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A Voice Teacher's Guide to Temporomandibular Disorders

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Dissertation

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Abstract

Temporomandibular Disorders are a prevalent group of disorders affecting the temporomandibular joints and surrounding structures, including the masticatory muscles, ligaments, and tissues. Voice pedagogy literature and social media suggest an incomplete understanding of TMDs among voice teachers, with no repository containing a synthesis of current information. The purpose of this dissertation was, therefore, to create a practical guide to Temporomandibular Disorders that would be relevant to singing and presented in a way that would be accessible to voice teachers in the teaching studio. The first section of the dissertation contains information about anatomy and pathophysiology of the TMJ from the perspective of the biopsychosocial medical model and a review of literature describing the relationship between TMDs and the voice. The second section describes the voice teacher's role in diagnosis and management of TMDs, discusses considerations for voice teacher response using the biopsychosocial model and outlines recommendations for adaptations in the voice studio. The entire document concludes with suggestions for future research and instructions for specific vocal exercises to be used for TMD management.

Acknowledgements

The creation of this document began many years ago when, as an undergraduate student at the University of Southern Maine, I first began experiencing symptoms of TMDs. These symptoms increased during my master's degree program at the University of North Texas. My voice teacher there, Jennifer Lane, had worked with a student with a TMD, and recommended I look into the issue. This personal interest aligned with a graduate research class, taught by Dr. Kris Chesky, that focused on Performing Arts Medicine. I chose the topic of TMDs in singers for a research proposal assignment that, before I graduated from UNT, became a bona fide study comparing the prevalence of positive TMD screenings in singers compared to instrumentalists. Under the guidance of Dr. Chesky and Dr. David Meyer from Shenandoah Conservatory, this study was completed and presented at the Voice Foundation's 46th Annual Symposium: Care of the Professional Voice in 2017. While I had expected to build upon this study for my dissertation, it soon became clear to me that what the voice pedagogy industry needed first was a document that presented a clear picture of the current understanding of the issue was and outline what from that information could be implemented in the studio. From conversations with other voice pedagogues, it was apparent that teachers working with such singers now could benefit greatly from such a synthesis of existing information.

Throughout this entire process, countless colleagues, friends, and family provided valuable advice, support, and input. Such acknowledgements very naturally lead into recollections of those who were of significant influence to me during my entire career as a singer and musician. I would like to thank all of my voice teachers throughout the years: Suzanne Manocchia, my first voice teacher; Leon Griesbach, who helped me through undergraduate auditions; the late Ellen Chickering, who was both my advisor and voice teacher at the

University of Southern Maine, as well as the first person who told me to consider pursuing a DMA in Voice Pedagogy; Jennifer Lane, my voice teacher at University of North Texas; and Dr. Kathryn Green, my academic advisor and voice teacher at Shenandoah Conservatory.

I could not have asked for a better dissertation committee, and would like to sincerely thank Dr. Anthony Meadows, who provided a valuable music therapy perspective, countless hours spent discussing and revising the document itself, and much needed positive encouragement at the times when writing was the most difficult; Dr. Kathryn Green, who offered advice, encouragement, and is truly a role model for who I aspire to emulate in academia; Dr. Matthew Edwards, whose innovative and practical approach to academia has always kept me grounded in purpose; and Dr. Tamara King, who I am pleased to call my colleague at the University of New England and whose expertise helped me navigate the challenges of writing on such a cross disciplinary topic.

I would also like to thank the other professionals who offered assistance, advice, and support: Dr. Kris Chesky and Dr. Stephen Austin from University of North Texas, Dr. David Meyer and Dr. Elizabeth Blades from Shenandoah University, Dr. Christopher Chang, Dr. Robert Sataloff, and Shannon DeAngelo and Dr. Louis Giordano from Giordano Family Dentistry where I was pleased to spend my internship learning about TMDs. Thank you also to my educational institutions, the University of Southern Maine, the University of North Texas, Shenandoah Conservatory and to the University of New England, where I currently teach as an adjunct. Thanks to Plural Publishing for the use of the exercises in Appendix B.

I would also like to thank my wonderful students, whose interest and questions validated my choice of this topic as something that would be truly useful. Working with you has allowed

me to explore the practical application of my discoveries and I am grateful for the experience that has reinforced the relevance of the information within this document.

One of the major themes explored in this document is the biopsychosocial model of health. It seems obvious to me that social support is a key factor in the success of any endeavor, whether maintaining vocal health or completing a 6 chapter dissertation. Therefore, I would like also to thank my dear friends, but especially all the those I made during my educational career and my those from the Georgetown Fire Department, especially Jerome and Karin Gamache, to whom I frequently turned for advice and support. And last and most importantly, I'd like to thank my family for your unwavering faith, support, and encouragement, especially my dear husband, Justin LoDolce.

In memory of Ellen Chickering

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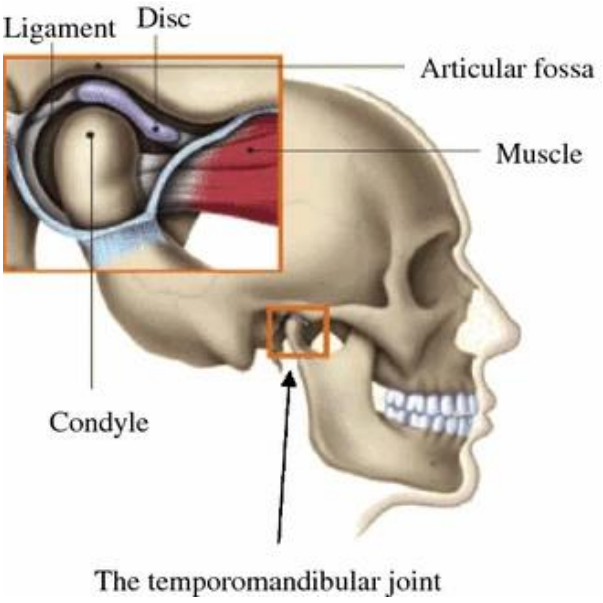
Chapter I: Background

Introduction

This document is a practical guide to Temporomandibular Disorders for voice teachers. It provides a framework through which voice teachers may better understand Temporomandibular Disorders in the context of the singing voice, and helps them, within their scope of practice as voice teachers, to facilitate the optimal well-being and performance of their students. Temporomandibular Disorders (TMDs) are a group of painful conditions commonly diagnosed in singers that affect the Temporomandibular Joints (TMJs) and surrounding structures.

Figure 1
Anatomical structure of the temporomandibular joint (TMJ). (Ingawalé, et al., 2009)



The two TMJs, (Figure 1) located where the mandible (jaw bone) connects the temporal region of the skull (thus *temporo-mandibular),* articulate to open and close the jaw. It is possible to palpate this joint by placing your fingertips gently on either side of the face, directly in front of the ears. When you open and close your jaw, you can feel the joints move forward and down.

"Temporomandibular Disorders" is an umbrella term for a complex syndrome that is defined by pain and dysfunction affecting the TMJs and masticatory musculature (Beaumont, et al., 2020). Demonstrating a wide range of severity and disability, TMDs can originate from neurological, muscular, structural, or even psychological origins, which necessitates a multidimensional understanding and approach to treatment and symptom management. Since TMDs were first described, they have been identified and described in a variety of ways, including Temporomandibular Disorder, Craniomandibular Disorder and Temporomandibular Joint Dysfunction, which vary in use by location and preference. In 1983, the American Dental Association determined that describing TMD in the plural as "Temporomandibular Disorders" more accurately reflected the group of multiple disease processes that fall under the broader term, however other terms persist within the literature. Most colloquially, Temporomandibular Disorders are simply referred to as "TMJ" (Yost, et al., 2020). Within this document, I will use "TMD" when describing a specific disorder variation (such a muscle - related TMD) but use "TMDs" to address the entire disorder group.

References to TMDs in voice pedagogy literature

A review of voice pedagogy literature provides a framework through which to understand what information is already accessible to voice teachers within their field. TMDs and the TMJs are discussed in a variety of ways and to varying degrees of detail within voice pedagogy literature. A brief review of voice pedagogy literature since the year 2000 revealed recommendations for jaw use during singing to achieve maximal resonance (Bozeman, 2014; Chapman, 2017; Malde, 2017; Miller, 2004; Murry & Benninger, 2008; Nair, 2007; Sataloff, 2017) and recommendations to relieve tension in the jaw or increase maximal opening (Chapman, 2017; Gagné, 2012; Murry & Benninger, 2008; Rosenberg & LeBornge 2014; Titze

& Abbott, 2012; Sataloff, 2017; Scearce, 2016). Many sources mentioned either the jaw or the temporomandibular joint without mentioning Temporomandibular Disorder (Chapman, 2017; Sapienza & Hoffman, 2018), some briefly described TMDs and the effects on singing (Miller, 2004; Sataloff, 2017), and some included experience-based theories as to the cause of TMDs in singers (Davies, 2015; Malde, 2017; Miller, 2004; Salaloff, 2017; Titze & Abbott, 2012). While some texts (LeBornge & Rosenberg, 2014; Sataloff, 2017) outlined the relationship between the larynx, jaw, and tongue, most descriptions were limited to the jaw itself or the masticatory system (Malde, 2017), and none addressed postural factors. Several authors referred to external practitioners for treatment, such as physical therapists, dentists, or oral surgeons (Scearce, 2016; Davies, 2015). Sataloff (2017) included the most thorough descriptions, focusing on the effects of TMDs on the voice, comorbidities, and effects of aging on an existing TMD. Of the two sources found that focused on voice disorders specifically (Sapienza & Hoffman, 2018; Stemple et al., 2018), neither mentioned TMDs and only Sapienza and Hoffman mentioned the TMJ. Mention of TMDs within these sources was inconsistent and incomplete, indicating that combined, these sources would still present only a partial picture of the disorder. This document serves to address this gap, describing the disorder comprehensively and in ways that may be useful for singers and voice teachers. Towards that end, comprehensive descriptions of pathophysiology, impact on singing, treatment, and adaptations in the voice studio are included.

Voice teachers' collective understanding of TMDs on social media

Another important and increasingly relevant source of knowledge can be found on social media. Social media groups, such as the Facebook group "Professional Voice Teachers", provide a forum for voice teachers and singers to discuss singing technique and share their questions about vocal health and pedagogy. Between 2018 and 2019, there were 33 questions

containing the keyword "jaw", "TMJ", "TMD", and "Temporomandibular" on this Facebook group, consisting of 15 questions concerning mitigation and prevention of jaw tension in singers, 6 questions about the effects of jaw surgery and care of the voice after jaw surgery, six general questions about how to address "TMJ"/TMDs and TMJ pain, two questions about "jaw popping" in students, two questions looking for advice on medical referrals, and one question about assigning repertoire to a student with dysphonia and TMD. Answers focused on referral to medical practitioners and personal and experience-based exercises for reducing jaw tension. Overall, voice teachers conceptualized TMDs as an issue of occlusion, and an issue of jaw tension from poor posture, stress, or tension radiating from other parts of the body. Recommended treatment modalities included yoga, Feldenkrais, Alexander Technique, massage, myofascial release, chiropractic adjustments, Botox, surgery, and occlusal adjustments. This dialogue and concomitant responses, suggest that, among voice teachers, questions regarding TMDs and TMD symptoms are frequent. Solutions offered by other teachers demonstrate a wide range of approaches to teaching students with TMDs, indicating a decentralized knowledge base that may not be built upon a comprehensive understanding of these disorders. While voice teachers can access a large body of information regarding TMDs, conceptualization of and recommendations for TMDs vary considerably between teachers and are largely experience-based. Further, it is unclear if voice teachers have access to sufficiently comprehensive, science-based knowledge of TMDs.

Rationale

Voice teachers have a dual responsibility to their students, in that, beyond the cultivation of musicianship, they play a central role in teaching singing technique while assisting singers in maintenance of a healthy and functional voice. While teaching the dysfunctional voice, the

teacher should strive to minimize further damage and to offer pedagogical instruction and tools to assist singers with voice disorders. Therefore, voice teachers could benefit from developing an understanding of common health problems, such as TMDs, affecting the singing voice. This understanding could facilitate vocal health through prompt recognition of signs and symptoms requiring a medical referral and the use of non-medical interventions and exercises in the voice studio (Brand, 2016).

Healthy jaw function is integral to normal voice production and resonance strategies while singing (Austin, 2007; Cookman & Verdolini, 1999; Nair, et al., 2016; Mautner, 2015 & 2016; Sundberg, 1997 & 2009). Existing literature shows that TMDs impact singing in multiple ways (Amorino & Taddy, 1993; Burt & Burt, 2014; Clukey, 2017; Frey, 1988), and are associated with voice disorders (Demmick-Geertman & Dejonckere, 2002; Gois, et al., 2018; Kerveskari, et. al., 1988; Luyten, et al., 2016; Moradi et al., 2014; Morisso, 2006; Pereira, et al. 2010; Pernambuco, et al., 2017; Silva, et al., 2007). Existing literature suggests that singers report inadequate understanding and insufficient guidance from voice teachers regarding singing through TMDs (Amorino & Taddey, 1993; Burt & Burt, 2014; Libin & Warren, 1988), possibly indicating that voice teachers have insufficient resources to address the disorder.

The purpose of this document is to summarize and synthesize information about Temporomandibular Disorders that are relevant to singing in order to support voice teachers in the teaching studio. The first section of this document, encompassing Chapters 1 through 3, establishes a foundational understanding of TMD and its relationship to singing for voice teachers. Chapters 1 and 2 include descriptions of TMJ anatomy and function, and an outline of the pathophysiology and progression of TMDs. A literature review in chapter 3 outlines the current research regarding associations between TMDs and the voice, the impact of TMDs on

singing and voice use, and the ways in which singing can exacerbate or mitigate symptoms of a TMD. Building upon the foundation laid in the first section, the remaining chapters offer specific guidelines for voice teachers. Chapter 4 contains tools to help voice teachers know when and to whom to refer students showing symptoms of TMDs. Chapters 5 and 6 include recommendations for voice lesson adaptations and recommendations for what information about TMDs should be passed along to the singing student. Chapter 7 concludes the document with a discussion of conclusions and areas for future research. Additional resources for voice teachers and singers are compiled in the appendix.

By comprehensively describing TMDs and addressing challenges for both singers and teachers, this dissertation addresses an important gap in voice pedagogy literature, providing a comprehensive understanding of TMDs and the multifaceted relationship between TMDs and singing.

Note on gender-related terminology

Terminology surrounding gender is currently being debated in the voice community, however the literature referenced in this document used the term “female” or “woman” without differentiating between biological characteristics and identity. The transgender, non-binary, and gender non-conforming community has not yet codified preferred language to reflect these differences, but "Assigned Female At Birth" may, at present, be the best available term to use. Despite this, the exact terms utilized in the literature were used when referencing specific articles.

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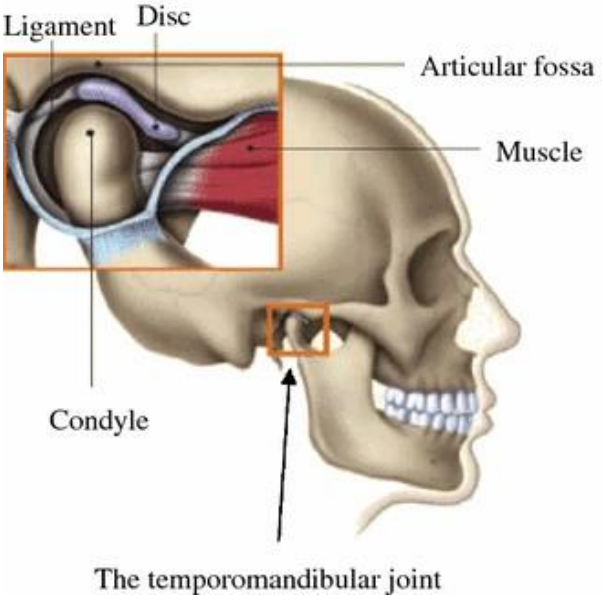
Chapter II: Anatomy and Pathophysiology of the Temporomandibular Joint

This chapter provides an overview of the anatomy and pathophysiology of the Temporomandibular Joint (TMJ). Section 1 describes the structure and function of the TMJ. Section 2 outlines the history of Temporomandibular Disorders. Section 3 describes the pathophysiology of Temporomandibular Disorders (TMDs), which occurs when there is inflammation of muscles or tissues surrounding the TMJ or dislocation of the TMJ cause pain or dysfunction to occur. This overview provides a framework for TMDs, with which voice teachers may better address voice problems that may arise in the voice studio as a result of TMDs.

