). Diagnostically, TMD was divided into three groups and into further subdivisions. The groups are,

1. Group I Muscle Disorders:
    a. Myofascial pain
    b. Myofascial pain with limited opening
2. Group II Disc Displacements:
    a. Disc displacement with reduction;
    b. Disc displacement without reduction with limited opening

c. Disc displacement without reduction without limited opening.

3. Group III Arthralgia, Arthritis, Arthrosis:
    a. Arthralgia
    b. Osteoarthritis
    c. Osteoarthrosis.

In 2014, Schiffman et al., 2014 recommended a revised version of RDC/TMD, called the Diagnostic criteria for temporomandibular disorders (DC/TMD). According to DC/TMD, TMD is broadly classified into four groups. The following flow chart represents classification according to DC/TMD.

1. Temporomandibular Joint Disorders
2. Masticatory Muscle Disorders
3. Headaches attributed to TMD
4. Associated structures -Coronoid hyperplasia

Figure 2- Temporomandibular Joint Disorders Classification (DC/TMD)

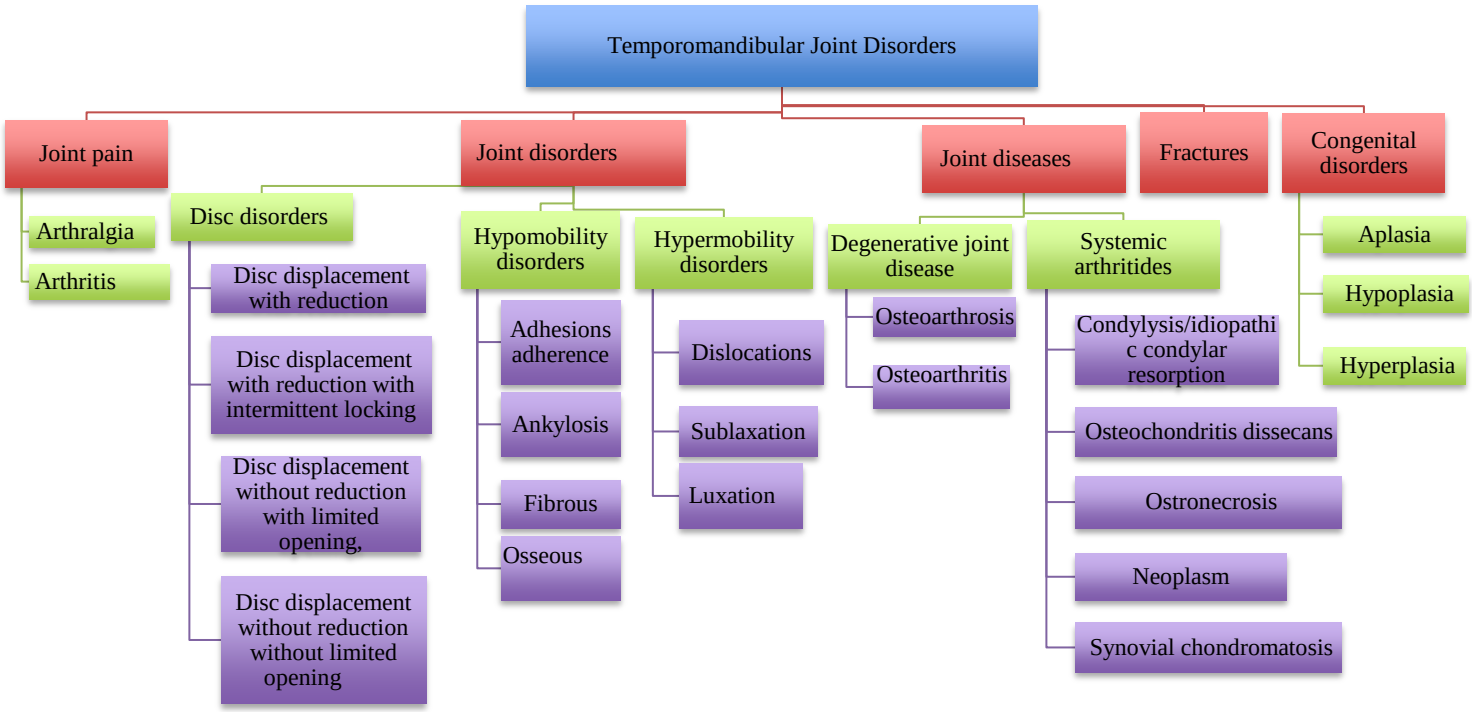
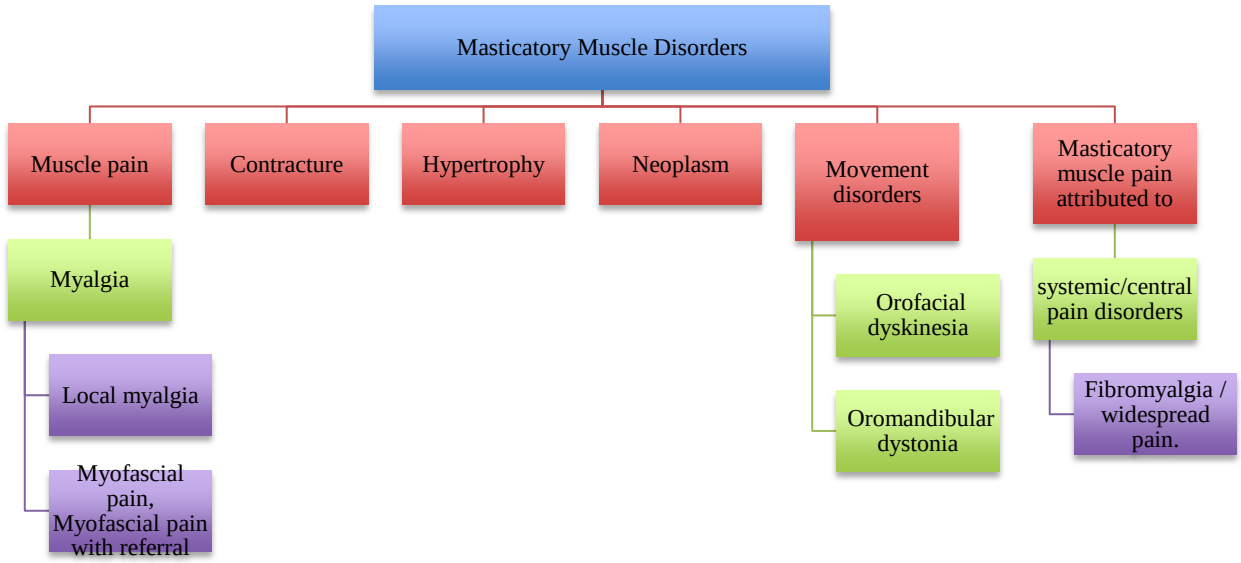


Figure 3- Masticatory Muscle Disorders Classification (DC/TMD)



As mentioned previously, thorough history taking along with detailed clinical examination plays a crucial role in diagnosing TMD. On clinical examination, pain in muscles of mastication and/or the temporomandibular joints, dysfunction of the temporomandibular joint, decrease in the range of motion of the jaw, intermittent locking of the jaw and temporomandibular joint noises such as crepitus are some of the most common symptoms documented. Other symptoms of TMD include but are not limited to headaches, tinnitus, dizziness, vertigo and hearing loss (Kitsoulis et al., 2011).

2.2 EPIDEMIOLOGY

According to National Institute of Dental and Craniofacial Research in 2014, the prevalence of TMD in general population above age of 18 years is ranged from 5% to 12%. TMD is considered the second most common musculoskeletal condition only after chronic lower back pain and that results in pain and disability. In 1996, the National Institutes of Health estimated that 10 million of American population complained of painful temporomandibular joint. According to Detamore MS et al., in 2003, higher rate of tinnitus was prevalent among younger population ranging 18 to 34 years of age and was twice as prevalent in women as men. He also reported that at least 20–25% of the population showed of at least one of the symptoms of TMJ dysfunction while it is estimated that 30 million American population suffered from it, with approximately one million new patients identified yearly.

2.3 ETIOLOGY AND RISK FACTORS

In general, complex diseases rarely have a single factor sufficient for “causing” the disease. Rather, the etiology of a complex disease is best explained as multiple risk factors acting

together within a web (Rothman et al., 2005). Similarly in TMD, findings from the OPPERA study have reinforced identification of TMD as a complex disorder within a bio-psycho-social illness model, confirming that, TMDs are conditions that are not localized to pathology of orofacial structures. Trauma to the mandible, the temporomandibular joints, or muscles in head and neck region, malocclusion either dental or skeletal, habits such as grinding or clenching of teeth, biological process such as aging and/or stress either induced by anxiety and depression are some of the common causes of temporomandibular joint disorders (Ingawale et al., 2009).

2.4 TREATMENTS AND MANAGEMENT

The primary goal of treatment of TMD is to provide symptomatic relief from pain. Conservative treatment modalities include managing Axis I and Axis II issues. Patient education and behavior management, physiotherapy consisting of passive jaw stretching exercises, medications such as analgesics, muscle relaxants and oral appliances such as occlusal splints are some of the approaches to treat TMD (Dworkin et al., 2002).

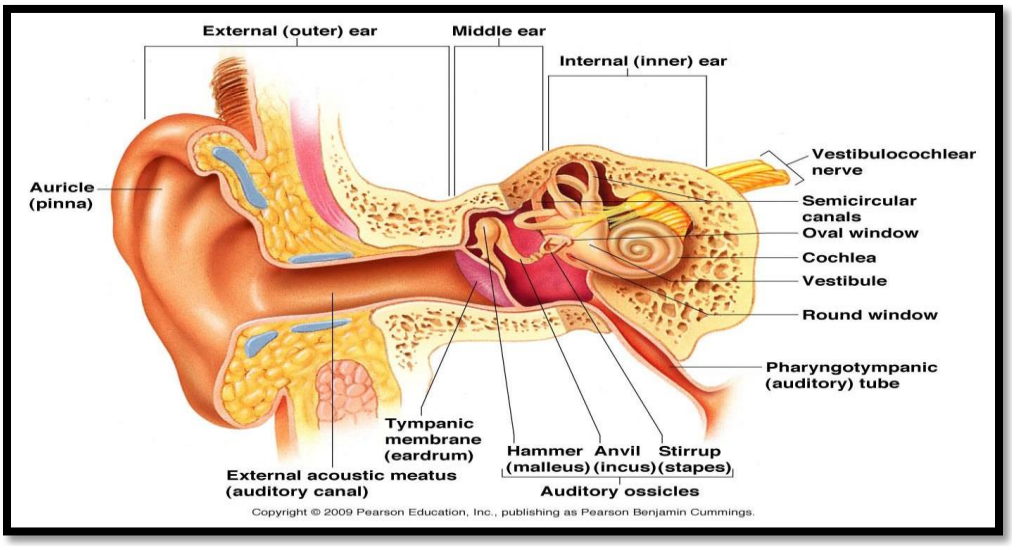
CHAPTER THREE

TINNITUS

3.1 DEFINITION

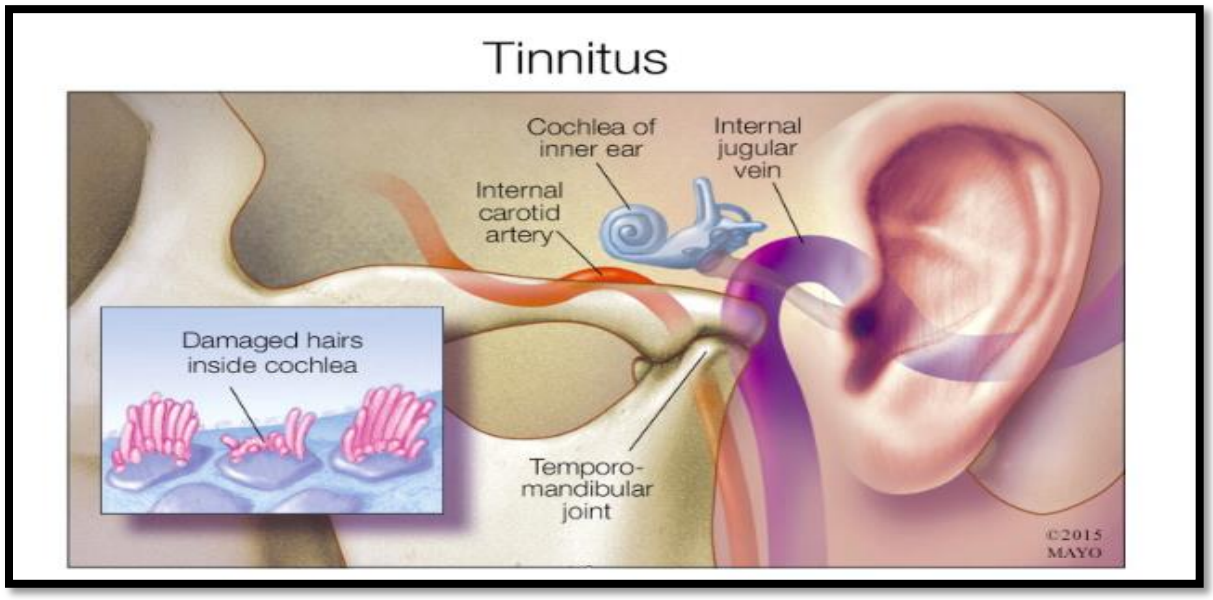
Tinnitus, according to the American Tinnitus Association in 2015 was reported as the third worst problem that can potentially affect human beings after pain and severe dizziness (Sanchez TG et al., 1997). Tinnitus is defined, as a phantom auditory perception. It is a perception of sound without any corresponding acoustic or mechanical associates in the cochlea of the ear. In the neurophysiological model, tinnitus is a result of abnormally processed sound that is generated in the auditory system. Tinnitus is explained to be a result of continuous firing due to hyperactivity (increased spontaneous activity) of the sensory receptor cells called hair cells of the cochlear fibers to the brain. Tinnitus may also be a result of permanent damage to these sensory receptor cells. Damaged cells generate a phantom sound that is transmitted to the brain and is heard as a real sound. (Jastreboff PJ et al., 1990) Most of the tinnitus sensations are frequently perceived as a buzzing, hissing, or ringing sounds. These sounds can be either unilateral or bilateral.

Figure 4: Anatomy Of The Ear (Pearson Cummings 2006)



Tinnitus is generally divided into two categories: objective and subjective. Objective tinnitus, which is also known as somatosound, is defined, as a sound that is generated in the body and at the same time is audible by the examiner. For example, myoclonic contractions of the tensor tympani muscle or altered blood flow in vessels near the ear are considered objective findings. Tinnitus is subjective if it is audible only to the patient. Subjective tinnitus is measured to be devoid of an acoustic etiology and any related movements in the cochlear partition or the cochlear fluid within the internal ear. Most of the current practitioners use the term tinnitus to designate subjective tinnitus while the term somatosound is used to designate objective tinnitus (Dobie RA et al., 2004). Since tinnitus is most of the times being measured, quantified and described based on responses of the subjects/patients, many physicians consider tinnitus as a subjective phenomenon, which is difficult to evaluate objectively.

Figure 5: Proximity Of TMJ To Ear (Mayo 2015)



3.2 EPIDEMIOLOGY

According to the National Health and Nutritional Examinations Survey (NHANES) in 1999-2004, an estimate of over 45 million Americans reported tinnitus. Tinnitus is thus rated as one of the most common health conditions in the USA. According to NHANES in 1999, the prevalence of tinnitus was 25.3%, which corresponds to a national estimate of about 50 million adults aged of 20 years or above. Also, the survey concluded that the prevalence of tinnitus increases with an increase in age until 60-69 years and then gradually decreases as age progressed. Within the population of USA, tinnitus is more prevalent among males than females and more prevalent among non –Hispanic whites than non-Hispanic blacks and Hispanics (Shargorodsky J et al., 2010).

3.3 ETIOLOGY

Like TMD, the cause of tinnitus is clinically heterogeneous and more than one cause may be present in same patient. Causes of tinnitus can be broadly grouped into otologic (pertaining to ear), neurologic (relating to central and peripheral nervous system), infectious causes, pharmacological, psychiatric and dental causes (Steinmetz LG et al., 2008).

Otologic causes of tinnitus include presbycusis (age related hearing loss), otosclerosis, otitis, impacted cerumen in the ear, and/or sudden deafness. Neurologic causes include injury to the head, whiplash blow, conditions such as multiple sclerosis, vestibular schwannoma and/or other cerebellopontine-angle tumors. Some of the infectious causes include otitis media and sequelae of Lyme disease, meningitis, and syphilis. Among the pharmacological causes where tinnitus is a side effect of drugs, salicylates, non-steroidal anti-inflammatory drugs (NSAIDS), antibiotics, diuretics, and chemotherapy agents such as cisplatins and vincristine are some of the common drugs (Byung IH et al., 2009). In some cases, stress and emotional issues are also responsible for

causing tinnitus (Hinton DE et al., 2005).

In regard to dental causes, temporomandibular joint dysfunction (TMD) is considered primary cause for tinnitus. TMD may also cause aural symptoms such as earache, vertigo, dizziness, referred pain and headaches apart from tinnitus (Isabela PT et al., 2016). Other dental causes include patient habits such as clenching and grinding of teeth. High-pitched noise from dental drills is also considered a possible cause for tinnitus (Messano GA et al., 2012).