Section 1: The Anatomy and Function of the Temporomandibular Joint

Structure of the Temporomandibular Joint

Figure 1
Anatomical structure of the temporomandibular joint (TMJ). (Ingawalé, et al., 2009)



Within the human body, joints connect pairs of bones in such a way that they can move, or articulate, to accomplish specific tasks. The TMJ is a condyloid joint, made up of the condyle,

a dome shaped prominence on the superior portion of the mandible, and the articular (mandibular) fossa, a similarly shaped cavity in the temporal bone (see Figure 1). Since the TMJ is a type of synovial joint, the condyle and articular fossa are not connected by solid tissue, but rather are divided by a cavity filled with synovial fluid, which lubricates articulation. Secretion of synovial fluid is stimulated by the demands of joint use, however prolonged compressive forces to the articular surfaces of the joint will deplete the supply of synovial fluid (Hand & Frank, 2014). The *meniscus*, or articular disc, a structure of dense, connective tissue, divides the cavity, forming a dual articulatory surface for the joint. The disc varies in thickness across its surface, and during normal function the condyle should be positioned in its centermost portion, which is the thinnest part of the disc. (Benoliel & Sharav, 2015; Hand & Frank, 2014).

Histology

The articular disc consists almost exclusively of densely organized collagen fibers. In contrast, the articular surfaces of the TMJ, that is, the articular eminence and the head of the condyle, consist of four layers: the articular zone, the proliferative zone, the fibrocartilaginous zone, and the calcified cartilage zone. The articular zone is the most superior layer, and in contrast to other synovial joints, contains dense, fibrous connective tissue rather than hyaline cartilage, making it better able to manage the biomechanical load on the joint. Beneath, the proliferative zone is responsible for the proliferation, or new growth, of articular cartilage in response to pressure upon the articular surfaces. The third layer, the fibrocartilaginous zone, contains a dense organization of collagen, proteoglycan, chondrocytes that is more resistant to tensile and shearing forces of mandibular movements. The deepest layer, the calcified cartilage zone, contains hypertrophic cartilage cells and is participant in the repair process of underlying bone tissue (Benoliel & Sharav, 2015; Hand & Frank, 2014).

Ligaments

The articular disc of the TMJ is held in place by tissue and ligaments. Unlike muscles, ligaments do not move the joint. Made of nonelastic fibers of set lengths, ligaments function to allow normal movement while limiting extremes of movement. However, if the joint consistently and repeatedly attempts to move past those limits, the ligaments will stretch and become permanently lengthened, a change that affects joint function (Okeson, 2020). The external ligaments that provide support to the entire joint are the temporomandibular and sphenomandibular ligaments, assisted by the stylomandibular ligament and the pterygomandibular raphe (David & Elavarsi, 2016).

Within the capsule, additional ligaments support and limit the movements of the disc itself, allowing for the forwards-backwards motion of the disc during mouth opening and closing, while limiting side-to-side movements. These capsular ligaments, which, unlike those supporting other synovial joints, contain vascularized tissue, form a web that surrounds and protects the entire joint structure (Benoliel & Sharav, 2015). The back of the disc also attaches to the retrodiscal tissue, which is bordered and, in a healthy joint, protected by the retrodiscal laminas. Since retrodiscal tissue is highly innervated and vascularized, however, the loading placed on it during disc dislocation in TMDs is often responsible for symptoms of pain (Hand & Frank, 2014; Okeson, 2020).

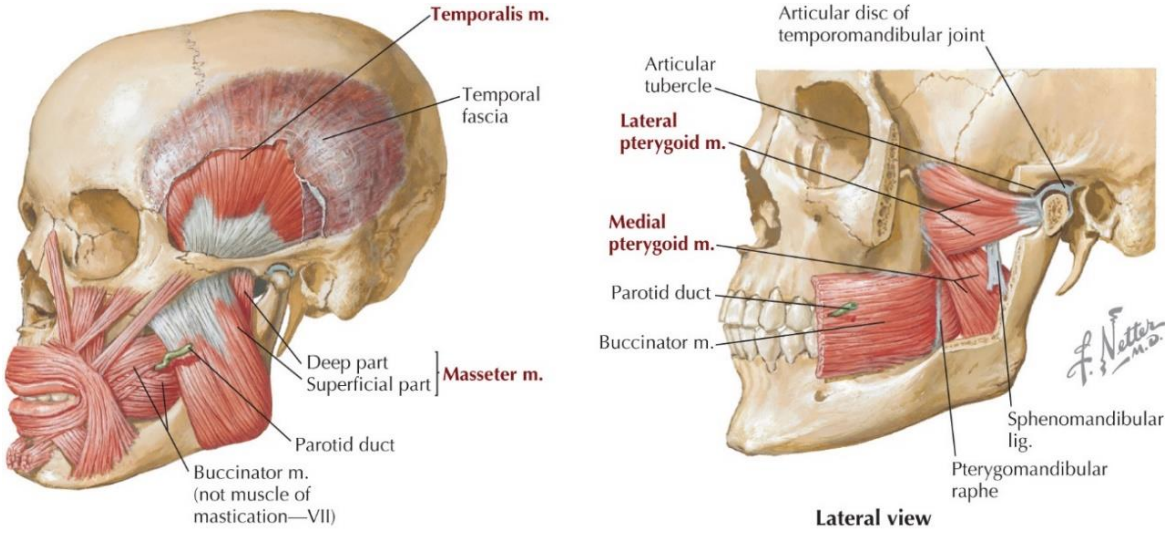
Musculature

Several muscles are responsible for the movement of the jaw. Mandibular depressors, which consist of the geniohyoid, the mylohyoid, the anterior bellies of the digastric muscles, and

portions of the lateral pterygoid, open the jaw. Figure 2 identifies these muscles and their location in relation to the jaw.

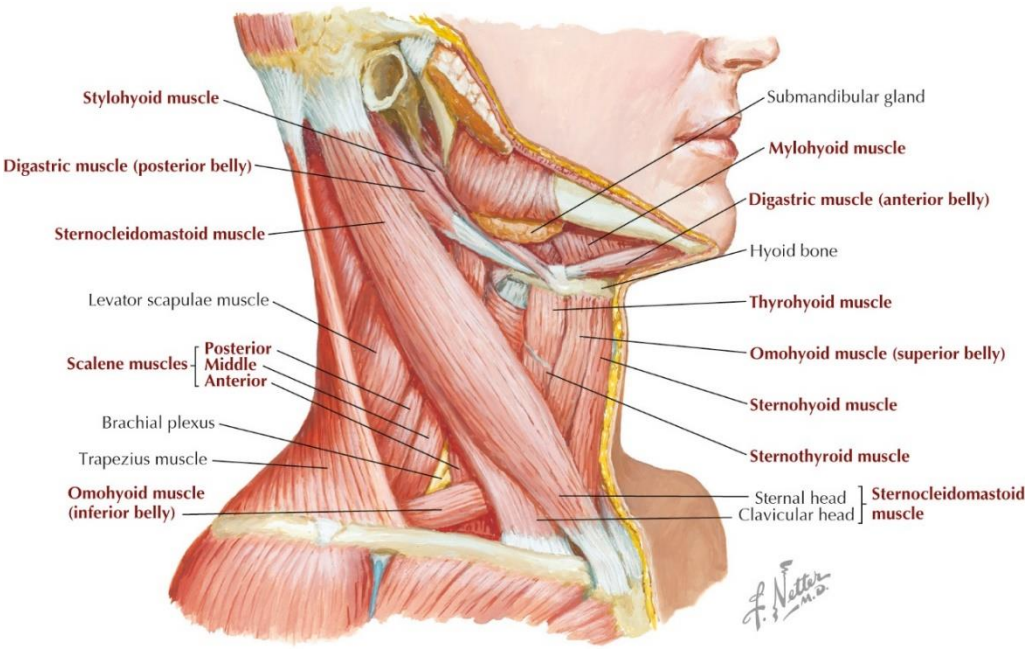
Figure 2

Muscles of Mastication (Hansen, 2018)



The masseter, medial pterygoid, and temporal muscles close the jaw. Protrusive (forward) movements are caused by the lateral pterygoid muscles, portions of the medial pterygoid, temporal, and masseter muscles. It is interesting to note that muscles from the opposite side contract, pulling the mandible towards them, to make lateral movements (Hohmann & Hielscher, 2014). With the retrodiscal lamina, the superior lateral pterygoid (SLP) muscle additionally works to stabilize the articular disc, contracting to limit forward translation of the joint (Benoliel & Sharav, et al, 2015). The SLP also works with the mandibular elevator muscles to close the mouth. The inferior lateral pterygoid contracts to move the TMJ forward during jaw opening. Additionally, the infrahyoid muscles (omohyoid, sternohyoid, and sternothyroid) and the suprahyoid muscles (digastric, stylohyoid, mylohyoid, and geniohyoid) work to stabilize the TMJ (Hand & Frank, 2015) (Figure 3).

Figure 3
Muscles of the Neck. (Hansen, 2018)



Innervation and vascularization

Vascularization and innervation vary throughout the TMJ. Blood vessels that supply the TMJ include the superficial temporal artery, the internal maxillary artery, the meningeal artery, the deep auricular artery, the anterior tympanic artery, and the ascending pharyngeal artery (Maini & Dua, 2020). The trigeminal nerve, which originates in the medulla oblongata, is the paired nerve responsible for innervation for the oral cavity, the masticatory muscles, and parts of the face. From the mandibular division of the trigeminal nerve stems nerves that control the masticatory muscles, named after the muscles that they innervate: the lateral pterygoid nerve, the medial pterygoid nerve, the temporal nerve, and the masseteric nerve (Hohmann & Hielscher, 2014). Sensation within the TMJ itself is primarily achieved through the auriculotemporal branch of the mandibular division, though the masseteric and deep temporal nerves also play a role. While these nerves are present within the capsule and synovium of the joint, they are largely

absent in the condyle and mandibular fossa. Normally, the articular disc is avascular and only peripherally innervated; therefore, joint pain is primarily radiated from the more highly innervated retrodiscal tissues, the capsule, or the synovial tissues. However, some research has shown that inflammation can trigger nerve sprouting into the central portion of the articular disc and can induce increased sensitivity to pain (Benoliel & Sharav, 2015).

Function

The TMJ is a *ginglymoarthrodial joint*, meaning it can both rotate and glide, or translate, forwards. To rotate, the condyle of the joint moves along the inferior surface of the articular disc, but to translate, both the condyle and interarticular disc must move as one unit, known as the *condyle-disc complex*, along the articular arch of the mandibular fossa (Hand & Frank, 2014; Okeson, 2020). Thus, the TMJ functions as a double joint, with one articular space superior and one inferior to the disc, the use of which depends upon the functional demands of mouth opening. Unlike other double joints, however, the two articulatory surfaces of the TMJs function concurrently (Beaumont, et al., 2020). During more narrow openings of the jaw, such as during most speech, the rotation of the condyle is sufficient. However, for wider openings, beyond approximately the first 20-30 mm, the joint must both rotate and translate forward to accommodate increased range of motion, while maintaining constant contact between the articular surfaces of the joint. Full range of normal mouth opening is on average at least 40mm. Limited lateral movements are also possible, allowing for asymmetrical motion during activities such as chewing and speech. During such movements, each TMJ articulates differently. For example, if the mandible moves to the right, the left TMJ translates forward, while the right remains seated in the articular fossa (Hand & Frank, 2014).

Due to its position in the skull and the complex motions of the TMJ, the joint is designed to withstand diverse mechanical forces. Therefore, the condyle of the joint is suited to withstand the compressive forces from closed or clenched mouth positions, and the articular eminence, which is the anterior portion of the mandibular fossa, is suited for the shearing and tensile forces of lateral and protrusive, full range jaw movements.

Mandibular movements are determined by three possible guidance factors. The capsule and ligaments, through condylar guidance, limit movements to the articular path formed by the shape of the condyle and disc, by the capsule and ligaments. Movements are further limited by tooth guidance, or the spatial arrangement of pairs of occluding teeth. The neuromuscular system of the masticatory muscles provides neuromuscular guidance (Hohmann & Hielscher, 2014). Alterations to any one of these guidance factors can affect TMJ function. For example, changes to the pressure on the surface of the disc can alter its shape, thus altering the movement of the joint resulting in changes that are associated with symptoms of TMDs. Trauma or repetitive lengthening of the ligaments that limit forward movement can allow the disc to become displaced forward through the action of the superior lateral pterygoid (Maini & Dua, 2020; Okeson, 2020).

The complexity of the joint and it the structures that control its movement provide many opportunities for symptoms of TMDs to emerge. This increases the challenges of TMD diagnoses and has contributed to much debate regarding the causes and corresponding treatments for TMDs.

Section 2: History of Temporomandibular Disorders

An agreed upon understanding of the origins and diagnostic criteria of TMDs has been the subject of much controversy and disagreement. One of the earliest researchers to describe

problems affecting the TMJ, observed atrophy of the TMJ after tooth extractions (Prentiss, 1918). Problems affecting the TMJ were first called "Costen's Syndrome" after Costen, an otorhinolaryngologist, theorized that dysfunction of TMJs, resulting from misalignment of the teeth, caused hearing problems and pain in the face and ears (Costen, 1934). While his theory was later disproved, Costen's definition became the first and most widely accepted in the field of dentistry, and his work encouraged clinicians and researchers to devote energy to treating TMJ and orofacial pain (Skármeta, et al., 2019).

Biomedical model

The theory that mechanical dysfunction caused TMDs persisted throughout the next few decades (Kandasamy & Green, 2020; Ohrbach & Dworkin, 2016; Skármeta, et al., 2019). Researchers believed that poor occlusion between teeth resulted in an incorrect condylar position and aberrant muscle patterns, causing pain, metabolic depletion, and muscle spasms. Such occlusal imbalances, however, were believed to be corrected with orthodontic treatment (Skármeta, et al., 2019). This view of a strictly mechanical etiology became particularly common in orthodontic practice, and was consistent with the traditional biomedical model that "assumes disease to be fully accounted for by deviations from the norm of measurable biological (somatic) variables" (Engel, 1977, p130). Orthodontists attempted to define an optimal occlusion pattern and condylar/disc position that could be achieved through orthodontics and surgery. While this theory is still widespread, systematic research has not shown a consistent association between TMD and mechanical position of the teeth and condyle, nor compelling evidence to the efficacy of invasive, mechanical treatment plans (Kandasamy & Green, 2020;).

Biopsychosocial model and the DC/TMD

The biomedical model of TMDs was first challenged in the field of psychology, and later in other medical fields. In 1955, Dr. Laszlo Schwartz proposed alternative etiological considerations for TMDs, describing his observations of TMD symptoms in conjunction with emotional stress and identifying several "predisposing emotional factors" (Schwartz, 1955; 1959). This research was later correlated with other studies that addressed the inconsistencies in a purely mechanistic model (Laskin, 1969;1970), and became the first step in the reconceptualization of painful TMDs as a chronic pain syndrome within the biopsychosocial model.

The biopsychosocial model, first proposed by Engel (1977), refers to three terms: "bio" meaning a biological problem, "psycho" meaning the emotional components of pain and suffering, and "social" meaning the social and cultural framework of the patient (Skármeta, et al., 2019). Drawing from the field of psychology and informed by the biopsychosocial model, Dworkin proposed the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD), a clinical and research tool that combined data from both physical and psychosocial patient profiles (Dworkin, 1992). More recently, research from a series of studies that began in 2006 (Orofacial Pain: Prospective Evaluation and Risk Assessment [OPPERA]) has significantly improved our understanding of risk factors in both the development of first-onset TMDs and their progression into chronic, painful conditions. Data from these OPPERA studies, in addition to supporting the biopsychosocial model, was used to refine and improve upon the RDC-TMD in the form of newer criterion systems, such as the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) and the Expanded DC/TMD (Ohrbach & Dworkin,

2016). Additionally, the OPPERA studies led to the classification of TMDs as internationally recognized chronic pain disorders (Kandasamy & Green, 2020; Skármeta et al., 2019).