3.4 TREATMENTS AND MANAGEMENT

Treatment for tinnitus is primarily targeted either to reduce the intensity of sound disturbance or to relieve the irritation related with tinnitus. Some medications such as tricyclic antidepressants (nortriptyline and amitriptyline) and benzodiazepines (alprazolam, clonazepam, and oxazepam) can help mitigate tinnitus. Electric suppression can sometimes help with reducing the intensity of sound. Cognitive behavior therapy, sound therapy and use of hearing aids can also help reduce the associated displeasure (Han BI et al., 2009).

CHAPTER FOUR

TINNITUS AND TMD COEXISTENCE

TMD patients, along with classic signs and symptoms of TMD, also complain of sudden hearing impairment or loss, plugged ear sensations and earache, a sore or burning throat, difficulties swallowing, tinnitus, and vertigo (Morais AA et al., 2012). The most frequent aural symptoms among TMD patients include tinnitus, and otalgia (Felicio CM et al., 2004). Some investigations suggested that at least more than one-third of TMD patients report tinnitus (Lam DK et al, 2012).

The relationship between the etiology of tinnitus and TMD is not well known. In order to understand this relationship, a brief review of the embryology and anatomy of ear and TMJ region may be necessary. Anatomically, the ear is divided into external ear, middle ear and inner ear. The external ear consists of auricle and external auditory canal, middle ear or tympanic cavity consists of tympani membrane and 3 auditory ossicles- malleus, stapes and incus, the inner ear consists of cochlea and labyrinth. There are 2 muscles that attach to the ossicles of the middle ear- the tensor tympani muscle and the stapedius muscle. Tensor tympani muscle is supplied by the 5^{th} cranial nerve and it is responsible for tensing the tympanic membrane of the middle ear.

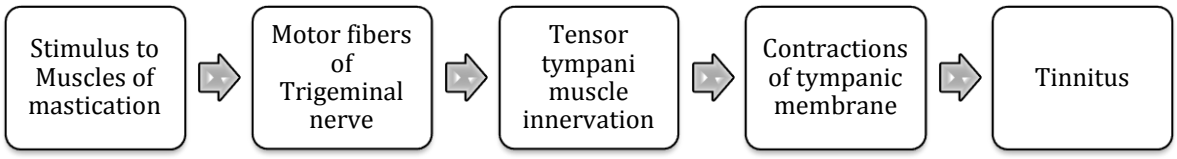
4.1 CAUSAL CONCEPTS

There has been a significant increase in understanding the relationship between ear symptoms and the craniomandibular disorders. However at present, very little data is available concerning the prevalence of tinnitus in TMD condition. Thus it may be difficult to assess the association between tinnitus and TMD (Harold et al., 1997).

Many theories have been proposed in relation to tinnitus and TMD. The most popular theories are,

1. *The Neuromuscular Theory*: It is believed that tinnitus is linked structurally and functionally to Tensor tympani (V3) muscle. According to this theory proposed by Attanasio G, et al, contractions in tensor tympani muscle, which originates from the cartilage of auditory tube (part of middle ear) and inserts on the handle of the malleus of the ear causes movement of the tympani membrane thus producing tinnitus. Tensor tympani, tensor palatine and the muscles of mastication are innervated by the trigeminal nerve. Also, these muscles share a common embryologic origin, which is the first pharyngeal arch. Neuromuscular theory is based on this embryological and functional relationship between middle ear muscles and masticatory muscles. Contractions due to chronic irritation in one group of muscles may be conveyed to the other muscles due to their close proximity.

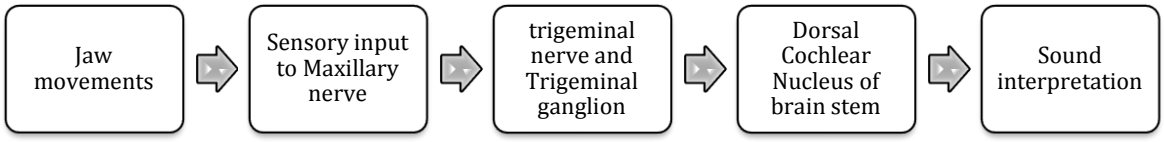
Figure 6:-Neuromuscular Theory Flowchart Representation



2. *The Somatosensorial Theory*: It based on neuro-anatomical interaction between the nervous input to the somatosensory afferent fibers of the maxillary nerve, which is the second branch of trigeminal nerve and the dorsal cochlear nucleus of the brainstem. According to this theory proposed by Levine et al., in 1999, sensory input to maxillary nerve due to tooth grinding movements is transmitted to the trigeminal ganglion, which

also innervates the dorsal cochlear nucleus. This interaction may affect both hearing and the interpretation of sound.

Figure 7:- Somatosensorial Theory Flowchart Representation



3. *The Anatomic Theory:* It is based on direct connection between the ligaments that attach to the jaw and one of the hearing bones that sits in the middle ear. In this theory proposed by Pinto et al., two fibro elastic tissues with ligamentous qualities, anterior malleolar ligament (AML) and discomallear ligament (DML) origin from the neck of the malleus above the anterior process, lay lateral to the chorda tympanic nerve and insert into the medio-posterior superior part of the capsule and meniscus of the TMJ. Prolonged stimulus producing movement of the meniscus and there by moving the ossicles and tympanic membrane may cause a direct acoustic effect.

Figure 8: - Anatomic Theory Flowchart Representation

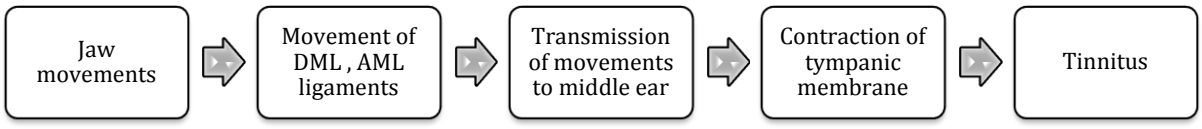
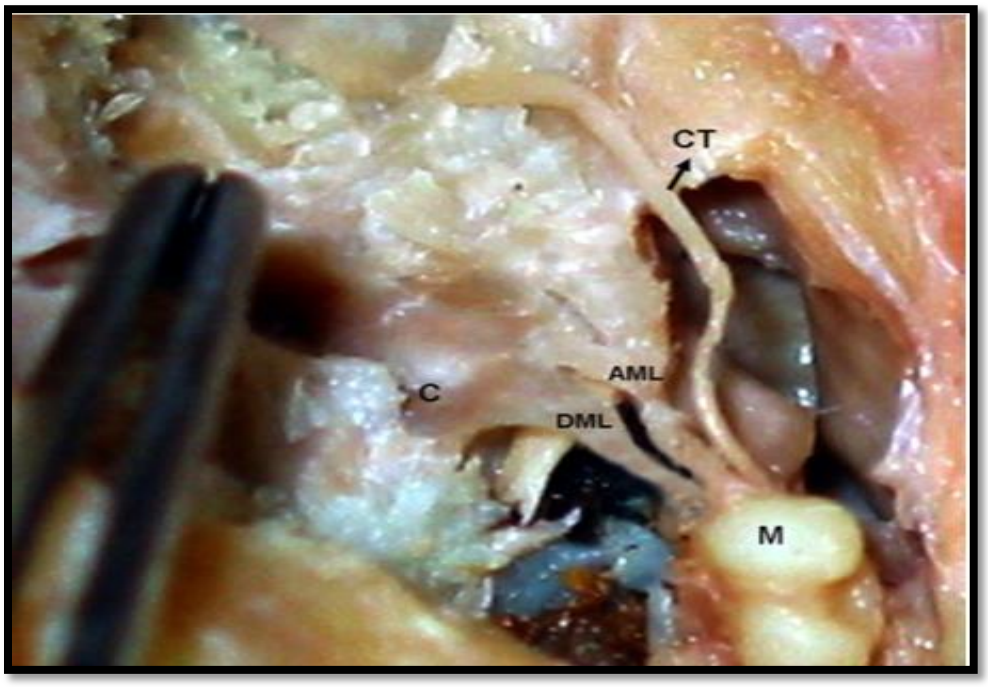


Figure 9: Anatomical And Functional Aspects Of Ligaments Between The Malleus And The Temporomandibular Joint (International Journal Of Oral And maxillofacial Surgery, October 2008)



4. 2 OTHER CONCEPTS

Other concepts to support the occurrence of tinnitus in TMD were proposed by Wright and Monson in 1933. They related occlusal disarrangements to aural symptoms such as tinnitus and neuralgia. In later years, Costen's theory based on mandibular joint functioning was thought to be one of the reasons for tinnitus. Sicher and Zimmeran (1951) proposed the theory of pressure on the blood vessels and nerve fibers due to posterior dislocation of the condyle caused by lax ligaments and subluxation as a cause for tinnitus. However, none of these theories could produce sufficient evidence to explain the etiology of tinnitus in TMD patients.

Myrhaug et al, (1964) found that subjects with both neuralgic pain (of face) and TMJ reported ear symptoms such as tinnitus and popping sensations. Later, theory related to tension and contraction of masticatory muscles and the tensor tympani muscle due to common nerve supply

from trigeminal nerve became popular. This theory was related to changes in the bite that caused tension in muscles. Another theory considered tinnitus as a fatigue response to prolonged irritation and stress that developed in the masticatory muscles along with tensor tympani muscle that are innervated by the trigeminal nerve. Furthermore, another theory proposed that bnormal spams in the muscles of mastication due to occlusal changes was a prominent cause of arthritis in the temporomandibular joint and ear symptoms like tinnitus (Jonck et al., 1978).

With Pinto's cadaver study findings in 1962, that examined ligament attachments between the middle ear and TMJ, a structural concept was addressed. Komori et al., (1986) reported ligaments that attach from intra articular disk of the TMJ via the petro tympanic fissure to the malleus in the middle ear. Movement of the TMJ was considered to cause movements of the ligaments, followed by movements in the chain of ossicles of the middle ear and thus the tympanic membrane leading to tinnitus. Additionally, fibrous connective tissue connection between the sphenomandibular ligaments and the anterior ligament of the malleus was also considered to play an important role in producing tinnitus (Bleiker et al., 1988).

Young et al (1958) believed that pertotympanic fissure is an outlet from the middle ear into the gleniod fossa transmitting through the tegmen tympani bone that contains lymphatic channels from the petrous bone. Compression of these lymphatic channels during closed bite and /or mandibular retrusion caused increase fluid pressure in the inner ear leading to ear symptoms. Furthermore, it was believed that mechanical impingement of the lymphatics could impair the lymphatic drainage mechanism. Nevertheless, these concepts on TMJ and tinnitus coexistence have not been supported with sufficient data from studies.

CHAPTER FIVE

METHODS AND MATERIAL

5.1 STUDY DESIGN

This secondary analysis study is designed to measure the association between the presence of tinnitus and TMD diagnoses in a TMD population evaluated for the Research Diagnostic Criteria for Temporomandibular disorder study. The RDC/TMD study consists of questionnaires and highly structured clinical and radiographic assessments. As part of the RDC/TMD study, extensive self reported data was collected including data on tinnitus. The purpose of the validation study was to define the diagnostic validity of the existing examination protocol and panel's recommendations for further revision of the Axis I diagnostic algorithms were assessed for reliability by using newly collected data from the ongoing TMJ Impact Project—the follow-up study to the Validation Project. (Schiffman et al., 2014). For convenience, our study refers to the Validation project as baseline study and the Impact study as follow up study.

5.2 STUDY POPULATION

Subjects from RDC/ TMD baseline and follow up study were included. Subjects for baseline and follow up study were from august 2003 till September 2006 and from June 2012- 2013 respectively at three sites- University of Minnesota, University at Buffalo and University of Washington.

5.3 STUDY DATA AND MEASURES

For measuring different TMD diagnoses and tinnitus, the following data from the Validation and Impact studies was used. The measures include clinical examination and self reported questionnaires.

- Baseline study
    - RDC/TMD examination raw data
    - History Questionnaire: “Do you have noises or ringing in your ears?” (15f)
    - Medical history: RDC/ TMD Questionnaire
    - Supplemental History: Initial Questionnaire
    - Gold standard Diagnoses RDC/TMD
    - Oral Behaviors Checklist
    - SCL-90-R
- Follow up study
    - CPSQ impact study – “ ringing in your ears- yes or no (18f)”
    - Diagnostic Criteria for Temporomandibular Disorders -Patient History Questionnaire
    - DC/TMD Examination Form: Impact Study

5.4 INLCLUSION CRITERIA

The inclusion criteria as defined by Schiffman et al:

<u>Cases:</u>

Subjects ages 18-70 years of age with at least 1 of the 3 cardinal signs and symptoms of TMD jaw pain, limited mouth opening or TMJ noise

Controls:

A. History

1) No lifetime history of TMD symptoms (“supercontrols”)

- Absence of TMJ noise, locking or catching of the jaw, and
- Absence of pain in the jaw or the temporal area, and
- Absence of headaches affected by jaw movement, function, or parafunction.

2) Prior history of TMD symptoms (“controls”)

- In the last 6 months, no history of TMD symptoms
- Prior to 6 months ago:
- No more than 5 isolated episodes of TMJ noise, with each episode lasting less than 1 day and not associated with jaw pain or limited mouth opening, and
- No more than 1–2 isolated episodes of locking or catching of the jaw in the wide-open mouth position, and
- No headaches in the temporal area affected by jaw movement, function, or parafunction.

B. Clinical examination

- Any pain produced by procedures must be nonfamiliar, and
- No TMJ clicking, popping, or snapping noises with more than 1 movement, and

- No coarse crepitus with any movement.

C. Imaging

- TMJ MRI is negative for anterior disc displacement, and
- TMJ CT is negative for osteoarthrosis.

5.5 EXCLUSION CRITERIA

Exclusion criteria as defined by Schiffman et al.,

I. History

1. Systemic rheumatic, neurologic/neuropathic, endocrine, or immune/autoimmune diseases or wide spread pain. (Exception: subjects with medical documentation of rheumatoid arthritis or fibromyalgia).
2. Pathologic processes found on imaging including neoplasm (Exception: Disc displacements and osteoarthritis/ osteoarthrosis)
3. Radiation treatment to head and neck.
4. TMJ surgery.
5. Trauma to jaw in the last 2 months (exclusion regardless of time: jaw trauma from auto accident).
6. Presence of non-TMD orofacial pain disorders.
7. Pregnancy.
8. Unable to participate due to language barrier or mental/intellectual incompetence.
9. Use of narcotic pain medication, muscle relaxants or steroid therapy unless discontinued for 1 week prior to examination.

10. Use of antidepressant drugs unless the participant has been on a stable dose for 60 days.
11. Use of prescription or over-the-counter nonsteroidal anti-inflammatory medications unless the medication(s) were discontinued for 3 days prior to the examination (use of acetaminophen was allowed as a rescue drug).
12. Drug abuse.
13. Ongoing dental treatments.
14. Wearing dentures.
15. Contraindications for imaging.
16. Ongoing TMD treatments unless on a stable regimen for at least 2 months.
17. Unable or unwilling to give informed consent.

II. Clinical examination

1. Presence of non-TMD orofacial pain disorders.

III. Imaging

1. TMJ MRI is positive for pathology other than disc displacements.
2. TMJ CT is positive for osseous pathology other than osteoarthritis or ostoeathrosis.
3. Panoramic radiograph is positive for osseous (non-TMJ related) or odontogenic lesions.

5.6 DATA COLLECTION

All data from the TMD/ RDC baseline and follow up study was gathered and stored in an encrypted drive and used for further analysis. Study data was accessible to the thesis group.

5.7 STATISTICAL ANLYSIS

From baseline study data, descriptive analyses were performed to summarize subject characteristics, such as age and sex, type of TMD diagnoses and tinnitus frequency. Log-binominal regression analysis was done to assess the risk factors and calculate adjusted relative risks (Daddens et al., 2004) with 0.05 level of significance ($p<0.05$). Major risk factors analyzed were,

1. Tenderness or pain on palpation in extra oral, intra oral and joint site muscles on palpation
2. Headaches in the temporal region
3. Oral habits such as grinding / clenching of the jaw
4. Anxiety, Depression and Characteristic pain intensity.
5. Jaw Movements- Left and right extrusion movements and protrusion.

At follow up, Data from the Impact study was similarly analyzed to measure the change in rate of tinnitus. Also, additional analysis was performed to measure the rate of tinnitus within the different TMD diagnoses at follow up. All statistical analysis was done using SAS 9.3 software (SAS Institute, Cary, NC).

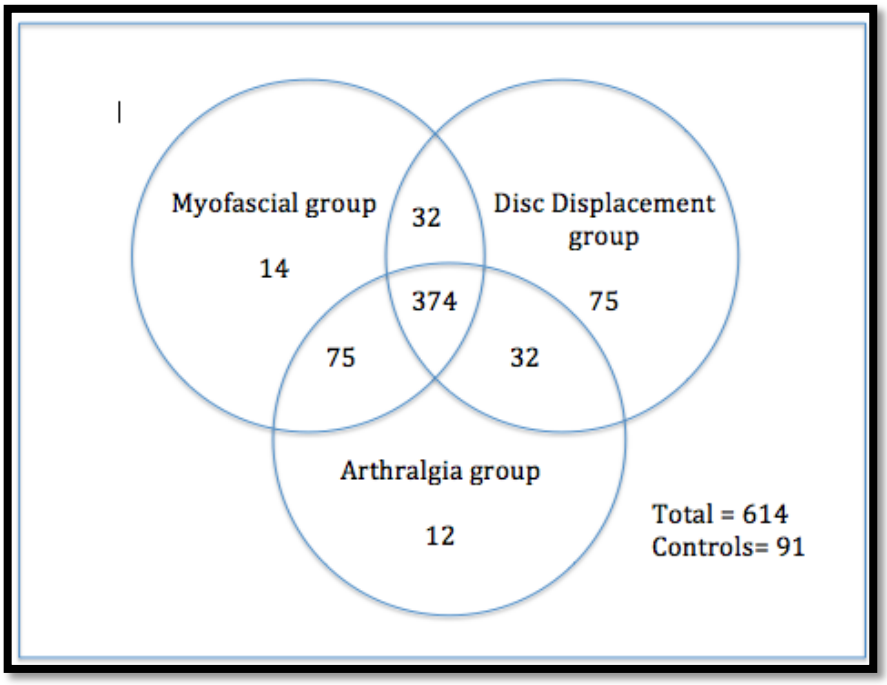
CHAPTER SIX

RESULTS

6.1 TINNITUS IN BASELINE STUDY

At baseline, 705 subjects were assessed to examine TMD subtypes (MPD, DD or DJD), tinnitus and risk factors associated with TMD and tinnitus. From this study population, a sample of 614 subjects met the required criteria for TMD diagnosis. 91 subjects were controls. The following Venn diagram shows the number of subjects in each group.