Section 3: Defining and Classifying Temporomandibular Disorders

Temporomandibular Disorders are now best understood as a group of painful and/or dysfunctional musculoskeletal conditions affecting the masticatory muscles, temporomandibular joints, and associated structures (Kapos, et al., 2020; Maini & Dua, 2020). Rather than a disorder localized in origin to the TMJ, TMDs are the result of multiple risk determinants (Ohrbach & Dworkin, 2016). As a result, a classification system for the various TMDs, delineated by etiology and symptoms, presents a clearer picture of their scope and impact.

Classification of TMDs

According to the Diagnostic Criteria for Temporomandibular Disorders (DC-TMD), the two broad categories for TMDs are joint-related disorders (sometimes called *arthrogenous* TMD), and masticatory muscle-related disorders (sometimes called *myogenous* TMD) (Benoliel & Sharav, 2015; Schiffman, et al., 2014; Valesan, et al., 2021). Masticatory muscle-related TMDs arise when pain in the masticatory muscles occurs during swallowing, speaking, or chewing. Such pain is associated with restricted mandibular function. This is the most common source of TMD pain. Joint-related TMDs can manifest as dislocation or displacement of the disc, alterations to the smooth articulatory surfaces of the joint (the disc, condyle, and mandibular fossa) causing friction or hypermobility during articulation; and inflammatory disorders of the TMJ.

Figure 4

Classification of TMDs (Schiffman, et al., 2014)

Taxonomic Classification for Temporomandibular Disorders

I. TEMPOROMANDIBULAR JOINT DISORDERS

1. Joint pain

A. Arthralgia

B. Arthritis

2. Joint disorders

A. Disc disorders

1. Disc displacement with reduction

2. Disc displacement with reduction with intermittent locking

3. Disc displacement without reduction with limited opening

4. Disc displacement without reduction without limited opening

B. Other hypomobility disorders

1. Adhesions / adherence

2. Ankylosis

a. Fibrous

b. Osseous

C. Hypermobility disorders

1. Dislocations

a. Sublaxation

b. Luxation

3. Joint diseases

A. Degenerative joint disease

1. Osteoarthrosis

2. Osteoarthritis

B. Systemic arthritides

C. Condylysis/idiopathic condylar resorption

D. Osteochondritis dissecans

E. Ostronecrosis

F. Neoplasm

G. Synovial chondromatosis

4. Fractures

5. Congenital/developmental disorders

A. Aplasia

B. Hypoplasia

C. Hyperplasia

II. MASTICATORY MUSCLE DISORDERS

1. Muscle pain

A. Myalgia

1. Local myalgia

2. Myofascial pain

3. Myofascial pain with referral

The DC-TMD identifies 12 common TMDs, classified by their clinical presentation: arthralgia (joint pain), myalgia (muscle pain and its three subcategories, related to the location of pain on palpation), four categories of disc displacement, degenerative joint disease, subluxation (self-reducing joint dislocation), and headache attributed to TMD. Additional, less common TMDs, such as arthritis, hypomobility, fractures, and congenital disorders are included in the Taxonomic Classification for Temporomandibular Disorders, proposed within the DC-TMD (Schiffman, et al., 2014), presented in Figure 4.

Prevalence of TMDs

TMDs are a commonly diagnosed group of disorders, affecting between 5 and 12% of the population, and is the most common cause of chronic pain in the orofacial area without a dental cause (Valesan, et al., 2021). Due to the inconsistencies in diagnostic criteria, however, there exists no consensus on actual prevalence. Sixty-five percent of painful TMDs present as recurrent symptom episodes. A recent meta-analysis conducted using either the RDC-TMD or DC-TMD, revealed overall prevalence of 31.3% for adults and 11% for children/adolescents (Valesan, et al., 2021). According to studies conducted with the RDC-TMD, TMD is twice as likely to be diagnosed in females[1], regardless of age group, and that females report more impact from TMD pain in their quality of life (Kapos, et al., 2020). Additionally, women are, at an 8:1 ratio, more likely to seek medical care at a clinic for TMD pain (Shaefer, et al., 2013).

It is also important to distinguish between acute and chronic TMDs. The OPPERA cohort study, for example, found that 51% of adults with new onset TMDs no longer met diagnostic criteria after eight months. However, remittance rates decreased with time, indicating

[1] The female/male and men/women binaries were used through the chapter to reflect the way data were reported in the research discussed in the chapter.

that more chronic TMDs may be less likely to self-resolve. It is more common for TMDs in women or female subjects to become chronic (Bueno, et al., 2018; Kapos, et al., 2020).

Causes of TMDs

As complex as the classification of TMDs is, so are the factors leading to TMD onset. TMDs are considered to have a multifactorial etiology, meaning that several factors can work congruently to cause and progress TMDs (Kapos, et al., 2020; Maini & Dua, 2020). These factors are commonly divided into three categories:

1. Predisposing factors that increase the risk of TMDs. These can be systemic, psychologic, structural, or genetic. Research in this area is ongoing, but some studies have begun to identify hormonal and genetic biomarkers associated with TMDs (Kapos et al., 2020). Other commonly associated predisposing factors include comorbid conditions such as irritable bowel syndrome (IBS), fibromyalgia, insomnia, or depression; higher pain interference with daily life; oral parafunctions, such as bruxism or gum chewing; masticatory muscle pain upon palpation; old age; and greater somatic awareness.

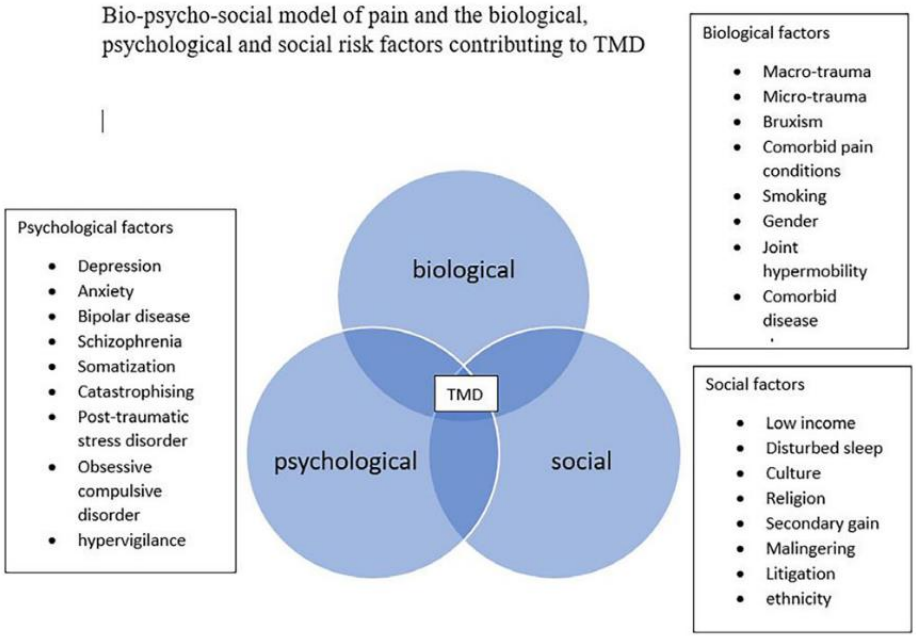
2. Initiating factors that precipitate disorder onset. Examples of this might be traumatic events involving the jaw such as dental surgery, head injury, oral intubation, or more chronic microtraumas such as those associated with bruxism or gum chewing.

3. Perpetuating factors that prevent or complicate healing and symptom management. The most significant perpetuating factors are pain sensitivity, pain severity, psychosocial factors, and comorbid conditions (Kapos, et al., 2020; Maini & Dua, 2020).

Etiologic factors can be further understood within the biopsychosocial model, since biological, psychological, and social factors all contribute to incidence of TMDs (Beaumont, et

al. 2020). Depending on the individual and on the TMD, the process of onset and severity progression can vary significantly. The OPPERA cohort studies revealed that gender differences in TMD prevalence all but disappeared when only new-onset cases were considered, indicating that the higher incidence in women may be due to a greater degree of chronicity, and that the presence of perpetuating factors, including gender, is associated with more severe, chronic cases. Beaumont (2020) provides a useful graphic outlining the various factors within this model (Figure 5).

Figure 5
Biopsychosocial model of pain (Beaumont, 2020)



Psychological factors in TMD pain and dysfunction

The biopsychosocial model highlights the psychological elements that factor in the experience of pain. In this model, pain is not merely a physical sensation, but also an emotional experience that is affected by the underlying emotional state. Psychological disorders such as depression, anxiety, or post-traumatic stress disorder can alter or increase pain perception,

contributing to the negative experience of pain (Schiffman, et al. 2014). This experience in turn influences coping strategies that arise in response to pain, which may help or hinder function, and thus impact the treatment outcome in patients with TMDs (Beaumont, et al., 2020; Schiffman, et al., 2014)). Coping strategies for pain may include thought processes or physical actions to mitigate or work through pain. (Aaron et al., 2005). Research shows that mal-adaptive strategies, such as catastrophic thinking (including negative beliefs on the patient's own ability to adapt to or recover from pain and dysfunction) or restrictions on normal mandibular behavior, are associated with more severe levels of pain and dysfunction that do not correspond with physical measures (Brister, et al, 2005; Turner, et al., 2001 & 2005). Significantly, disability in non-masticatory activities, including phonatory activities such as laughing or speaking, was significantly associated with negative beliefs and catastrophizing (Turner, et al., 2001).

Thus, pain is both a disease, that is, objectively observable tissue damage, and an illness, that is, a subjective experience (Sharma, et al., 2019). Personal beliefs about pain correspond both with experience and prognosis within pain disorders, including TMDs.

TMDs as Central Sensitization Syndromes

Another potentially useful way researchers conceptualize chronic TMDs is within the framework of *Central Sensitization Syndromes,* defined as "disorders characterized by chronic nonneuropathic and non-nociceptive pain; the pain is not proportional to the type of injury/ damage and it must be accompanied by the presence of neurophysiological/ neuropathological phenomena" (Monaco et al., 2017, pp. 1-2). In such syndromes, neural signaling within the Central Nervous System (CNS) is amplified in such a way that elicits hypersensitivity to pain, resulting in a lower threshold for pain stimulus and more intense, longer activation. TMD pain is often disproportionate to observable symptoms and, moreover, is frequently comorbid with other

chronic pain syndromes, such as fibromyalgia, headache/ migraine, irritable bowel syndrome, and low back pain (Dworkin & Massoth, 1994, Monaco et al., 2017). In the case of TMDs, central sensitization is triggered by muscle tension or joint/tissue inflammation, but once established, becomes independent of injury or damage to the masticatory system. Thus, pain is resistant to healing of original damage (Monaco et al., 2017). In turn, then, the neuroplastic changes to the CNS produced by sustained pain perception result in subsequent motor behavior changes. Functionally, these changes to motor behavior, such as jaw opening or deviation, result in increased levels of disability, poorer quality of life, and a vicious cycle of increased perception of pain (Gil-Martínez et al., 2018).

TMD symptoms and signs

Distinguishing between TMDs is challenging due to their overlapping symptomology and the occurrence of both muscle and joint-related signs and symptoms within a single case. While the exact range of symptoms will vary between patients, cases requiring treatment will show pain and functional limitations, particularly to range of motion, and tend to present as recurring rather than singular episodes (Kapos, et al., 2020). Joint-related pain can originate from the discal ligaments, the retrodiscal tissue, the TMJ capsule, or the articular surfaces of the joint (arthritis). Muscle-related pain originates from the masticatory muscles (myalgia) (Okeson, 2020). It is significant to note that most limitations to mouth opening are muscular in origin (Benoliel & Sharav, 2015, p. 278).

Tinnitus, dizziness, fullness of the ear, earache, mandibular deviation upon opening, neck pain, bruxism, and joint clicking or crepitus are also possible symptoms (Benoliel & Sharav, 2015, ch.8-9; Chang et al., 2018). Further, symptoms will fluctuate throughout the disease process and new symptoms can emerge as others are resolved. A high baseline pain frequency,

painful palpation sites, and other body sites with pain are all indicators of persistent chronicity of the disorder (Benoliel & Sharav, 2015).

Section 4: TMJs and the Voice

Given the nearness of the laryngeal and masticatory systems, it is not surprising to observe numerous physiological connections between TMJ and vocal function.

The singing voice is produced when contraction of the muscles located within the larynx form resistance to expiratory airflow. The larynx, a group of interlocking cartilaginous structures, is suspended from the hyoid bone, which, in turn is located inferior, and slightly forward in relation to the TMJs. Free movement of the larynx is necessary for both swallowing and singing, however tension in the infrahyoid and suprahyoid muscles can limit this movement. The infrahyoid muscles and suprahyoid muscles that function to stabilize the TMJs also work to stabilize and move the larynx (Leborgne & Rosenburg, 2014; McCoy, 2019). Furthermore, the suprahyoid muscles directly connect the hyoid bone and the mandible, indicating overlap between the masticatory and phonatory systems. Since the suprahyoid muscles connect the hyoid bone to the mandible and tongue, it is possible that jaw and tongue tension could contribute to laryngeal tension.

Research on the muscular and neurological connections between these structures adds support to this perspective (Luo, 1991; Travers, 1983; West, 1995). Zhang et al. (2005) observed neural circuitry directly connecting jaw opening and laryngeal muscular movement, possibly for coordinating jaw movement and speech. Additionally, the adjacency of the cranial nerves that innervate the jaw and the laryngeal muscles could lead to a relationship between their function and pain response (Leborgne & Rosenberg, 2014).

Conclusions

A baseline understanding of the anatomy and function of the TMJs and associated structures provides a framework for an understanding of TMDs. The biopsychosocial model of TMDs provides the most comprehensive understanding of these disorders, encompassing factors that many singers deal with in their work lives. As such, this model provides voice teachers with a lens through which to understand TMDs in singers. From this perspective, it is important to understand that the TMJs, rather than existing in an isolated system, are connected physiologically and functionally to the larynx. This knowledge functions as a foundation for understanding the ways in which TMDs can be understood and addressed in singers.

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Chapter III: TMDs in Singers

Introduction

Voice teachers may find it helpful to develop an understanding of the relationship between TMJ function and singing both in healthy singers and in those with TMDs. As such, this chapter describes jaw function in singing and other voice use, explores the relationship between TMDs and singing, discusses etiological variables common in the singer population, and addresses comorbidities with TMDs that affect the singing voice. The chapter concludes with major takeaways for the voice studio, limitations of existing research, and areas for future research.

Section 1: Jaw Function in Singing

Researchers have discussed the importance of TMJ/jaw function in normal voice production, both in speech and singing, primarily through its effects on phonation and resonance. Thus, changes to jaw function have a measurable impact on voice parameters.

In phonation

Cookman and Verdolini (1999) found that, in non-singers without TMDs, jaw opening and jaw biting pressure affected laryngeal adduction (closing pressure of the vocal folds). Specifically, at conversational pitch, a more open jaw position was associated with increased adduction in males and females[2], and a more relaxed biting pressure was associated with decreased adduction in male subjects. At higher pitches, results were more variable between subjects. Research has shown that, while sufficient adduction is needed to sustain healthy phonation, hyperadduction can cause voice pathologies and negatively impact voice quality (Stemple et al., 2014; Sataloff et al., 2017). Jaw opening further correlated with speaking

[2] The female/male and men/women binaries were used through the chapter to reflect the way data were reported in the research discussed in the chapter.

fundamental frequency (average pitch of the speaking voice) (Limet al., 2006) and aerodynamic efficiency (Mercer & Lowell, 2020). Associations between jaw opening and voice quality were also observed in the aging speaking voice (Mautner, 2015; Mautner, 2016).

In resonance

Singers use jaw opening as a strategy to control resonance. The vocal folds produce frequencies that are sent through the vocal tract where, depending on its shape, some are amplified (resonated) and others attenuated. The resulting sounds are what we perceive as vowels and timbre. For resonant singing, the sung pitch must fall within the pitch ranges naturally amplified by the mouth and throat, known as the first and second *formants* of the voice, respectively. Moving the jaw modifies the shape of the mouth to raise or lower its formant (Formant 1, or F1), thus ensuring clarity and resonance of vowels throughout the range (Bozeman, 2014). Sundberg and Skoog (1997) studied jaw opening in conjunction with resonance strategies in 10 singers, observing variability in magnitude of jaw opening, but a consistent opening when the fundamental frequency (in singing, the perceived pitch) became higher than F1. Dropping the jaw raised F1, a strategy consistent with the acoustic coupling between the fundamental and F1 necessary to maintain resonant head voice, or falsetto, in singing. This occurred primarily on open vowels, while on closed vowels, the singers utilized tongue position to raise F1 (Sundberg & Skoog, 1977). Sundberg later observed that a professional soprano consistently opened her jaw wider when the fundamental frequency sung became approximately five semitones above the normal range of her first formant (Sundberg, 2009). It is also significant to note that the second formant, responsible for definition, ring, and clarity of vowels is primarily influenced by tongue position (Bozeman, 2014; Bozeman, Sundberg & Skoog, 1997). Since the jaw and tongue are muscularly connected, it seems

reasonable to expect that the concurrent tongue and jaw tension associated with TMDs might impact tongue position and, indirectly, the effectiveness of F2 resonance strategies[3] (Bozeman, 2021; Sataloff, 2017).

Jaw position for singing

Optimal jaw position must be relatively dynamic throughout the singing range to accommodate vowel and acoustic requirements. Austin (2007) observed a wider jaw opening for the vowel [a], compared to [i] or [u], and wider opening for higher pitched singing among both "novice" and "experienced" singers. One technique observed in singers was the Low Mandible Maneuver (LMM) (Mercer & Lowell, 2020; Nair et al., 2015; Saltürk et al., 2020). While depictions of the actual maneuver vary somewhat, this position indicates a lower mandibular position overall for all vowels throughout the range, while still maintaining vowel clarity. Nair et al., (2015) observed a higher percentage of mouth opening during singing, lowered posterior portion of the mandible, lowered larynx, more active tongue movement, and neck muscles free of tension as observable markers for the maneuver in five elite singers (Nair et al., 2015). Mercer and Lowell (2020) found this jaw position increased aerodynamic efficiency in speech, and Saltürk et al., (2020) reported that symptoms of mutational falsetto in speech were resolved after use of this technique. While this jaw positioning strategy has not been observed in non-classical singers, it is an example of an evidence-based technique used in singing that requires control and freedom of jaw movement.

To summarize, it is not possible to describe a one-size-fits-all approach to jaw opening in singing. While certain jaw positions do correlate with specific vocal and acoustic parameters,

[3] For more information on formants in singing, please refer to sources such as Bozeman (2014 & 2021), Rosenberg and LeBorgne, (2014), or Miller (2008).

enough variability exists to warrant more research and an individualized approach in the voice studio. Despite this, it is important for voice teachers to understand the impact that any changes to jaw function, however minor, can have an impact on the voice. Given the previously described relationships between jaw opening, resonance, and phonation, it is also reasonable to expect that functional limitations from TMDs could dramatically impact singing.

Section 2: TMDs and the Voice

Literature overview

In order to frame the current understanding of the relationship between TMDs and the voice, it is important to summarize and integrate existing research. A search of databases including Medline, PubMed, Science Direct, Wiley Online Library, ProQuest, and Google Scholar utilizing the combination of the keyword [temporomandibular], voice-related keywords [sing], [singer], [voice], [vocal], [phonation], and [speech] elicited limited results. Some additional sources were found in the reference sections of the literature found, for a total of thirty-five relevant articles. Six sources contained studies assessing the prevalence and impact of TMDs in singers, in which data were gathered through questionnaires (Almeida, 2013; Amorino & Taddey, 1993; Caetano et al., 2017; Clukey et al., 2016; Frey, 1988; Van Selms et al., 2019). Another four articles described case studies or clinical observations of singers with TMDs, reflecting professional opinion of causative factors and impact (Burt & Burt, 2014; Howard, 1991; Sataloff et al., 2017; Taddey, 1992). Additionally, five articles were literature reviews that referred to one or more of the previously mentioned articles (Attallah et al., 2014; Bath, 2008; Rodriguez-Lozano et al., 2011; Van Selms et al., 2017; Yeo et al., 2002).

Nineteen articles explored TMDs and singing indirectly. Some of these articles related singing to one or more symptoms of TMDs (Vaiano et al., 2013; Vaiano et al., 2016), while others looked at TMDs or symptoms of TMDs and non-singing phonation (Boton et al., 2011; Caine, 1998; Carnauba et al., 2010; David & Elavarasi, 2016; Ferreira et al., 2008; Ferreira et al., 2010; Gois et al., 2018; Kirveskari, 1988; Luyten et al., 2016; Machado et al., 2009; Machado et al., 2014; Moradi et al., 2014; Morisso, 2006; Panday & Dutta, 2015; Pereira et al., 2010; Pernambuco et al., 2017; Silva et al., 2007). Each of these categories will be discussed in the forthcoming sections of this chapter.

Voice-related symptoms in subjects with TMDs

Numerous voice-related symptoms have been found to correlate with TMDs and/or symptoms of TMDs. David and Elavarasi (2016) identified laryngitis, sore throat, excessive throat clearing, and "voice irregularities" as possible symptoms associated with TMDs; however no references for these observations were included (pg. 106). Additional articles described associations between symptoms of TMDs and voice-related symptoms, including voice quality changes or roughness (Caine, 1998; Ferreira et al., 2008; Kirveskari et al., 1988; Morrisso, 2006; Pereira et al., 2010), dysphonia (Panday & Duta, 2015), pitch inflexibility (Caine. 1998), reduced maximum phonation time (Ferreira et al., 2008), resonance alterations (Ferreira et al., 2008; Morisso, 2006), pain or discomfort in the vocal tract (Luyten et al., 2016), vocal fatigue (Ferreira et al., 2010), self- perceived voice handicap (Moradi et al., 2014; Pereira et al., 2010), and reduced voice intensity (Silva et al., 2007). Several studies correlated TMDs or symptoms of TMDs with a screened or diagnosed voice disorder (Gois et al., 2018; Kirveskari et al., 1988; Machado et al., 2009; Machado et al., 2014; Pernambuco et al., 2017; Tohidast et al., 2020). Only one study (Carnauba et al., 2010) found no correlation between symptoms of TMDs and

voice changes, suggesting that TMDs may not always precipitate measurable changes to the voice.

Conversely, some results appear to suggest that voice changes observed in subjects with TMDs are not related to symptoms of TMJ pain. Boton et al., (2011) found a correlation between an *absence* of TMJ pain and changes in voice turbulence, a component of voice quality related to the energy level of high frequency noise during phonation. These authors suggested that observed voice quality changes may be more related to other symptoms of TMDs, such as functional limitations, rather than pain (Boton et al., 2011). Indeed, a physical therapy program that increased range of motion in subjects with TMDs resulted in improved resonance parameters (Min & Lee, 2011). Based on the physiological connections between the orofacial and external laryngeal muscles (see Chapter 2) and the importance of jaw opening in vocal resonance, it seems plausible that the singing voice could be impacted by TMDs even when no pain is present.

Whether or not these symptoms are, in fact, related to pain, researchers have found a positive correlation between treatment of symptoms of TMDs and improvement of voice-related symptoms, and, conversely, between treatment of voice disorders and improvement of symptoms of TMDs. Caine (1998) found that dental and chiropractic treatment of two subjects, a singer and an actress with TMJ pain/ asymmetry, improved voice-related parameters and allowed for a return to normal voice use. Similarly, Dworkin et al. (2000) found that treatment of Muscle Tension Dysphonia (a prevalent voice disorder) resolved both voice-related symptoms and symptoms of TMDs. Additionally, Van Lierde et al. (2004) reported that Laryngeal Manual Therapy resolved TMJ pain and improved voice quality. Thus, the research suggests a close relationship between treatment for TMDs and voice disorders.

Prevalence of TMDs in singers

Several studies (Almieda, 2013; Clukey, et al, 2016; Olufemi et al., 2020; Van Selms et al., 2019 & 2020; Vaiano, 2013, 2016) assessed the prevalence of TMDs or symptoms of TMDs in singes, with varied results. Almeida (2013) found no difference between the incidence of TMDs in singers and a control group. Olufemi et al. (2020) assessed the prevalence of TMJ pain in musicians, 75% of which were singers. While incidence of such symptoms was low (19%), it was higher in musicians than in non-musicians. Clukey et al. (2016) used a screening tool to assess the difference between TMDs in singers and instrumentalists and found that TMDs were significantly more prevalent in singers. The difference in mean TMD severity, however, was only significant when gender was not considered, as symptoms were significantly more severe in female subjects. Similarly, Van Selms et al. (2019) found significant differences between singers and other instrumentalists that disappeared when controlling for gender, time spent practicing, and harmful oral habits such as clenching and teeth grinding. Vaiano et al. (2013) found that non-professional choral singers had less body pain overall, and there was no significant difference in TMJ pain between singers and controls, but that there was a significant correlation between consultation with an SLP due to vocal problems and TMJ in both groups. In contrast, Vaiano, et al. (2016) also found that mandibular pain occurred infrequently in professional voice users, and that of all groups studied, classical singers reported body pain the least frequently.

While TMDs are common in singers, there does not appear to be a strong correlation between being a singer and a higher incidence of TMDs or symptoms of TMDs compared to other groups. It is likely that the high incidence found in singers in two of these studies (Clukey et al., 2016; Van Selms et al., 2019) was due to other factors; namely, gender, time spent practicing, and presence of harmful oral habits. Furthermore, there were significant limitations in

the methodologies of these studies. One limitation was that questionnaire design relied upon self-reporting and screening tools to assess presence of TMDs/ TMD severity, rather than a clinical diagnosis. Ultimately, more research that incorporates stronger study designs and more definitive diagnoses is needed to establish prevalence and association of TMDs in singers.

Impact on Singing

Clukey et al (2016) found that singers reported a significantly higher impact of TMD symptoms on their singing when compared to instrumentalists. Frey (1988) found that 24% of responding singers reported impairment to singing from TMJ discomfort, and in a short answer portion of the same questionnaire, singers described their experiences of tinnitus, TMJ pain during talking and singing, and jaw dislocation during singing. Amorino and Taddey (1993) gathered data from singers with a TMD diagnosis or symptoms of TMDs regarding the ways in which TMDs affected their singing. Most frequently, participants reported impact on range (from 73% of participants), emotional state (73%), endurance (71%), and tone quality/ resonance (65%). Given the importance of jaw function in resonance, and the interrelated nature of these other factors, the high frequency of reported effects is unsurprising. Only 49% of participants reported impact on diction, however those that did used adjectives such as "chewed", "crushed", and "tight" to describe their diction, which could be an indication of restricted jaw movement. In addition to the small sample size (n=51), a significant limitation of the study was that it was not possible to say whether the impact these singers reported was in fact caused by TMDs. Despite this limitation, voice teachers may wish to consider the impact that singers' perceptions of their voices can have on their singing.

In addition to these studies, several studies found in this literature search were case studies of individual singers and observations drawn from clinical practice. Burt and Burt (2014)

described a singer with a TMD who experienced difficulty singing, concurrent with frequent jaw pain. Subsequent diagnosis and treatment from Russell Burt, a dentist, in conjunction with training from Diane Burt, a voice teacher, contributed to improvement both of symptoms and singing technique. Howard (1991) encountered a heavy metal singer whose jaw would frequently lock open during singing performances, necessitating his stopping the performance to seek assistance. Similarly, Sataloff (2017) observed in his otolaryngology practice that tension from TMDs resulted in decreased range, vocal fatigue, change in vocal quality, change in resonance, and tongue retraction or tension.

Does singing cause TMDs?

"Cause and effect" is difficult to assess in singers diagnosed with TMDs. The complex etiology of TMDs suggests that singing as a single causal factor is unlikely, although Van Selms, et al. (2019) found "harmful oral habits" such as clenching and grinding to be a major associative factor in TMDs in singers. With this in mind, it is possible that singing techniques that incorporate an overactivation of masticatory muscles could contribute to TMDs in singers. Further, Sataloff (2017) observed excessive tongue retraction in conjunction with laryngeal tension in subjects with TMDs. This finding correlates with observations of limitations to tongue function in subjects with TMDs (Rosa et al., 2019). Additionally, any habits harmful to singing, such as poor posture, may precipitate voice disorders concurrently with TMDs. Such comorbidities are discussed later in this chapter.

Clinical examples provide further information regarding possible singing-related etiological factors. Howard (1991) described a 15-year-old singer who slept with her fist in her mouth in order to increase her jaw opening for singing. Her symptoms of TMDs were resolved with cessation of that behavior (Howard, 1991). Similarly, Libin and Warren (1988) observed

that "too wide" mouth opening and inappropriate involvement of the masticatory muscles during singing contributed to symptoms of TMDs in dental patients. These authors also observed self-reported improvement in voice quality following treatment of these TMDs. Finally, Burt and Burt (2014) described a colleague's observation of the tendency for young singers to engage the digastric muscles rather than the respiratory muscles to support singing, contributing to jaw tension. Thus, singing with excessive mouth opening, tongue retraction, and inappropriate engagement of masticatory muscles may increase or exacerbate symptoms of TMDs.

Another aspect of singing that may factor in the development of TMDs is increased time spent singing. For example, Taddey (1992) observed that, during his treatment of three vocalists, reduction in practice time had the most effect in mitigating symptoms of TMDs, suggesting that "overuse due to practice for a performance or a class appeared to be the main activating factor" (p. 244). Van Selms et al. (2019) found similar results in a large-scale questionnaire study, observing a strong correlation between incidence of TMDs and hours of daily singing practice.

TMDs and speech

While the relationship between TMDs and voice use in non-singers has already been addressed, there are some considerations specific to speech that may also be of relevance. The jaw is one of the primary structures of articulation, and must coordinate with the lips, tongue, and larynx for both speech and singing of vowels and consonants (Matsuo et al., 2010; Mooshammer et al., 2007; Ostry & Flanagan, 1989). A high level of jaw and phonatory coordination was observed in healthy adults, compared to those with speech disorders such as stuttering (Loucks et al., 2007). TMDs have been associated with fatigue after speaking, functional speech limitations, and deviations of normal speech patterns (Bianchini, 2005; Bianchini et al., 2008; Ferreira et al., 2009; Isberg et al., 1987; Silva (2014); Taucci & Bianchini,

2007), though it is interesting to note that the only study exploring the relationship between TMDs and speech disorders in children did not report any correlation (Pizolato et al., 2011).

Section 3: Additional Variables

Beyond the research examining the etiology and characteristics of TMDs and the voice, there are additional factors that may impact the development of TMDs among singers, namely gender and stress. Additionally, there are comorbidities associated with TMDs that have been reported to affect the singing voice.

Gender

Frey (1988), Clukey et al. (2016), and Van Selms, et al. (2019) reported a higher incidence of TMDs in female singers. Frey (1988) found TMDs were most prevalent among sopranos, who made up 49% of the subjects reporting symptoms of TMDs. Frey suggested this difference is related to the increased jaw opening necessary for tuning the first formant in the higher soprano range (Sundberg & Skoog, 1977).

While the roles that gender and biological sex play in incidence of TMDs in singers are not fully understood, researchers have found that TMDs are more prevalent in female subjects (Kapos et al., 2020). For the voice teacher, this difference is noteworthy. According to the National Center for Education Statistics, from 2007-2018, on average 2.23 times as many subjects identified as women as men received secondary degrees in voice/opera from educational institutions participating in Title IV federal financial aid programs (Table 1). Similarly, the National Association of Schools of Music (NASM) reported that, among collegiate singers enrolled in accredited collegiate level programs in Fall 2019, 67% were female and 33% male (Table 2). Furthermore, of those enrolled, the majority (46%) were sopranos. While these findings are limited to students at the collegiate level, they suggest that voice teachers are likely

to encounter singers with TMDs in their studios and that the majority of those with TMDs will identify as women.