Figure 10: TMD Subtype Distribution



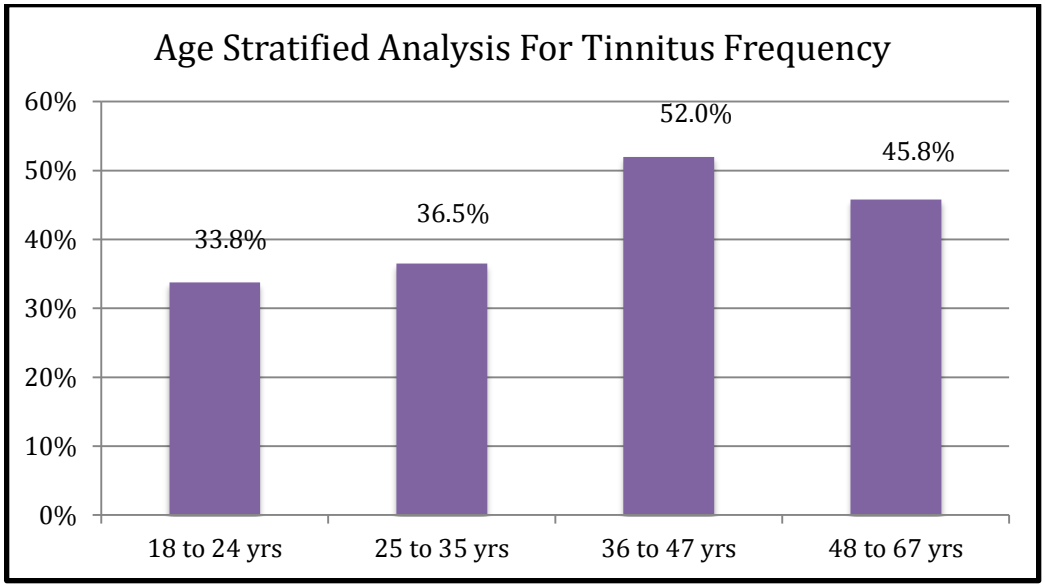
Among 614 subjects with TMD, about 60% (374) of subjects were diagnosed with all subtypes of TMD (MPD+DD+DJD) and the rest received at least one or more TMD diagnosis. Approximately, four fifths of the sample, 495 (80.6%) had MPD diagnosis in combination with DD and/or DJD. Of the remaining 119 subjects, 75 received only DD diagnosis, 12 only DJD and 32 had DD along with DJD diagnosis.

After descriptive analysis was performed, the following information was gathered. The mean age of the population was 36.5 years and 85.3% (535 of 705) were females (Table 1). Age when divided into quartiles, the highest prevalence of tinnitus i.e. 52% (79 of 152) was seen in age group 36 to 47 years. Figure 11 shows the rate of tinnitus at different age groups.

Table 1: Gender And Age Distribution At Baseline

GENDER	**CASES N**	**TINNITUS RATE n (%)**
Female	535	37(40.2%)
Male	92	226(42.2%)
AGE (in years)		
18 to 24	154	52(33.8%)
25 to 35	156	57(36.5%)
36 to 47	152	79(52.0%)
48 to 67	166	76(45.8%)

Figure 11: Age (In Years) Distribution In Baseline TMD Population



6.2 TINNITUS WITHIN TMD SUBTYPES AT BASELINE

Prevalence of tinnitus in this sample population was 41.2% (253 of 614) among TMD subjects and 5.5% (5/91) among the controls. Within the TMD subtypes, the rate of tinnitus was higher in the MPD group (48.1%) where as non MPD group (DD+DJD) reported only 15.6%. About 94% (238/253) of the TMD subjects had MPD and tinnitus. Subjects that received only MPD diagnosis reported 64.3% tinnitus while exclusive DD and DJD groups reported only 10.7% and 16.7% respectively.

Table 2: Rate Of Tinnitus In TMD Subtypes

TMD Diagnosis	**Cases N**	**Tinnitus N (%)**	**No Tinnitus**
TMD (any type)	614	253 (41.2%)	361 (58.8%)
Controls	91	5 (5.5%)	86 (94.5%)

TMD DIAGNOSIS	Cases N	Tinnitus n (%)	No Tinnitus
MPD	495	238 (48.1%)	257 (51.9%)
MPD only	14	9 (64.3%)	5 (35.7%)
MPD and DD only	32	15 (46.9%)	17 (53.1%)
MPD and DJD only	75	38 (50.7%)	37 (49.3%)
DD	513	204 (39.8%)	309 (60.2%)
DD only	75	8 (10.7%)	67 (89.3%)
DD and DJD only	32	5 (15.6%)	27 (84.4%)
DJD	493	221 (44.8%)	272 (55.2%)
DJD only	12	2 (16.7%)	10 (83.3%)
MPD + DD + DJD	374	176 (47.1%)	198 (52.9%)

When the risk for tinnitus among the TMD subtypes was estimated, the relative risk values were higher for MPD group than the other two groups. The adjusted relative risk for tinnitus among MPD group was 2.6 (95%CI: 1.53, 4.39; p= 0.0004). Here, relative risk values were adjusted for age, gender, site of examination and somatization (SCL 90R). In the DD and DJD groups, RR values were 0.94 (95%CI: 0.75,1.18; p=0.60) and 0.95 (95%CI: 0.71,1,27; p=0.75), respectively, and were not statistically significant (Table 3).

Table 3: Tinnitus By Type Of TMD Diagnosis

TMD Diagnosis	Cases N	Tinnitus %	Adjusted Relative Risk*	
			RR (95% CI)	P-value
MPD	495	48.1%	2.60(1.53, 4.39)	0.0004
DD	513	39.8%	0.94(0.75, 1.18)	0.60
DJD	493	44.8%	0.95(0.71, 1.27)	0.75
*Adjusted for sex, age quartiles and study site (UW, MN or NY) and somatization items				

6.3 ATTRIBUTED RISK FACTORS

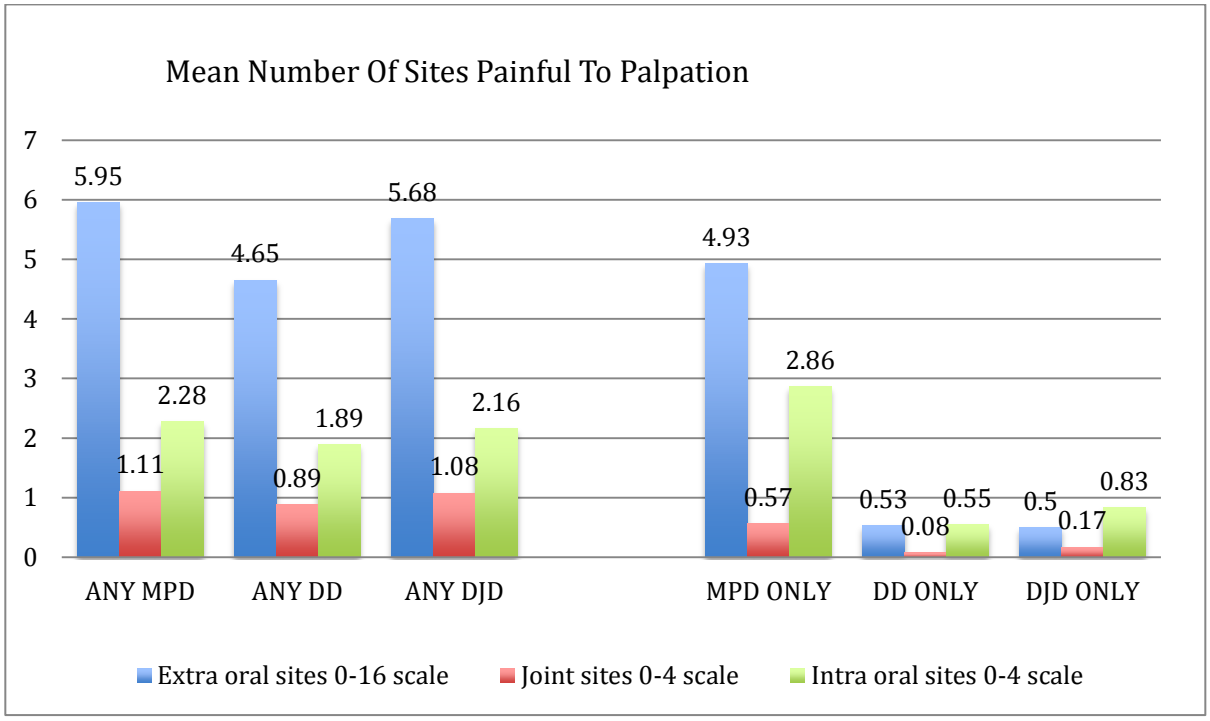
Various underlying characteristics were examined to assess the possible explanatory factors for developing tinnitus in TMD subjects. Pain in muscle sites during palpation, oral habits such as clenching and grinding, headaches, anxiety, depression and somatization, jaw movements such as protrusion and extrusion, opening measures of the jaw, other ear symptoms were some them. The following sections elaborate on the mean values and relative risk ratios for tinnitus recorded for risk factor.

6.3.a Painful Site On Palpation

For each subject, 20 sites (10 on each side of the face) were palpated to elicit pain that is familiar. Pain was recorded as a dichotomous variable (yes or no). The extra oral sites included posterior, middle and anterior temporalis muscle, origin, body and insertion of masseter muscle, posterior mandibular site and submandibular site. Lateral pole of the joint and posterior attachment of the joint were examined under joint sites while lateral pterygoid area and tendon of

temporalis were the intra oral sites examined. For analysis, these sites were divided into three groups and number of sites with familiar pain was recorded on scale 0-16 for extra oral sites, 0-4 for joint sites and 0-4 for intra oral sites. The following table (Table 4) reports mean and standard deviation for the number of painful sites in each group by TMD subtypes.

Figure 12: Mean Number Of Painful Sites To Palpation In TMD Subtypes



The mean number of extra oral sites, joint sites and intra oral sites painful to palpation were higher than in MPD group compared to other groups. When exclusive MPD, DD and DJD groups were compared, the mean values were distinctly higher. Furthermore, when the relationship between the number of painful sites to palpation and tinnitus was analyzed, the adjusted relative risk for tinnitus was highest for joint sites followed by intra oral and extra oral sites (Table 5). Additionally, it was observed that the risk for tinnitus between MPD group and the all TMD cases did not differ drastically.

Table 4: Risk Ratios For Tinnitus By Number Of Sites Painful To Palpation At Baseline

	Cases N	**Adjusted Risk Ratio**	
		RR (95% CI)	P-value
Extra oral sites (0-16 scale)	TMD	1.05 (1.02,1.07)	<. 0001
	MPD	1.03 (1.01, 1.05)	0.0083
Joint sites (0-4 scale)	TMD	1.14 (1.05, 1.22)	0.0006
	MPD	1.08 (1.00, 1.16)	0.044
Intra oral sites (0-4 scale)	TMD	1.11 (1.04, 1.18)	0.0004
	MPD	1.08 (1.01, 1.15)	0.011
RR, relative risk (estimated using log-linear regression analysis). Adjusted for sex, age quartiles, study site (UW, MN or NY) and somatization. TMD N= 614 and MPD N= 495			

6.3.b Headaches

Headaches in the temporalis region were examined as a risk factor for tinnitus. When descriptive and regression analysis were performed, within the baseline population, 427 had headaches with 47.1% (201/427) reporting tinnitus. Among subjects with a TMD diagnosis and headaches in the temporal region, the relative risk for tinnitus was 4.52, which was much higher than subjects with only HA (RR=0.73), and only TMD (RR=3.17) as shown in Table 5. Similarly, when examined within the TMD diagnoses, MPD group with headaches was at a higher risk for tinnitus (RR =3.59) than only headaches (RR =1.75) or only MPD (RR = 3.02) as shown in Table 6 below.

Table 5: Tinnitus By TMD Diagnosis And Headaches For TMD Subjetcts

Diagnosis	**Cases N**	**Tinnitus n (%)**	**Adjusted RR (95% CI)**	**P-value <0.001**
Headache only (controls)	31	6 (19.4%)	0.73 (0.09, 5.66)	0.76
TMD only	119	44 (37.0%)	3.17 (1.18, 8.46)	0.022
TMD and headache	376	194 (51.6%)	4.52 (1.67, 12.19)	0.0028
TMD DIAGNOSIS X HEADACHE INTERACTION				0.47
Without headache: TMD diagnosis	154	53 (25.6%	3.17 (1.18, 8.46)	.022
With headache: TMD diagnosis	207	200 (49.1%)	6.20 (0.96, 39.7)	.054
Adjusted RR for age, sex, study site, somatization and other TMD diagnoses.				

Table 6: Tinnitus By TMD Diagnosis And Headaches For MPD Baseline Subjects

Diagnosis	**Cases N**	**Tinnitus (%)**	**Adjusted RR (95% CI)**	**P-value**
Headache only	19	5.0%	1.75 (0.68, 4.49)	0.24
MP only	154	25.6%	3.02 (1.51, 6.01)	0.0016
MP and headache	207	49.1%	3.59 (1.82, 7.06)	0.0002
MYOFASCIAL PAIN X HEADACHE INTERACTION				0.44
Without headache: Myofascial pain	119	37.0%	3.08 (1.48, 6.39)	
With headache: Myofascial pain	376	51.6%	2.02 (0.96, 4.21)	
• Adjusted for age, sex, study site, somatization and other TMD diagnoses.				

6.3.c Oral Habits

The oral behavior checklist was used to assess the relationship between tinnitus and habits. This 21 checklist examines the most frequent positioning of the jaw at sleep and during waken hours. Although each item on the checklist were examined, there was no habit identified that had a significant association with tinnitus.

Table 7: Mean Values Of Oral Habits In Baseline Subjects

Number of oral behaviors (0-21)					
Tinnitus	**N**	**Mean**	**Std**	**Min**	**Max**
All	628	12.83	3.52	0.00	21.00
No	364	12.33	3.40	4.00	21.00
Yes	264	13.52	3.57	0.00	20.00

6.3.d Anxiety, Depression, Characteristic Pain Intensity And Interference At Baseline

The following tables represent the mean values and standard deviation of anxiety, depression, characteristic pain intensity (CPI), disability days and interference of pain with daily activity values recorded at baseline among both TMD subjects and MPD subjects. Data from SCL 90R questionnaire was used to perform descriptive analysis was performed to calculate mean values. Mean anxiety values were twice in subjects with tinnitus (0.42) than without tinnitus (0.24). Mean depression values were recorded higher in subjects with tinnitus (0.61) than without tinnitus (0.42). Similarly, mean values of CPI, disability days and interference of pain were observed higher in t subjects with tinnitus than without. CPI disability days and interference of pain scores were further analyzed at follow up for better understanding.

Table 8: Anxiety (SCL-90) In Baseline TMD Subjects

Anxiety SCL-90					
Tinnitus	**N**	**Mean**	**Std**	**Min**	**Max**
No	363	0.24	0.38	0.00	3.10
Yes	262	0.42	0.60	0.00	3.30

Table 9: Depression (SCL-90) In Baseline TMD Subjects

Depression SCL-90					
Tinnitus	**N**	**Mean**	**Std**	**Min**	**Max**
No	364	0.42	0.48	0.00	3.45
Yes	262	0.61	0.55	0.00	3.10

Table 10: Characteristic Pain Intensity (CPI) In Baseline TMD Subjects

Characteristic pain intensity 0-100					
Tinnitus	**N**	**Mean**	**Std**	**Min**	**Max**
No	364	35.07	27.46	0.00	100.00
Yes	264	51.91	22.72	0.00	100.00

Table 11: Interference In Baseline TMD Subjects

Interference score (0-100)					
Tinnitus	**N**	**Mean**	**Std**	**Min**	**Max**
No	364	12.01	18.69	0.00	90.00
Yes	264	21.93	23.94	0.00	100.00

Table 12: Disability Days In Baseline TMD Subjects

Disability days					
Tinnitus	**N**	**Mean**	**Std**	**Min**	**Max**
No	362	0.17	0.61	0.00	3.00
Yes	262	0.45	0.93	0.00	3.00

6.3.e Jaw Movements

Protrusion and left and right extrusion of the jaw were examined to measure the mean value of range of motion. The mean values did not differ from subjects with and without tinnitus. Moreover, when examined in subjects with MPD diagnosis, the mean values did not vary with tinnitus diagnosis. The following table represents the mean values of jaw movements.