Table 1

National Center for Education Statistics Source: https://nces.ed.gov/programs/digest/

318.30 Bachelor's, master's, and doctor's degrees conferred by degree-granting institutions, by sex of student and discipline division

Year	Bachelor's degrees			Master's degrees			Doctor's degrees			Any degree		
	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females
2017-18	294	90	204	294	81	213	17	7	10	605	178	427
2016-17	354	115	239	263	84	179	26	5	21	643	204	439
2015-16	325	101	224	285	85	200	22	9	13	632	195	437
2014-15	300	100	200	235	77	158	30	14	16	565	191	374
2013-14	352	89	263	231	87	144	28	18	10	611	194	417
2012-13	320	100	220	217	79	138	19	6	13	556	185	371
2011-12	306	96	210	209	64	145	16	5	11	531	165	366
2010-11	340	104	236	259	70	189	21	6	15	620	180	440
2009-10	347	110	237	219	63	156	18	7	11	584	180	404
2008-09	317	93	224	237	75	162	20	7	13	574	175	399
2007-08	273	70	203	203	63	140	18	6	12	494	139	355
Average	320.73	97.09	223.64	241.09	75.27	165.82	21.36	8.18	13.18	583.18	180.55	402.64
Standard Dev	26.11	11.98	19.20	30.39	9.02	25.74	4.67	4.12	3.22	45.16	17.53	31.85
Median	320	100	224	235	77	158	20	7	13	584	180	404
T-Test	P= 0.0000000			P= 0.0000001			P= 0.007978			P= 0.0000000		

In Conclusion: Significantly more female singers, on average, conferred with voice/opera degrees.

Table 2

National Association of Schools of Music
Higher Education Arts Data Services Data Summaries 2019-2020

	Female			Male		
	Soprano	Alto	**Subtotal**	Tenor	Bass	**Subtotal**
Associate of Fine Arts or Equivalent (65% Music content) - Voice Performance						
Music Major Enrollment, Fall 2019	132	94	**226**	108	45	**153**
Bachelor of Music or Other Professional Degree Programs (65% Music content) - Voice Performance						
Music Major Enrollment, Fall 2019	2,403	802	**3,205**	938	692	**1,630**
Specific Master's Degree Programs - Voice Performance						
Music Major Enrollment, Fall 2019	570	156	**726**	207	138	**345**
Doctoral Degree Programs in Music - Voice Performance						
Music Major Enrollment, Fall 2019	179	57	**236**	90	58	**148**
Baccalaureate Bachelor of Music or Other Professional Degree Programs (65% Music content) - Voice						
Music Major Enrollment, Fall 2019	3337	1328	**4,665**	1,318	1,056	**2,374**
Baccalaureate Degree Programs in Music Education, Music Therapy, Musical Arts, and Music Combined with an Outside Field (50% Music content) - Voice						
Music Major Enrollment, Fall 2019	4,615	2,299	**6,914**	1,811	1,386	**3,197**
Baccalaureate Liberal Arts Degree Programs in Music (30-45% Music content) - Voice						
Music Major Enrollment, Fall 2019	1,870	983	**2853**	849	747	**1596**
Undergraduate Level Non-Degree Granting Programs - Voice						
Music Major Enrollment, Fall 2019	48	28	**76**	18	13	**31**
Total Enrollment, Fall 2019	13,154	5,747	**18,901**	5,339	4,135	**9,474**
	46%	20%	**67%**	19%	15%	**33%**

One additional concern for voice teachers is that, due to physiological differences, women are also more susceptible to voice disorders (Hunter et al., 2011). Thus, the effects of TMDs may impact women more noticeably and may be more likely to trigger voice disorders in this population. Future research should explore the associations that gender identity, distinct from biological sex, might have with TMD incidence and impact.

Stress

Another impactful factor is the role that singing-related stress plays in the development of TMDs. Stress is considered a major etiological factor in the development and outcome of TMDs (see Ch. 2). Stress can be defined as a "physical, mental, or emotional factor that causes bodily or mental tension" (Davis, 2021, p. 1). Anxiety and stress are often concurrent, and chronic stress can lead to burnout, a condition of "emotional exhaustion, depersonalization, and lack of perceived personal accomplishment resulting from long-term stress" (Orzel, 2010, p. 5).

While some studies found that the activity of singing can lower stress, researchers caution that these results may not be applicable to the higher-stakes environment of professional and pre-professional singing. Caetano et al. (2017) found that amateur choral singers had lower anxiety levels and incidence of TMDs compared to non-singers. These authors hypothesized that the lower levels found in this group may be related to the reduced singing time and stress-relieving effects of amateur singing and may not be transferrable to professional singer populations. Furthermore, singers with TMDs may be less likely to join or stay in choirs, resulting in a self-selecting population. Such differences in stress response between professional and amateur singers is supported by Grape et al. (2003), who found significantly higher cortisol levels among professional singers after singing when compared to amateur choral singers, whose levels decreased after singing.

Many voice students are college music majors, a population that has shown elevated levels of stress and other mental health-related symptoms such as anxiety, depression, and burnout (Demirbatir, 2012; Gilbert, 2021; Koops & Kuebel, 2021; Orzel, 2010; Sternbach, 2008). Burnout, an indication of chronic stress, is similarly prevalent in college music education majors (Bernhard et al., 2005 & 2010). Additionally, professional musicians reported similar symptoms of stress, anxiety, and depression (King et al., 2019; Wills & Cooper, 1987; Scech, 2021; Spahn et al., 2010).

Identifying stressors experienced by singers with TMDs is an important first step in managing TMDs. Common stressors for singers may be financial, personal, academic, or occupational (Gilbert, 2021). Musical performance anxiety (MPA), defined as "persistent, intense, and distressing apprehension in situations involving music performance in public" (Sabino, 2018, p. 1) is one stressor commonly experienced by singers (Cui et al., 2021; Spahn et al., 2021). Singers show symptoms of stress, such as elevated heart rate, elevated blood pressure, and lowered heart rate variability (HRV) related to singing and these symptoms can occur before, during, and after singing (Cui et al., 2021; Spahn et al., 2010). Furthermore, in professional choral singers, singing in front of an audience resulted in a higher heart rate and lower HRV than singing in rehearsal, regardless of the difficulty of the music being sung (Harmat & Theorell, 2010). It is possible that musical performance, the very scenario most singers work towards, might be one that exacerbates the incidence of TMDs. It is important to note, however, that not all stressors have negative consequences. Psychologists distinguish between "eustress" - stress that motivates and allows for personal growth, and "distress" - stress that is harmful (Gilbert, 2021). Even MPA, when contextualized and managed, can serve as

"preparation for action, aid concentration and focus on the task" (Papageorgi et al., 2007 p. 93), and thus may not necessarily exacerbate or cause TMDs.

Section 4: Comorbidities

Voice teachers should also consider the medical comorbidities associated with TMDs that affect the singing voice. The voice is a complex mechanism that involves the musculoskeletal, respiratory, and nervous systems; therefore, disease processes that affect these systems may also have an impact on the voice (Rosenberg & LeBorgne, 2014; Sataloff et al., 2017).

Hearing disorders

Because singers rely upon their hearing to sing accurately, hearing disorders present significant limitation to singing (Isaac et al., 2016). Tinnitus, defined as "perception of sound when no actual sound is present" (Attanasio et al., 2015, p. 724), is highly prevalent in subjects with TMDs (Attanasio et al., 2015; Morais & Gil, 2012), and treatment of TMDs successfully resolved concurrent symptoms of tinnitus (Buergers et al., 2014). Similarly, hearing loss is also significantly associated with TMDs (Magalhães et al., 2017).

Posture and breathing

TMDs may also indirectly affect the voice through their relationship with posture and breathing. Multiple studies confirm a correlation between posture and TMDs (Lee et al., 2017; Rocha et al., 2013). Incorrect posture may increase tension in the neck, back and facial muscles, leading to increased loading and strain on the TMJ and surrounding musculature (Bartley, 2010; Corrêa & Bérzin, 2004; Rockland et al., 2010). Forward head posture (FHP), characterized by rounded shoulders and a forward head position places particular strain upon the TMJ and frequently leads to the development of incorrect breathing patterns, including overuse of

accessory muscles (clavicular breathing), insufficient engagement of primary muscles of respiration (abdominals, intercostals, and diaphragm), oral (mouth) breathing, overinflation during the inhale, and anxious or tense breathing (Bartley, 2010; Corrêa & Bérzin, 2004; Hruska, 1997). Thus, incorrect posture, dysfunctional breathing patterns, and TMDs are disorders observed concurrently in patients and may be interconnected.

These postural and breathing habits have been observed to negatively impact the voice. Craniocervical (head and neck) dysfunction has been shown to be associated with dysphonia (Rodrigues-Bigaton et al., 2010), and aligned posture has been shown to optimize singing (Wilson Arboleda & Frederick, 2008; Staes et al., 2009). Craniocervical position was further observed to be different for singing than for normal standing positions in student opera singers, however it is unclear if these students were singing with an aligned posture during the study (Johnson & Skinner, 2009). Dysfunctional breathing patterns, such as those caused by forward head posture, prevent effective respiration for singing, oral breathing increases phonatory effort, and inappropriate muscle engagement limits the efficiency of breath management in singing (Sivasankar & Fisher, 2003; Rosenberg & LeBorgne, 2014).

Sleeping disorders

Subjects with TMDs frequently report sleep disruption, poor sleep quality, insomnia, and obstructive sleep apnea. Nighttime oral parafunctions, such as bruxism and clenching, are also a prevalent and a contributing factor to the development of painful TMDs (Rener-Sitar et al., 2016; Sanders et al., 2016; Shedden Mora et al., 2012). Insufficient or poor-quality sleep, besides being detrimental to general health, is reported by singers to impact breath support, vocal endurance, voice quality, focus, and emotional state while performing (Getsy et al., 2017).

Gastroesophageal reflux

Gastroesophageal reflux disorder (GERD), also known as acid reflux, is a disorder associated with TMDs and a causative factor in sleep disruptions, which can in turn exacerbate GERD symptoms (Fass, 2010; Gharaibeh, et al. 2010; Li et al., 2019). Laryngopharyngeal reflux (LPR) is a classification of GERD directly affecting the pharynx and larynx. LPR is an etiological factor in many voice complaints, and voice-related symptoms include laryngitis, hoarseness, voice fatigue, difficulty warming up, and voice practice disruptions. Additionally, in severe cases, LPR can lead to voice disorders such as vocal fold nodules, vocal fold polyps, Reinke's edema, and Muscle tension dysphonia (MTD) (Sataloff et al., 2017).

Muscle tension dysphonia

Research suggests correlations between musculoskeletal pain, particularly in the orofacial and submandibular regions, and dysphonia (Santos et al., 2019; Ramos et al., 2018, Silverio et al., 2014). TMDs are a subcategory of musculoskeletal disorders such as muscle tension dysphonia (MTD), defined as "the pathological condition in which an excessive tension of the (para)laryngeal musculature, caused by a diverse number of etiological factors, leads to a disturbed voice" (Van Houtte et al., 2011, p. 202). While there is limited research that directly explores the relationship between MTD and TMDs, two studies showed a significant correlation between the incidence of TMJ pain in subjects with MTD when compared to controls (Demmink-Geertman & Djonckere, 2002, 2008, 2010). Furthermore, one study suggested that TMDs could precipitate postural changes leading to the development of MTD. Both disorders involve tension in extrinsic laryngeal muscles and both affect the voice. Additionally, as with TMDs, stress and Laryngopharyngeal Reflux (LPR) are factors in the development of MTD (Angsuwarangsee & Morrison, 2002; Van Houtte et al., 2011).

There is also overlap in treatment for MTD and TMDs. Stretches and exercises involving the TMJ and masseter muscles were successfully implemented as part of a physical therapy treatment plan for TMD (Craig et al., 2015), and treatment of MTD in a subject with voice loss resolved both voice-related and TMD-related symptoms (Dworkin et al., 2000). While more research is needed, it seems possible that the two disorders could be confused, thus pointing to the necessity of a medical exam and diagnosis.

Section 5: Conclusions

A broad range of studies suggest a relationship between TMDs and the singing voice, and that their prevalence among singers, especially professional singers, may have far reaching impact. This impact may extend to the speaking voice, an indication that TMDs may affect singing voice students in areas of their life beyond singing. While current research is inconclusive as to whether "incorrect" singing causes TMDs, many habits that inhibit proper technique singing, such as dysfunctional breathing or misaligned posture, may contribute to the development of TMDs. When considering the etiology of TMDs in singers, it is also important for voice teachers to acknowledge the roles gender and stress play in the development of TMDs, and to recognize these risk factors in the voice studio, particularly at the college level. Voice teachers should also be aware of the comorbidities affecting the voice that can emerge along with TMDs and further complicate the management and treatment process.

Table 2

TMD/Voice Literature Methods Distribution

TMD/Voice Literature Methods Distribution

	TMD Diagnosis				Voice data collection					Sample Size			Population	
	Reported symptoms	Screening/ diagnostic tool	Reported Diagnosis	Clinical Diagnosis	Self-report	Screening/ diagnostic tool	Clinical observation	objective parameter measures	perceptive - hearing	Case Study	Small sample (<100)	Larger sample (>100)	Singer	Non-singer
Almeida, et al., 2013		X				X					X		X	
Amorino & Taddey, 1993	X		X		X						X		X	
Boton, et al., 2012		X		X				X						
Burt & Burt, 2014				X	X		X			X			X	
Caetano, et al., 2017		X				X					X		X	
Caine, 1998				X			X			X			X	X
Carnauba, et al., 2010		X				X								X
Clukey, et al., 2016		X			X	X					X		X	
David & Elavarasi, 2016				X			X							X
Ferriera, et al., 2008				X				X			X			X
Ferriera, et al., 2010	X				X							X		X
Frey, 1988	X				X						X		X	
Gois, et al., 2018			X			X						X		X
Howard, 1991				X	X					X			X	
Kirveskari, et al., 1988				X			X				X			X
Luyten, et al., 2016	X					X								X
Machado, et al., 2009		X		X		X	X							X
Machado, et al., 2014		X				X						X		X
Moradi, et al., 2014				X		X					X			X
Morisso, et al., 2006		X		X	X		X	X	X		X			X
Panday & Dutta, 2014				X			X			X				X
Pereira, et al., 2009		X				X					X			X
Pernambuco, et al., 2017			X			X						X		X
Sataloff, 2017				X			X			X			X	
Silva, et al., 2007		X		X				X	X					
Taddey, 1992				X			X			X			X	
Vaiano, et al., 2013	X										X		X	
Vaiano, et al., 2016	X				X							X	X	X
Van Selms, et al., 2019		X				X						X	X	

Limitations of current research

In reflecting upon these conclusions, it is important to consider the limitations of the research discussed in this chapter. One significant limitation relates to variations in data collection across studies. Table 2 summarizes the differences in methods of data collection, sample size, and sample population. While some researchers identified TMDs through a clinical diagnosis, other researchers observed symptoms of TMDs, used a screening or diagnostic tool to establish presence of TMDs, or recorded self-report of a past TMD diagnoses. Since TMDs share symptoms with many other disorders, it is possible that the symptoms not confirmed by clinical diagnosis were, in fact, characteristics of a different disorder.

In gathering voice-related data, methodology was equally diverse, with some data collected through self-report, some through screening/diagnostic tools, some through clinical observation, some through objective parametric measures (such as spectrography or aerodynamic measures), and some through perceptual-hearing evaluations. Additionally, in some cases, as singers were asked to report their own experiences of TMDs and their impacted their singing, these results were not possible to verify through observation (Amorino & Taddey, 1993; Clukey et al., 2016).

Furthermore, some studies examined voice parameters in the context of singing and others in the context of speech, two tasks that contain many differences in function and execution. Due to the limited research currently available, the information within this chapter was supplemented by literature that addressed non-singing voice use, such as in everyday speech. Lastly, the relatively small sample sizes in many of the studies limits the generalizability of this information. While preliminary conclusions can be drawn from existing literature, it is clear that more research is needed.

Areas for future research

Future studies should address these limitations by incorporating uniform methods of data collection, uniform parameters for identification of TMDs, and should gather more data from singers. Additionally, while studies relying on self-report provide important information about the subjective experience of TMDs, studies that gather data through external observation and clinical diagnosis of singers are needed to limit bias in self-reporting. Thus, studies with more uniform data collection and larger sample sizes of singers that rely upon clinical diagnosis could more accurately assess the relationship between TMDs and the singing voice.

Summary for voice teachers

- There is a strong relationship between TMDs and the singing voice, which may impact both student and professional singers.
- TMDs may also impact singers' quality of life through its effects on the speaking voice.
- Many incorrect singing habits, such as dysfunctional breathing or misaligned posture, may contribute to the development of TMDs.
- Voice teachers should assess the risk for TMDs in their singing students with careful consideration of the effects of gender, stress, and time spent practicing on development of TMDs.
- Teachers should be familiar with TMD comorbidities that affect the singing voice, such as hearing disorders, posture and breathing disorders, sleeping disorders, GERD, and muscle tension dysphonia.
- Voice teachers should understand the limitations of current research and stay up to date in research surrounding TMDs and the voice.

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Section II: So, You Think Your Singing Student Has TMD

Chapter IV: Treatment and Management of TMDs

Introduction

Having identified a singer with a possible TMD, the voice teacher may wonder "what next"? Because one of the most important things a voice teacher can do in the treatment process is make a speedy referral for medical help, an understanding of the diagnostic and treatment process may be helpful. Furthermore, since concepts in diagnosis and treatment of TMDs have evolved significantly, it is important that the voice teacher has current information with which to assist the student. In this chapter, information regarding diagnosis and treatment of TMDs can be found, as well as recommendations for voice teachers who may wish to screen for TMDs or make a referral for TMD treatment.

Section 1: Diagnostic Process

Who makes a diagnosis?

While treatment modalities for TMDs exist within many specialties, dentists are the primary medical professionals to provide diagnosis and treatment of TMDs (Greene & Bertagna, 2019; Reid & Greene, 2013). Dentists may also screen for TMDs or risk of susceptibility prior to dental procedures that could trigger or aggravate an existing TMD, such as lengthy procedures requiring extended periods of jaw opening (Beaumont et al., 2020). After a primary exam, a dentist may make an external referral (for example, physical therapy or psychotherapy), depending on the TMD classification and etiological factors determined (Beaumont et al., 2020; Li & Leung, 2021). Additionally, professionals from other medical disciplines may encounter and treat patients with TMDs, or patients may also independently seek treatment for their symptoms from non-dental professionals, as practitioners from many disciplines advertise

diagnostic and treatment services. Furthermore, other medical professionals, such as primary care physicians, otolaryngologists, orthodontists, and physical therapists, may have received training in diagnosis and treatment and may screen for and identify TMDs (Greene & Bertagna, 2019; Lee et al., 2021).

Diagnostic examination

The Diagnostic Criteria for Temporomandibular Disorders (DC-TMD) is the most widely accepted tool for diagnosis and classification of TMDs (Li & Leung, 2021; Schiffman, 2014). The entirety of the protocol is available at www.rdc-tmdinternational.org (Orbach, 2016). This protocol is often used during clinical examinations and has sections (Axis I and II) that address both biological and psychosocial factors in accordance with the biopsychosocial model (see Chapter 2).

A typical diagnostic examination will begin with patient history acquisition, the gathering of information about the patient's chief complaint(s), history of trauma, past symptomatic episodes, and any past treatment for TMDs. The patient will be questioned regarding factors that aggravate symptoms, such as eating or talking, and incidence of any parafunctional habits such as clenching or grinding. Questions regarding general medical history, including a medication list, may reveal comorbidities. Questions about stress and mental health may reveal additional psychological factors.

The examiner will use manual palpation to confirm the location and extent of pain, determining whether it is localized to a specific area or radiates beyond its confines. Clicking or crepitus of the TMJ can be assessed using a stethoscope, though in some cases the presence and location of such signs can differ with the way the patient experiences them. The examiner will also measure range of motion with and without pain and observe any deviation upon mouth

opening. An intra-oral exam can assess pathologies of the oral cavity that may present with TMD-like symptoms (Beaumont et al., 2020; Beecroft et al., 2018; Li & Leung, 2021).

In some cases, imaging is used as an additional diagnostic tool in conjunction with a clinical exam. Magnetic Resonance Imaging (MRI) can accurately visualize bone, joint and disc structure, along with peripheral muscles and ligaments. Because of the cost of an MRI, referrals tend to be reserved for atypical presentations of TMDs, as well as prior to any surgical intervention. The examiner may order bloodwork for systemic TMD-related conditions, such as rheumatoid arthritis, and take tissue samples in cases of rare diseases or neoplasms (Beecroft et al., 2018; Li & Leung, 2021).

In making a diagnosis, medical professionals typically integrate the findings from patient history, exam, and any additional testing, understanding that the etiology may be multifactorial. Moreover, patients may present with multiple TMDs simultaneously (Li & Leung, 2021). Since several serious illnesses can mimic TMDs, the examiner should be aware of certain "red flag" signs and symptoms; for example, loss of smell, loss of hearing, acute vision problems, and motor function changes can point to a possible malignancy (Beecroft et al., 2018). Certain clinical findings during the initial exam point to specific diagnoses (see Chapter 2 for the complete list according to the DC/TMD). Myalgia (muscle pain) is suspected if the patient reports pain in the masticatory muscles that changes with jaw function and such reports are corroborated by the exam. Pain in the masticatory structures (i.e. TMJs) that changes with jaw function, and pain upon palpation of the TMJ or upon maximum jaw movements, points to Arthralgia (joint pain). Clicking, popping, or snapping noises with jaw locking or limited opening, reported by the patient and observed during movement, may indicate the presence of an Intra-articular TMD. If noises reported by the patient present as crepitus upon maximum

movement, this may be a sign of a degenerative joint disorder (Beaumont et al., 2020). It is important to note that joint sounds alone do not necessarily indicate a need for treatment; pain and functional limitations must also be present (Beaumont et al. 2020; Kapos et al., 2020; Li & Leung, 2021).

Section 2: Types of Treatment

Treatment goals

The goal of treatment is to mitigate signs and symptoms of TMDs, most commonly, pain and functional limitations (Beecroft et al., 2018; Li & Leung, 2021; Gil-Martínez et al., 2018). Alleviation of pain is perhaps the primary treatment goal because patients tend to seek treatment most often for pain and because musculoskeletal pain produces subsequent changes in motor behavior, resulting in or contributing to functional limitations (Gil-Martínez et al., 2018). Gil-Martínez et al. (2018) suggests a three-part approach in treatment to relieve pain: "reduction in pain perception, improvement of motor behavior, and improvement of cognitive and emotional factors related to the experience of pain" (p. 581). Thus, treatment to reduce pain should include immediate pain-relief strategies, training of "normal" motor behaviors, and psychological and cognitive support directed at the "pain experience".

While management of TMD-related pain will usually result in improvement of function, simultaneous management of physical limitations such as joint locking or catching, masticatory stiffness, and limited range of motion, should be addressed through resolution of the underlying cause(s) of limitation. Such causes can vary greatly, encompassing behavioral, structural, inflammatory, or degenerative factors, which necessitate a clear diagnosis and an individualized treatment plan (Gil-Martínez et al., 2018; Wright et al., 2009).

Treatment options

There are a wide range of treatments available to patients with TMDs, though there is plenty of controversy regarding the effectiveness of many of them. It can be challenging for the layperson to determine the best treatment options, necessitating a reliance upon the initial diagnosing medical provider. An introductory understanding of treatment options, the current evidence supporting each treatment, and the impact of each treatment may, however, be useful to those seeking treatment after an initial diagnosis. According to the American Association of Dental Research, except with "specific and justifiable indications to the contrary" (p. 138), treatment of TMDs should be both conservative (i.e., non-invasive and reversible) and evidence-based (Green, 2010; Beaumont, et al, 2020; Reid & Greene, 2013). Furthermore, professional treatment should be augmented with home self-care management (Green, 2010).

Conservative treatments

Conservative treatments, presenting minimal risk of harm, are often indicated early in the treatment process, and may be sufficient to resolve signs and symptoms (Li & Leung, 2021). Behavior modifications, namely, identification and cessation of parafunctional habits such as nail biting, gum chewing, clenching, grinding, and excessively wide mouth opening, can provide symptom relief and prevent further damage (Beaumont et al., 2020; Beecroft et al., 2018; Durham et al., 2016; Gauer et al., 2015). While pain from chewing can be prevented through a "soft diet", Durham et al. (2016) advocate for a "pain-free diet" that adapts to changing pain levels to gradually reintroduce “chewier” foods.

Similarly, general lifestyle changes can mitigate the signs and symptoms of TMDs. Sleep quality can be impacted by, and, in turn, exacerbate TMDs. Patients can support high quality sleep through developing consistent routines, the creation of a restful sleep environment, regular

exercise during in the day, limits on caffeine and alcohol intake, and the avoidance of large meals before bed. Additionally, both nicotine and caffeine have been shown to increase pain perception, and should be limited or avoided (Beecroft et al., 2018). Finally, stress is a major etiological factor in TMDs and lifestyle stressors should be managed (Guaer et al., 2015).

As discussed in Chapters 2 and 3, psychological components such as stress, anxiety, depression, and catastrophizing can all impact the progression and outcome of TMDs. Cognitive Behavioral Therapy (CBT) has been shown to be effective in managing such factors in patients with TMDs (Beecroft et al., 2018; Häggman-Henrikson et al., 2020). This approach is supported by research that proposes Central Sensitization Syndrome as a factor in chronic TMD progression, as outlined in Chapter 2. Since, in cases of CSS, pain is resistant to healing of damage or injury, psychological or psychiatric therapies are often indicated (Monaco et al., 2017). The experience of having TMDs can create fear of pain, accompanied by subsequent negative adaptations such as pain guarding (Gil-Martínez et al., 2018), and fear of uncertainty, particularly surrounding diagnosis and prognosis (Durham et al., 2010; Durham et al., 2016). Thus, a speedy diagnosis and education surrounding the etiology, progression, and generally favorable prognosis of most TMDs can be comforting to the patient (Beaumont et al., 2020; Durham et al., 2016).

Certain pharmacological interventions also fall into the category of conservative management, though they are typically only prescribed should behavior modification prove insufficient. The goals of pharmacological intervention are relief from pain, reduction of inflammation, and muscle relaxation. Non-Steroidal Anti-Inflammatory Drugs (NSAIDs) are commonly prescribed for pain relief and inflammation. NSAIDs present some risk for GI (gastrointestinal) bleeding; however, Ibuprofen appears to be the safest of the NSAIDs in that

regard. Opioids can also be prescribed for pain relief, though less frequently due to the risk of dependency. Anti-depressants, such as tricyclic antidepressants (TCAs) or selective serotonin reuptake inhibitors (SSRIs), and anticonvulsants have been shown to reduce orofacial pain. Muscle relaxants or benzodiazepines can be taken before bed to relieve acute muscle spasm and improve sleep quality; however, their sedative side effects warrant caution (Beecroft et al., 2018; Gauer et al., 2015; Ouanounou et al., 2017; Gil-Martínez et al., 2018).

Limited research exists regarding the efficacy of over-the-counter supplements. Kui et al. (2021) reported an association between Vitamin D deficiency and TMDs, suggesting the possible benefit of Vitamin D supplementation in deficient patients. Rajaran and Choi (2017) observed reduced chronic TMD pain after four weeks of Vitamin B complex (B1, B6, and B12) supplementation compared to a placebo. Wong and Cairns (2019) observed myofascial pain relief in rats after intramuscular injection of cannabinoids, suggesting possible benefit from supplementation for TMDs. Anecdotally, other supplements, such as Magnesium, Calcium, and Vitamin C are suggested to be beneficial; however, no research was found to support these claims. In all cases of pharmacotherapy and supplementation, a physician or medical provider should be consulted for any possible contraindications or side effects.

Voice teachers should be aware of certain voice-related side effects from medications and supplements. NSAIDs may interfere with clotting, increasing risk of vocal fold hemorrhage, and their use is discouraged in professional singers. Corticosteroids may result in gastric irritation, mild mucosal drying, and fluid retention, all of which may indirectly affect the vocal folds (Hancock & Stemple, 2014; Sataloff et al., 2017). Anti-depressants may also be dehydrating and cause dysphonia, and Vitamin C, in large amounts, may be similarly dehydrating (Bock, 2019;

Nemr et al., 2017; LeBorgne & Rosenburg, 2019). Voice teachers should take note of voice changes that occur after a singer begins any new medications or supplements.

Physical Therapy is a common treatment for TMD that has been shown to be effective, particularly in cases of myogenic (muscle-related) TMDs. Physical therapists in the United States are trained in TMD diagnosis and management (Greene & Bertagna, 2019), and utilize a wide variety of treatment modalities, including therapeutic exercises, electro-physiological modalities, manual therapy, neuromuscular re-education, myofascial release, soft tissue massage, muscle awareness relaxation therapy (MART), biofeedback training, dry needling or acupuncture, and low-level laser therapy (Beecroft et al., 2018; Fisch et al., 2020; Gil-Martínez et al., 2018). Treatment goals include pain reduction and improved strength, mobility, coordination, and range of motion (ROM) (Lee et al., 2021). In particular, manual therapy has been shown to be most effective in conjunction with therapeutic exercise (Gil-Martínez et al., 2018).

Figure 1
Example of an Occlusal Splint

Occlusal splint therapy (Figure 1) (Li & Leung, 2021) is primarily used to prevent dental damage from nighttime clenching and grinding and to reduce condylar loading (Gil-Martínez et

al., 2018; Lee et al., 2021). The most commonly used type of splint is hard plastic, fitted by a dentist to either the upper or lower arch (Beecroft et al., 2018). The hard occlusal splint works by stabilizing and separating the occlusal surfaces, allowing for relaxation of the masticatory muscles. These occlusal splints have been shown to reduce pain and improve ROM, however some research suggests this may be due to the placebo effect (Li & Leung, 2021). Nevertheless, this is a standard and widely accepted dental treatment for TMDs. There are several other types of splints, namely soft splints and those that reposition the bite; however, these have been shown to be less effective and may cause permanent occlusal changes or damage to the jaw (Dhannawat et al., 2020; Fricton et al., 2010).

Self-management (SM), or self-care, can encompass the entirety of treatment for TMDs, or can function as part of a more complex treatment plan. SM plans are frequently delivered verbally by the medical provider and supported by written information and instructions that can be practiced independently by the patient at home. There are currently no standardized SM plans, however common components include, according to Story et al. (2016) "1. Basic elements of cognitive behavioral therapy including education. 2 Relaxation techniques. 3 Reinforcement of desired behaviors and withdrawal from unwanted behaviors. 4 Home physiotherapy. 5 Non-prescription pharmacological therapy, but this may vary depending on local prescribing regulations" (p. 761). While the SM plan can be expanded upon over time, and is dependent upon the patient's individual needs, typical components include education, exercise, self-massage, thermal therapy, dietary and nutritional advice, and monitoring and avoidance of parafunctional behaviors (Beaumont et al., 2020; Beecroft et al., 2018; Durham et al., 2016; Li & Leung, 2021).

Overlap exists between physical therapy and Complementary and Alternative Medicine (CAM), since physical therapists tend to utilize some of the same modalities (DeBar, et al, 2003; Fisch et al., 2020). Fisch et al. (2003) found patients reported frequent and generally satisfactory use of CAM therapies, most often in conjunction with more traditional therapies; the most common of which were massage, chiropractic care, biofeedback/visual imagery, and over-the-counter herbal supplements.

There are some additional management options found in the literature that have also been discussed, though it should be noted that this list may not be exhaustive. Hypnosis was found to successfully reduce pain and increase range of motion in three randomized control trials (Zhang et al., 2015). While Kim et al. (2018) concluded more research was needed, they recommended certain Korean Medicine modalities (acupuncture, laser acupuncture, pharmacopuncture (bee sting venom), traditional herbal medicine, Chuna Manual Therapy, Mae-son (thread embedding acupuncture), and Korean Medicine Physiotherapy) for clinical treatment of TMDs based on a systematic review of the literature. Similarly, Traditional Chinese medicine (acupuncture and herbs), was shown to reduce pain and improve quality of life in patients with TMDs (Ritenbaugh et al., 2012).