Table 13: Jaw Movements And Tinnitus By TMD And MPD Diagnosis

Lateral excursion - RIGHT					
Tinnitus	**N**	**Mean**	**Std**	**Min**	**Max**
All	627	9.51	2.79	1.00	38.00
TMD and Tinnitus	263	9.30	2.72	1.00	16.00
MPD and Tinnitus	247	9.35	2.74	1.00	16.00
Lateral excursion - LEFT					
Tinnitus	**N**	**Mean**	**Std**	**Min**	**Max**
All	626	9.75	2.55	1.00	17.00
TMD and Tinnitus	263	9.73	2.56	1.00	16.00
MPD and Tinnitus	247	9.75	2.55	1.00	16.00

Protrusion					
	N	**Mean**	**Std**	**Min**	**Max**
All	626	5.63	2.32	0.00	14.00
TMD and Tinnitus	263	5.60	2.43	0.00	12.00
MPD and Tinnitus	247	5.58	2.45	0.00	12.00

6.4 TINNITUS IN FOLLOW UP STUDY

Baseline subjects were followed for a period of 7.8 years. At follow up, 388 subjects were observed. Of which, 279 received a TMD diagnosis. The mean age of the subjects was 45.2 years and 90.6% were females. The rate of tinnitus in cases and controls with TMD diagnosis was 44.8% (121/270) and 11% (1/9) shown in Table 14.

Table 14: TMD And Tinnitus At Follow-Up

Diagnosis	**Cases N**	**Tinnitus n(5%)**	**No tinnitus**
Total number of cases	279	79 (28.3%)	200 (71.7%)
MPD	206	62 (30.1%)	144 (69.9%)
MPD Only	15	6 (40.0%)	9 (60.0%)
DD	182	44 (24.2%)	138 (75.8%)
DD Only	33	8 (24.2%	25 (75.8%)
DJD	215	61 (28.4%)	154 (71.6%)
DJD Only	20	8 (40.0%)	12 (60.0%)

6.5 TINNITUS WITHIN TMD SUBTYPES AT FOLLOW UP

In comparison from baseline study to follow up study, 279 subjects were diagnosed with TMD. The rate of tinnitus at follow up was 28.3%. The rate of tinnitus in MPD, DD and DJD groups were 30%, 24% and 28% respectively. The decrease in rate of tinnitus from baseline study to follow up study in the TMD population was 12.9%. However, there was a 5% increase in tinnitus rate in the control group (Figure 13).

Based on the TMD subtypes at follow up, 206 received MPD diagnosis. Among them, 193 had a MPD diagnosis at baseline and follow up while 13 subjects received MPD diagnosis only during the follow up study. In comparison from baseline to follow up, the rate of tinnitus in MPD group has decreased from 48% to 30% and in the non MPD group, the rate of tinnitus increased from

12% to 21%. Interestingly, among these subjects who did not change in their MPD diagnosis, the rate of tinnitus improved from 51% (99/193) to 25%(59/193) (Table 16).

Table 15: Tinnitus At Baseline And Follow-Up

Diagnosis		**Cases N**	**Tinnitus n(%)**	**No tinnitus**
Total number of cases	Baseline	334	133 (39.8%)	201 (60.2%)
	Follow up	279	79 (28.3%)	200 (71.7%)
MPD	Baseline	260	126 (48.5%)	134 (51.5%)
	Follow up	206	62 (30.1%)	144 (69.9%)
MPD Only	Baseline	10	6 (60.0%)	4 (40.0%)
	Follow up	15	6 (40.0%)	9 (60.0%)
DD	Baseline	276	104 (37.7%)	172 (62.3%)
	Follow up	182	44 (24.2%)	138 (75.8%)
Only DD	Baseline	75	8 (10.7%)	67 (89.3%)
	Follow up	33	8 (24.2%	25 (75.8%)
DJD	Baseline	267	116 (43.4%)	151 (56.6%)
	Follow up	215	61 (28.4%)	154 (71.6%)
DJD Only	Baseline	12	2 (16.7%)	10 (83.3%)
	Follow up	20	8 (40.0%)	12 (60.0%)

Figure 13: Comparing Tinnitus At Baseline And Follow Up

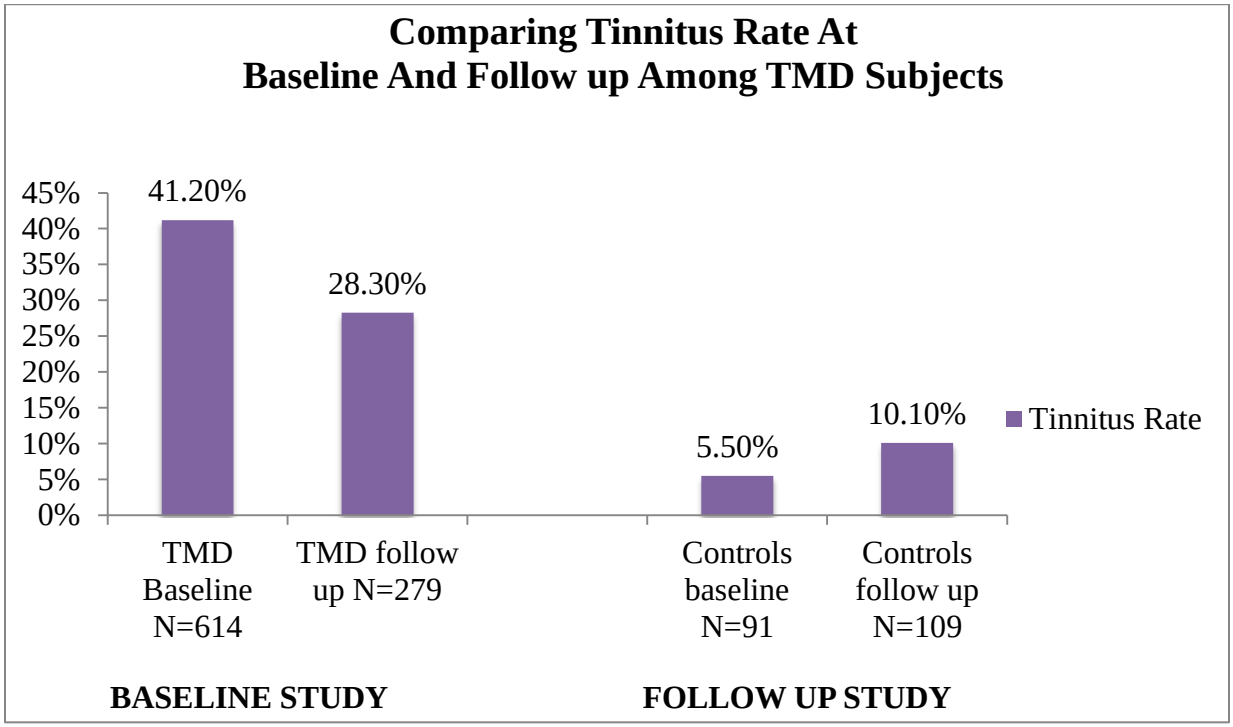


Figure 14: Comparing Tinnitus Between MPD And Non-MPD Groups

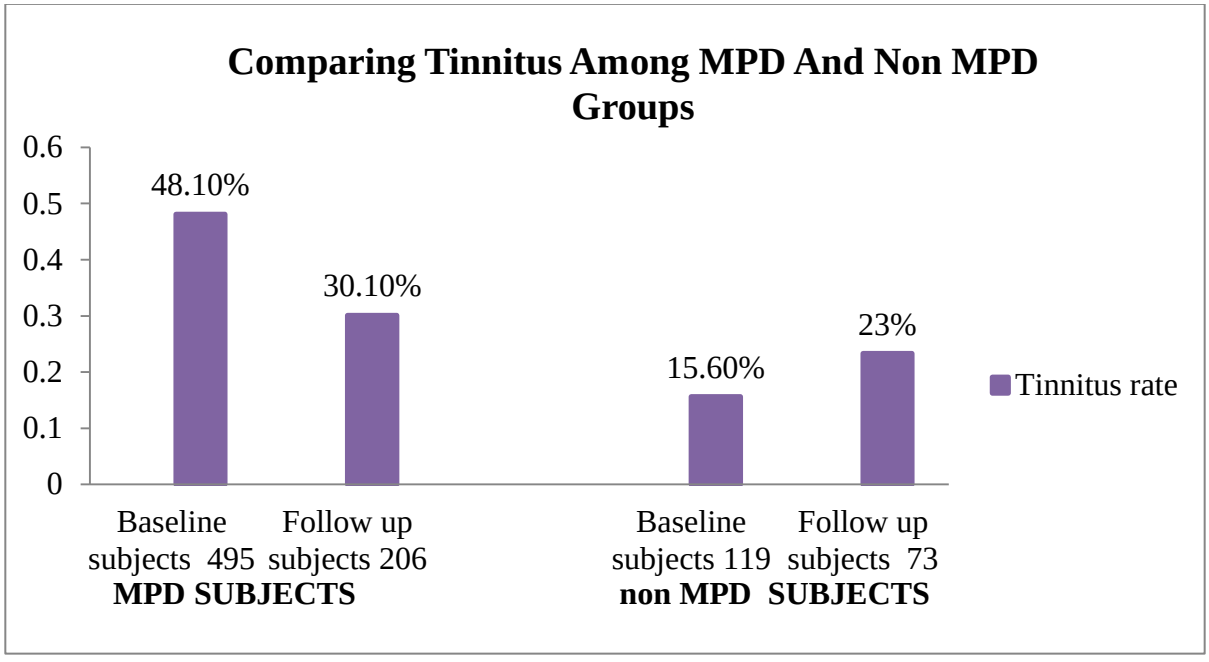


Table 16: Tinnitus Among MPD Subjects From Baseline To Follow up

MPD and tinnitus at baseline and follow-up		**Tinnitus at baseline**				**All**
		No		Yes		
		Tinnitus at follow-up		Tinnitus at follow-up		
		No	Yes	No	Yes	
MPD (Baseline)	MPD (Follow-up)	99	8	3	5	115
No	No					
	Yes	10	1	.	2	13
Yes	No	36	4	16	11	67
	Yes	84	10	50	49	193
All		229	23	69	67	388