The number and variety of conservative therapies and treatments available to patients make the decision to proceed with riskier and more invasive treatments often unnecessary. The reported success of conservative treatments should be reassuring to singers with TMDs seeking management strategies that have less potential for negative impact upon singing.

Invasive treatments

As previously stated, there must be clear indications for more invasive or irreversible treatments (i.e., injection and surgery): namely, severe symptoms that are unresponsive to

conservative treatments. Furthermore, occlusal adjustments that involve modification of the dental surfaces (i.e. orthodontics, tooth grinding or condylar repositioning), while once common practice, are not supported by current research and are no longer recommended (Gauer et al., 2015; Gil-Martínez et al., 2018; Li & Lieung, 2021).

In cases of severe joint inflammation, corticosteroids may be injected directly into the TMJ (Gil-Martínez et al., 2018). Injection of Botulinum toxin (Botox or BTX) into the masticatory muscles is also a common, minimally invasive treatment for pain relief and muscle relaxation; however, results of its efficacy are inconclusive (Beecroft et al., 2018; Gauer et al., 2015; Gil-Martínez et al., 2018). While voice-related side effects are not well known, one patient reported a "nasal tone of voice… and flu-like symptoms" five days after BTX injection, which self-resolved after another nine days (Emara et al., 2013).

Indications for surgery are rare; only approximately 5-10 percent of patients undergoing treatment require surgical intervention, and it is usually considered an "option of last resort" (Dimitroulis, 2018). The purpose of surgery is either to repair or remove damaged tissue, and in some cases, to replaced missing tissue with grafts. Indications for surgery include chronic and severely limited mouth opening, and painful clicking and crepitus that is unresponsive to conservative measures. Pain should be localized to the TMJ and activated by palpation or functional movements. Surgery is not indicated in the case of muscle-related or chronic pain-related TMDs; but, rather, specifically for joint-related diseases (Dimitroulis, 2018).

Dimitroulis (2018) further described a category system for various surgical interventions, ranging from least invasive to most invasive (Table 1) (p. S87). Closed joint surgeries include arthrocentesis and arthroscopy (also known as arthroscopic lavage). Arthrocentesis involves the insertion of two large needles above and below the TMJ, acting as an inlet and outlet for

irrigation fluids, lubricating fluids, or medications such as hyaluronic acid or corticosteroids. Arthroscopy is a more complex and invasive version of arthrocentesis that involves the subsequent insertion of a camera for the purpose of surgery ranging from removal of tissues to disc repositioning (Dimitroulis, 2018).

Table 1
Categorization of TMJ Derangement (Dimitroulis, 2018)

Classification for TMJ Internal Derangement, but encompasses a wider range of TMJ surgical disorders with guidance as to the most appropriate surgical procedure where conservative/non-surgical measures have failed to alleviate the symptoms

CATEGORY 1	TMJ Normal Although painful, the joint itself shows normal, smooth joint function and radiology confirms no joint pathology. TMJ Surgical intervention is contra-indicated
CATEGORY 2	TMJ Minor Changes (All components Salvageable) An example is early stage TMJ internal derangement which has resulted in closed lock. TMJ arthrocentesis or TMJ arthroscopic lavage may be helpful in releasing the joint
CATEGORY 3	TMJ Moderate Changes (Mostly Salvageable) Examples include non-reducing disc displacement or recurrent TMJ dislocation where TMJ operative arthroscopy or TMJ arthroplasty/disc repositioning may be appropriate
CATEGORY 4	TMJ Severe Changes (Partly Salvageable) Example includes severely displaced and deformed discs which have resulted in chronic pain and limited mouth opening. The disc cannot be salvaged and these cases require discectomy
CATEGORY 5	TMJ Catastrophic Changes (Nothing is Salvageable) A classic example in this category is end-stage joint disease such as severe osteoarthritis. These cases are best treated with total joint replacement

Highly invasive, open joint surgeries are only indicated in rarer, Category 4 and 5 situations. Collectively known as arthrotomy, open joint surgical procedures should only be undertaken when the joint itself is damaged, through trauma, degenerative, or inflammatory disease, beyond the point of conservative treatments. Arthrotomy includes disc repair, repositioning or removal. In situations of condylar disease, such as osteoarthritis, the entire condyle may need to be replaced. Such procedures typically require an overnight hospital stay and a recovery period of at least two weeks (Dimitroulis et al., 2018; Li & Leung, 2021). During this time, patients may be referred to postoperative physiotherapy, which has been shown to positively affect function and pain levels (De Meurechy et al., 2018). The impact of an open or closed joint surgery upon the singing voice is not well researched. However, based on the

articulatory requirements for healthy singing, it is likely to be significant and should not be taken lightly.

In summary, a wide range of management options for TMDs are available, however treatment should be selected carefully with emphasis upon non-invasive, reversible, and evidence-based treatments. It is reasonable to expect that additional treatments, not listed here, that address etiological factors, such as stress or posture, might show similar improvement in signs and symptoms of TMDs. Singers should be aware of the possible impact selected treatment(s) may have on singing in order to make informed choices.

Section 3 : Treatment Decisions

Controversy

As previously described in Chapter 2, the older, mechanistic model of TMDs is now understood to be less relevant than the biopsychosocial model. Research does not support the efficacy of many treatments that have been associated with the mechanistic model, such as occlusal alteration or jaw repositioning, and only supports open joint surgeries in severe, end-stage disease (Kapos et al., 2020; Li & Leung, 2021; Reid & Greene, 2013) In fact, researchers have found that, in most cases, conservative (non-invasive and reversable) treatments that address both biological and psychosocial factors are effective in improving signs and symptoms of TMDs (Kandasamy & Green, 2020; Skármeta et al., 2019). Despite evidence to the contrary, however, practicing dentists may still rely upon older etiological models, consequently pursuing invasive, mechanistic treatment plans such as those involving occlusal adjustments (Desai, et al, 2016; Greene & Bertagna, 2019; Reid & Greene, 2013; Sharma et al; 2019).

Choosing a medical provider

This problem is perpetuated by a lack of standardized education about TMDs. Despite the expectation that dentists provide first-line care for TMDs, several studies have found that training and education in TMDs among general dentists may be incomplete and lacking up-to-date information (Dalanon et al., 2020; Klasser & Greene, 2007; Reissmann et al., 2015; Simmons, 2016).

While the standardization of care varies globally, within the United States there are no clinical care guidelines endorsed by the American Dental Association, and no formally recognized "TMD Specialty" (Desai et al., 2016; Reid & Greene, 2013; Sharma et al., 2019). This may result in practice that Reid and Greene (2013) described as "unregulated, widely diverse, and characterized by unconstrained professional autonomy" (p. 547). Reid and Green further argue that this lack of oversight leaves the diagnostic and treatment process vulnerable to clinical decisions influenced by financial gain or other interests, rather than the good of the patient; for example, advocating for an expensive surgery in lieu of an at-home, self-care regimen.

One additional problem for patients seeking care is the wide range of unregulated information available on the internet. Desai et al. (2016) searched dental websites in the United States, finding considerable misinformation regarding etiology and management of TMDs; namely, conceptualization of TMDs as a single disorder, association of TMDs with occlusal problems, and advocacy for incorrect occlusal treatments. Similarly, Green and Bertagna (2019) found widespread internet advertising for treatment of TMDs among non-dental practitioners such as chiropractors, massage therapists, and alternative medicine therapists; professions that may lack a comprehensive education in TMD diagnosis and treatment. In contrast, Green and

Bertagna (2019) did find that the Commission on Accreditation in Physical Therapy Education included training in diagnosis and management of muscle-related TMDs in their guidelines.

It is important to note that, when needed, voice teachers are able to refer their students to practitioners who will effectively treat TMDs. Education in basic principles of TMD pathophysiology and simple guidelines for choosing practitioners empower the student to make informed healthcare decisions. Since current research does not support the routine use of expensive, irreversible treatments, singers should be wary of dentists advocating for such treatments or those describing outdated etiological theories, such as those that place a strong emphasis on occlusal factors (Green & Bertagna, 2019). Green and Bertagna (2019) also offered internet resources for patients seeking care: The American Academy of Oral Medicine has a "Find a Doctor" search engine (https://www.aaom.com/find-a-doctor#/), while the American Academy of Orofacial Pain has a directory for practicing members (https://aaop.clubexpress.com/content.aspx?page_id=2720&club_id=508439). It may be useful for voice teachers to preemptively utilize these resources to locate nearby providers prior to the need for a referral.

Section 4: The Role of the Voice Teacher in Treatment

Roles and responsibilities

The primary responsibilities that the voice teacher may choose in the treatment of TMDs are recognition and referral. Voice teachers are not qualified to treat or diagnose medical conditions; however, they have an ethical obligation to advocate for the general and voice-specific health and wellness of their students (Brand, 2016). Indeed, according to the National Association of Teachers of Singing (NATS) Code of Ethics, "In cases where a Member

determines that involving other professionals in a student's instruction may be of benefit (for medical, technical, artistic, musical, pedagogical, or other reasons), Members shall strive to work collegially with these professionals" (National Association of Teachers of Singing, 2018, p. 1).

Voice teachers have a unique opportunity to observe the jaw "in action", and the nature of the teacher-student relationship necessitates numerous conversations regarding the vocal and general health of their students. In addition to instruction in singing technique, singers usually look to their teachers for expert, voice-related health advice (Heman-Ckah et al., 2008; Jaworek & Sataloff, 2015). Thus, voice teachers may be able to recognize signs and symptoms of TMDs early on in the disease process and are usually in a position to advise students to seek diagnosis and treatment. Early diagnosis and treatment has been shown to improve outcomes in TMD prognosis (Durham et al., 2010; Durham et al., 2011), suggesting that a speedy referral from a voice teacher may positively impact the treatment process for singers with TMDs. For example, Burt was able to recognize symptoms of TMDs in a young singer and refer the student to dental and psychological care. When combined with supportive vocal instruction, the student experienced significant symptom relief and improvement in singing outcomes (Burt & Burt, 2014). Therefore, it may be advantageous to the student for voice teachers to be prepared with knowledge and tools to identify and refer to treatment singers with possible TMDs.

Recognition

Researchers have advocated for the benefits of medical screenings for singers prior to the commencement of singing lessons (Brand, 2016; Jaworek & Sataloff, 2015). Regarding medical screenings for laryngeal pathologies, Jaworek and Sataloff (2015) stated: "The information gained can guide decisions made about lessons, rehearsals, performance, repertoire, and possibly medical treatment. Medical documentation also can establish that abnormalities were present prior to the start of singing lessons, as opposed to having been caused by lessons" (p. 52). Brand

(2016) suggested such documentation might, in addition to providing useful information, protect the voice teacher from future possible litigation. While studio-wide referral to a dentist may be prohibitively expensive and possibly unnecessary, numerous, easy-to-use screening tools exist that allow the voice teacher to rule out TMDs in their students (Borges et al., 2021; González-González & Herrero, 2021). Presented to incoming students, a screening tool might help the voice teacher discover the presence of a TMD and, presented to students complaining of voice problems, help the teacher make a referral to the most appropriate medical professional. The voice teacher should emphasize to the student that screening is not a substitute for a diagnosis; research suggests that such tools are most accurate in conjunction with a physical examination (Borges et al., 2021).

Two commonly used screening tools are the 3Q/TMD (Figure 3) (Kapos, et al., 2020, p. 326) and the TMD Pain Screener (Figure 4), drawn from the DC/TMD (Gonzales et al., 2011, p. 1187). Kapos et al. (2020) suggested that "Clinicians who are not trained in the DC/TMD examination protocol or do not have time to use it can use one of these brief assessments to inform their decision to refer patients to a colleague with orofacial pain training" (p. 325).

Figure 3
3Q/TMD screening instrument

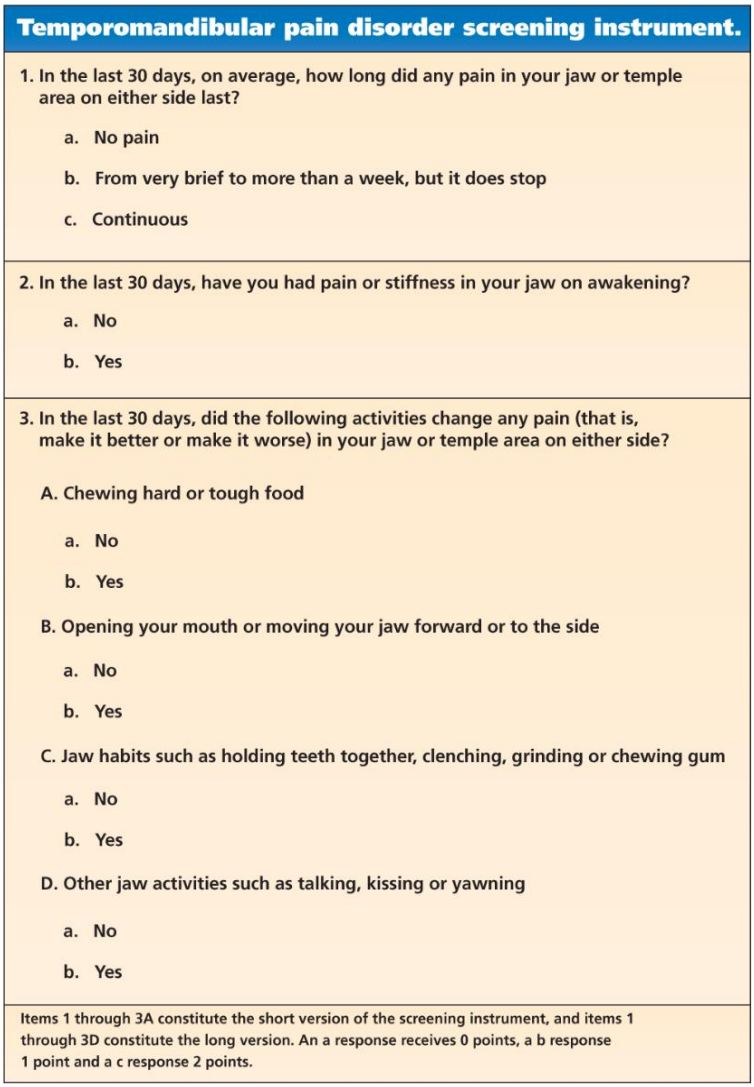
3Q/TMD[56]

1. Do you have pain in your temple, face, jaw or jaw joint once a week or more?
    a. No
    b. Yes
2. Do you have pain once a week or more when you open your mouth or chew?
    a. No
    b. Yes
3. Does your jaw lock or become stuck once a week or more?
    a. No
    b. Yes

Scoring: Any affirmative answer yields a '3Q-positive' result.
Interpretation: 3Q-positive score suggests need of further TMD evaluation.

Figure 4

DC/TMD pain screening instrument



Temporomandibular pain disorder screening instrument.

1. In the last 30 days, on average, how long did any pain in your jaw or temple area on either side last?
   - a. No pain
   - b. From very brief to more than a week, but it does stop
   - c. Continuous

2. In the last 30 days, have you had pain or stiffness in your jaw on awakening?
   - a. No
   - b. Yes

3. In the last 30 days, did the following activities change any pain (that is, make it better or make it worse) in your jaw or temple area on either side?

   A. Chewing hard or tough food
   - a. No
   - b. Yes

   B. Opening your mouth or moving your jaw forward or to the side
   - a. No
   - b. Yes

   C. Jaw habits such as holding teeth together, clenching, grinding or chewing gum
   - a. No
   - b. Yes

   D. Other jaw activities such as talking, kissing or yawning
   - a. No
   - b. Yes

Items 1 through 3A constitute the short version of the screening instrument, and items 1 through 3D constitute the long version. An a response receives 0 points, a b response 1 point and a c response 2 points.