Table 17: Comparing Change In Tinnitus Among MPD Subjects From Baseline To Follow up

	Cases N	**Tinnitus N(%)**
MPD subjects at follow up	206	62 (30.1%)
Subjects who did not improve in MPD	193	59 (30.5%)
Subjects who improved in MPD	67	15(22.3%)

6.6 Characteristic Pain Intensity, Disability Days And Interference With Daily Activity At Follow Up

In follow up study, mean values of CPI scores were observed because of the differences recorded in baseline study. It was observed that, mean CPI values decreased from 51 to 33 among tinnitus subjects. Similar trend was observed in subjects without tinnitus (decreased by 10).

When the risk factors were examined at follow-up, it was observed that the mean values of these parameters decreased from the baseline study in subjects with and without tinnitus. The following tables represent the mean values and standard deviation at follow up.

Table 18: CPI (characteristic pain intensity) In Follow-up TMD Subjects

Characteristic Pain Intensity (0-100)					
Tinnitus	**N**	**Mean**	**Std**	**Min**	**Max**
No	207	25.78	19.97	0.00	86.67
Yes	82	33.09	20.78	0.00	80.00

Table 19: Interference In Follow-up TMD Subjects

Interference Score (0-100)					
Tinnitus	**N**	**Mean**	**Std**	**Min**	**Max**
No	206	8.53	18.09	0.00	100.00
Yes	82	13.37	19.58	0.00	80.00

Table 20: Disability Days In Follow-Up TMD Subjects

Disability Days					
Tinnitus	**N**	**Mean**	**Std**	**Min**	**Max**
No	207	0.16	0.56	0.00	3.00
Yes	82	0.33	0.80	0.00	3.00

CHAPTER SEVEN

CONCLUSION AND RECOMMENDATIONS

Tinnitus is one of the common ear symptoms among TMD patients. As mentioned before, association between ear symptoms and TMD was first hypothesized in early 1934. Despite the underlying association, researchers failed to explain a cause effect relationship between tinnitus and TMD. The literature suggests that tinnitus is more prevalent among TMD patients than those without TMD (Bush FM et al., 189987). A recent study by Buergers R et al., in 2014 suggested that tinnitus is eight times more prevalent in subjects with TMD than those without TMD. However, few studies evaluated tinnitus within TMD subgroups. Our study examined tinnitus report among different TMD subtypes rather than as a whole and the attributed risk factors.

The prevalence of tinnitus in the over all study population was 41.2% with at least 85% females. And age related prevalence pattern of tinnitus ranged from 33 to 52% within the four age groups. The rate of tinnitus among our TMD population is consistent with previous literature on tinnitus rate ranging from 31 to 64% (Manfredinin D et al., 2012). The decrease rate of tinnitus with increased age was consistent with previous reports on tinnitus. It is interesting to note that although there were more number of subjects in the 4^{th} quartile (age ranging from 48-67 years) the rate of tinnitus reported was less than the 3^{rd} quartile (36-47 years)

Then, rate of tinnitus was high in the myofascial TMD than DD and DJD type. Moreover, the risk for tinnitus was doubled with MPD while this trend was not seen in the other two groups. Such finding may have important clinical implications, particularly with regard to the possible mechanism underlying the causal relationship between the tinnitus and TMD. It can be

speculated that clinical findings of tinnitus in the MPD group age 36-47 years may be due to a chronic tension of jaw muscles that provoke an abnormal response on the muscles regulating ear function.

To analyze attributed risk factors, sites painful to palpation were examined. Interestingly, the risk for tinnitus did not differ much in terms of painful sites to palpation among the different TMD sub types. The risk for tinnitus was slightly higher in painful joint sites (RR=1.14) as compared to muscle sites (extra oral sites- RR=1.05 and intra oral sites- RR=1.11). Based on neuromuscular theory, one would expect MPD group to be at a higher risk than DD and/or DJD. But since DJD included painful joint sites (arthralgia), the results did not differ much from MPD group.

With the data available, our study further evaluated risk factors such as headaches and oral habits. Based on the theory that abnormal dental occlusion and habitual jaw positioning may displace the condyle posteriorly thus producing ear symptoms, one may expect that oral habits such as clenching and grinding may also alter the condylar position. Although, studies speculated the role of oral habits in TMD, our study did not find any strong association between reported oral habits and tinnitus.

In regard to headaches and tinnitus, the literature suggests that tinnitus and headaches may have a common underlying pathophysiological mechanism and may not be purely coincidental (Berthold L et al., 2015). The findings of our study suggest that TMD patients with headaches are more likely to report tinnitus than TMD patients without headaches. Additionally, MPD patients with headaches are at least three times at a higher risk for tinnitus than MPD patients

without headaches (RR less than 1 in DD and DJD groups). One could imagine chronic stimulus to the muscles of the jaw; particularly the temporal region would sensitize the trigeminal system thus facilitating the development of tinnitus. However, it may be important to note that the test for interactions between TMD & headaches and MPD & headaches were not statistically significant (p=0.47). However, the unadjusted results, as well as the two RRs by headache and without headache, indicate that the risk of tinnitus with a TMD diagnosis is higher if the subject also has a headache than without a headache. Further electrophysiological or neuroimaging studies may be needed to evaluate this neuromuscular theory behind tinnitus, headaches and TMD.

From the follow up study, we observed that the frequency of tinnitus among the TMD population increased by at least 3%. Interestingly, in the MPD group, tinnitus dropped by at least 20 % from baseline to follow up. As MPD improved over time (80 to 73%), we noticed that tinnitus rate in this population also improved (48 to 30%). This improvement was not observed in DD and DJD groups. In fact, tinnitus rate increased in DD and DJD groups at follow up. Such findings may help contribute to the neuromuscular theory (where chronic stimulus to muscles may trigger tinnitus). As pain in the muscles improved, tinnitus decreased accordingly. Nevertheless, it is interesting to note that at follow up, mean values of characteristic pain intensity improved from baseline. This may suggest that as pain decreased, tinnitus decreased or that subjects were less likely to report tinnitus or be bothered enough by tinnitus to report its presence. Additional studies explaining the role of psychological factors and over all impact of pain may be necessary.

While being a cohort study and long term follow up are some of the merits of the study, the methodology of tinnitus report and loss of subjects to follow up and some of the limitations. Furthermore, tinnitus was a dichotomous variable where it was reported as either present or absent but in our follow up study, tinnitus was reported within the questions of any noises in the ear. In future studies, it may be worthwhile to differentiate tinnitus from other noises. Also other studies that score frequency of tinnitus or measure the impact of tinnitus on daily activity may be useful.

Although our study had a larger population, it was difficult to explore factors associated with tinnitus in patients with exclusive MPD due to smaller sample size. Long follow up studies including subjects with exclusive myofascial pain may be useful to support the role of neuromuscular system in tinnitus.

CHAPTER EIGHT

SUMMARY

From this large prospective multicenter TMD study, we found that the prevalence of tinnitus is at least three times higher in TMD population than healthy individuals. Risk for tinnitus is higher in MPD group than the other two groups and is six times higher in patients with a TMD diagnosis and headaches. A thorough TMD screening in patients with tinnitus is recommended. Notwithstanding that, our study showed significant correlation of tinnitus with MPD and headaches, thus providing support for neuromuscular theory; future research that assesses clinical correlation is demanded.

NOMENCLATURE

TMJ	Temporomandibular joint
TMD	Temporomandibular joint disorders
MPD	Myofascial pain disorder
DD	Disk displacement
DJD	Degenerative Joint Disease/Arthralgia
DML	Discomallear ligament
AML	Anterior malleolar ligament
CT	Chorda Tympani
M	Malleus of the ear
N	Number of Individuals
Std	Standard Deviation
Min	Minimum range value
Max	Maximum range value

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