Note. positive score = 2 for the short version and 3 for the long version

Additionally, voice teachers may be able to observe "red flag" signs of a possible TMD during singing lessons (please refer to Chapter 3 for more detail regarding signs and symptoms of TMDs in singers.) Some TMD-specific observations might include asymmetry in jaw opening, facial tension, inability to open the mouth wide enough for singing, clenched masticatory muscles while singing, excessive tongue tension, difficulty resonating or modifying vowels, postural imbalances, student complaints of clicking or ear popping, and jaw or

masticatory muscle pain while singing. Changes in voice quality are associated with TMDs; however, these may be indicative of different voice pathologies and so should be considered in conjunction with TMD screening. Additionally, voice teachers should familiarize themselves with the signs and symptoms of common voice pathologies in order to make a referral to the most appropriate medical professional.

Referral

When discussing all health matters with students, it is important to respect students' autonomy and agency in their healthcare decisions. There are a variety of reasons why students may choose to pursue or not to pursue treatment; financial cost, insurance coverage, and time are some possible non-health-related factors. Some controversy exists regarding the ethics of refusing to teach a student who will not seek care upon referral; one argument being that teaching a student who refuses to seek care could inflict more damage and expose the teacher to unnecessary professional risk, while an alternative perspective is that refusing to teach such a student is unethical, akin to a medical professional refusing to treat a patient who will not follow medical advice (Jaworek & Sataloff, 2015). Regardless of the individual voice teacher's decision, it may be wise for the teacher to articulate such policies clearly during the first voice lesson.

Since a speedy referral has been shown to positively impact patient outcomes, it may also be useful for voice teachers to compile a "Voice Care Team" - a group of proximate professionals who can provide care for the voice beyond the scope of the voice teacher (Heman-Ackah et al., 2008). In consideration of the biopsychosocial model, such a team might include an otolaryngologist, speech language pathologist, singing voice specialist, physical therapist, psychologist, and dentist. If the teacher works at a university or other educational institution, there may be on-campus professionals who can see students for free or at a reduced rate.

Should the student refuse referral, and the voice teacher agree to continue singing lessons, the voice teacher may direct the student to self-care practices that reduce the negative impact of TMDs. A self-management (SM) plan, as described earlier in this chapter, provides options for immediate, self-directed relief. While helpful, it is important for the voice teacher to emphasize that this is not medical advice and is not a substitute for medical treatment (Table 2).

Table 2

Examples of self-care practices	
Physical exercises	Jaw stretches, tongue stretches, neck stretches Postural aligning exercises Core strengthening exercises *examples of possible exercises compiled in Appendix A
Thermal	Recommend application of cold or heat packs for acute pain
Medications / Supplements	Ibuprofen has less risk for vocal fold hemorrhage Magnesium, Vitamin D, Vitamin B CBD Oil
Avoid parafunctional habits	Consciously release clenched jaw throughout the day; notice when and why it occurs Avoid nail biting, chewing gum, chewing foods that cause pain
Psychosocial	Improve mental wellness through exercise, socializing, meditation, yoga, journaling.
Sleep/ Stress	Eat nourishing foods, avoid caffeine/ alcohol before bed, make sure bedroom is dark, have regular sleep schedule, avoid stressful activities before bed, address stressful life situations.

Lastly, the student may choose not to discuss their health at all. Bigler et al., (2021) have argued that voice teachers should never require involuntary health disclosure, but that the voice teacher must, in this case, also decide if this is a student they are willing to teach. Education in vocal anatomy and function may help the student better understand the interconnectedness of vocal health and vocal technique, and the necessity of such discussions, recognizing that any health information the student chooses to disclose must be kept confidential (Bigler et al., 2021).

The voice teacher may wish to consult with colleagues regarding TMD-related voice problems; however, in this situation, all identifying information about the student should be removed from the conversation.

Support in treatment

In making a referral, the voice teacher may wish, with the student's permission, to give the medical provider information gathered during lesson. A written or verbal narrative of the voice teacher's observations may provide useful information to the provider. It may also be useful to send a copy of the TMD Screening results with the student to his or her first appointment.

Since most providers who treat TMDs will likely not have training in vocal function, it may be useful to discuss with the provider the role of the jaw in singing. Providers should know that the patient is a singer, and, ideally, watch the patient sing. The student should feel comfortable asking how each treatment might affect the singing voice, and whether there is any long-term impact from treatment that should be factored into performance planning or other educational singing requirements.

The voice teacher may also wish to follow up with the student throughout treatment. Increased accountability may help the student retain consistency with a self-care plan recommended by a medical provider. The voice teacher is also encouraged to ask the student about treatments and should be ready to ask for a second opinion should the provider recommend invasive or unsubstantiated treatments. If a more invasive treatment is determined necessary after conservative treatments prove ineffective, the voice teacher should try to adjust the timing of singing engagements or vocal juries to accommodate the procedure and recovery schedule.

Section 5: Conclusions

While the prospect of identifying and making an appropriate referral may seem overwhelming, a common-sense approach that honors the agency and privacy of the student is recommended and summarized below. Voice teachers should be aware of current research surrounding best treatment practices and advocate for evidence-based treatments, while being sensitive to the financial limitations of many students. They should further educate students regarding non-invasive, nonmedical, self-care practices. Through communication with providers, and accountability during lessons, voice teachers can support the student during and after treatment.

Voice teacher summary

- Many treatment options are possible; however, research supports conservative, non-invasive, and reversible treatments as a starting place for care
- Voice teachers can educate and assist students in selecting healthcare providers with specific training in diagnosis and treatment of TMDs.
- Voice teachers can identify students who may need referral using easy to use screening tools.
- Voice teachers should respect students' privacy and autonomy in making healthcare decisions.
- Voice teachers can support students in the treatment process through education in self-care practices, communication with medical providers, and accountability during weekly lessons.

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Chapter V: Management of TMDs In Voice Lessons

Introduction: revisiting the biopsychosocial model

As described in Chapter 4, voice teachers have the opportunity to provide valuable support in the management of TMDs during voice lessons. Indeed, Heman-Ackah et al. (2008) state that the voice teacher is "usually regarded by the student as the source of all knowledge about anything vocal" (p. 583). The World Health Organization Constitution (1948) defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity", a definition which aligns with the biopsychosocial model. This definition also runs in parallel with the humanistic pedagogical model, described by Brand (2016) as voice pedagogy to "address the entire student" so that singers "leave the studio with a higher sense of well-being than when they entered" (pg. 11). Brand cautions that "singers are more than just the beauty of their voices, their artistry and their dramatic presence. If we ignore the state of the person behind the voice, the singer may never reach his or her full potential." (p. 10). The implications of this philosophy are two-fold: first, that well-being is an important factor in the ability of singers to achieve "artistry", and second, that it is worthwhile to consider the multifaceted nature of disease, or the "person behind the voice". A view of vocal health through the lens of the biopsychosocial framework reveals a myriad of ways in which the voice teacher can support both the wellness and artistry of singers with TMDs.

Section 1 : In-Studio Support of Singers with TMDs

Implementing the biopsychosocial model in the voice studio

The voice teacher has the opportunity to assist students with TMDs, as an expert, non-healthcare professional, in singing-related management. Within the biopsychosocial framework,

the ways in which the voice teacher may act to support a student with a TMD are in direct response to specific etiological factors in each of the biological, psychological, and social categories of health (Table 1).

Table 1

Voice teacher actions in support of TMJ health and TMD management

	Etiological Factor/Symptom	Voice Teacher Action
Bio-	Biological factors	Educate in TMJ anatomy & function/ TMD pathophysiology
	Physical symptoms	Screen/ refer to qualified dentist/physical therapist
		Provide physical self-care strategies
	Physical demands from singing	Provide physical accommodations/adaptations in voice studio
		Prioritize physical well-being in singing
Psycho-	Psychological factors	Screen/refer to mental health professional(s)
		Provide self-care mental wellness strategies
	Catastrophizing TMDs	Provide understanding, encouragement, accountability in lessons
	Emotional demands from singing	Prioritize psychological well-being in singing
Social	Psychosocial factors	Recognize and respond to external pressures
	Social impact from TMDs	Encourage a positive social environment in the voice studio
		Destigmatize illness/ need for accommodations
	Social demands from singing	Prioritize Social Well-being in Singing

Voice teacher actions supporting biological health

The voice teacher may explain normal TMJ and masticatory muscle function for singing, demonstrating the application of such knowledge through pedagogy that is physiologically accurate. Should the teacher observe signs of a TMD, or should the singer complain of TMD

symptoms, it may be useful for the teacher to give a succinct explanation of pathophysiology. This will make the singer aware of the possible impact on singing and the necessity of seeking further care. Since, in this author's experience, not every student has the desire to delve deeply into pathophysiology, the voice teacher may anticipate the need to adapt their explanation to the individual student.

Screening and referral, discussed at greater length in Chapter 4, may become necessary in the presence of a possible TMD. In the short term, in response to physical symptoms, the voice teacher may feel comfortable recommending pain-relieving strategies, such as over-the-counter medication, applied heat and cold, or simple stretches and massages. Additionally, singing creates specific demands upon the masticatory system, namely, repeated or wide jaw opening for resonance and articulation. For a student with more severe TMDs, the presence of pain and dysfunction may require certain adaptations to singing, which are discussed later in this chapter.

Voice teacher actions supporting psychological health

Since psychological factors are a significant characteristic of TMDs, it may also be useful for the voice teacher to refer students to a psychologist. The stressors and mental health concerns contributing to a TMD may very well have similar impact on the singing voice, so ensuring such factors are addressed is important. Conversely, the negative emotions that singers with TMDs may experience as a result of the disorder may negatively impact their experience of singing (Amorino & Taddey, 1993). Day-to-day stress is a reality that many singers face (Gilbert, 2021; Koops & Keubel, 2021), so they may benefit from learning about stress management or other self-care strategies. Signs of chronic stress such as anxiety, depression, low self-esteem, depersonalization, or a loss of interest in singing or other activities are indications for the possible need for referral to a mental health professional (Bernhard, 2010; Koops & Keubel,

2021). Voice teachers may also use their role as mentor and guide to support students in developing healthy habits to manage stress, such as adequate sleep, exercise, nutrition, and mindfulness practices.

Catastrophic thinking, such as rumination on pain or negative beliefs about the singer's ability to recover or adapt from TMDs, has been shown to increase pain and dysfunction in patients with TMDs (Brister et al., 2005; Turner et al., 2001; Turner et al., 2005). In contrast, self-efficacy has been shown to predict lower pain, disability, and psychological distress (Brister et al., 2005). In support of self-efficacy, voice teachers may encourage and model positive self-talk that highlights students' agency in overcoming barriers to normal singing in order to support students' self-efficacy in recovery and management of TMDs. Furthermore, while avoiding jaw opening that causes severe pain might be useful in the short-term, long-term avoidance of normal singing tasks (i.e., "pain guarding"), might not lead to improved function and could contribute to increased psychological distress (Amorino & Taddey, 1993; Brister et al., 2005). When taken as a whole, promoting self-efficacy in symptom management may improve over-all quality of life and positively impact the experience of singing through TMDs.

During speech, human emotion is perceived through a combination of vocal and facial expression (Young et al., 2020) both of which can be impacted by the presence of a TMD (Amorino & Taddey; 1993). As such, "the job of a (singing) performer is to convey to an audience, through vocal production, physical gestures, and facial expression, a most heightened state of emotion" (Rosenberg & LeBorgne, 2019, p. 84). Thus, emotional regulation towards an expressive goal, conveying the emotions of the song, is an important skill singers must master. Not only does this place an increased emotional burden upon the singer, but also makes the act of singing exceptionally vulnerable to the effects of psychological distress. This distress, in turn,

can contribute to the development of TMDs, limit expressiveness during singing, and negatively impact the singing voice (Larrouy-Maestri & Morsomme, 2014; Van Puyvelde et al., 2018).

While some level of stress is normal and unavoidable when singing, there may be voice-related effects of such stressors. As voice teachers get to know their students, they may be able to more easily recognize when eustress, or stress that motivates growth, becomes distress, or stress that is harmful (Gilbert, 2021). For example, while it is beneficial encourage students to participate in many singing engagements, the voice teacher may recognize that, for an overwhelmed student, such demands may lead to burnout and, potentially, a stress-related TMD. Thus, for a voice teacher utilizing the biopsychosocial model, psychological well-being is priorized as much as physical well-being in the voice studio.

Voice teacher actions supporting psychosocial health

Underlying psychological factors can be influenced or exacerbated by psychosocial factors, such as culture and social environment (Suvinen et al., 2005). Many pressures that students face outside of the voice studio, over which the voice teacher has no control, may impact the singer in the studio, affecting both their general and temporomandibular health. Voice teachers may, in the course of developing a personal relationship with their students, become more aware of the external cultural and social factors that impact the students' attitude and response towards challenges such as TMDs, and their subsequent limitations. This recognition may, in turn, help voice teachers address more directly the factors that emerge in management of TMDs.

Additionally, students may face isolation or stigmatization as a result of the limitations TMDs place on the singing voice. Amorino and Taddey (1993) reported that singers with TMDs were "upset at the treatment they received from those around them who may not have fully

understood their jaw problem" (p. 8) and felt "wrongly judged 'incapable', 'lazy', and even 'crazy' by the vocal community" (p. 10). The voice teacher has the opportunity to create a positive social environment in the voice studio, through modeling and encouraging positive and supportive interactions between students and with parents or other authority figures. Through frequent, honest conversations around vocal health, voice teachers can normalize the challenges that impact vocal development, and destigmatize the presence of voice-related disorders, such as TMDs, in singers. Voice teachers may wish to emphasize that every singer has different strengths and weaknesses and may discourage moralistic judgements from parents, colleagues, and other students.

Finally, the pressures of wanting to perform well, meet voice-related goals, and impress teachers and colleagues can place significant demands upon even the healthiest singer. This may complicate compliance with any recommendations that voice teachers make to manage stress, as students may feel that external pressures are more important than self-care. Students may, therefore, require encouragement from teachers to make psychosocial health a priority. Such encouragement may be most effective in conjunction with advocacy on the part of the voice teacher; for example, a voice teacher might seek postponement of an end-of-semester vocal exam when the student is experiencing a TMD flare-up.

It is clear that in each of these areas of action, the voice teacher's primary focus is the benefit of the student. Prioritizing biopsychosocial health in the vocal studio is one way to support temporomandibular health, and it is reasonable to suggest, improve singing outcomes long-term.

Section 2: Adaptations to Voice Lessons

The following section includes recommendations for specific adaptations the voice teacher may choose to make in the studio to support students with TMDs and facilitate masticatory health. These suggestions are not exhaustive but instead serve as a starting point and inspiration for individualized adaptations the voice teacher may wish to make.

Setting up the voice studio space

Voice teachers conduct lessons in a variety of locations: private or public schools, universities, private studios, and virtual spaces, to name just a few. While teachers may have limited control over the arrangement of the studio, certain modifications to the studio space and the items available to the student may be useful. Diagrams or graphics containing information regarding vocal health and anatomy can be a useful reference during lessons and may assist the voice teacher in normalizing conversations about vocal health. A diagram of the TMJ and masticatory muscles may help the student gain awareness of their own masticatory systems, and recognize the close connection between the TMJ, masticatory muscles, tongue, and laryngeal structures. The voice teacher may also consider printing out and laminating short screening tools for TMDs or stress and anxiety. Finally, the teacher may consider having paper or electronic handouts available upon request with information about TMDs, resources, and self-care recommendations.

Additionally, voice teachers can create opportunities for students to receive singing feedback that targets TMDs. While voice teachers can provide important verbal feedback regarding appropriate jaw function in singing, students may additionally benefit from application of various *biofeedback* modalities in the voice studio. Biofeedback can be defined as "extrinsic feedback … that provides the user with additional information, above and beyond the

information that is naturally available to them" (Florjanski et al., 2019, p. 2). There are several different kinds of biofeedback, including visual, audio, spectrographic, and electromyographic (EMG) measurements (Madden, 2012; Florjanski et al., 2019). While EMG-biofeedback is frequently used in treatment of TMDs as a way to aid patients in retraining muscle patterns, it is not easily accessible in the voice studio. In contrast, students may easily gather visual and audio biofeedback from tools that are easily accessible in the voice studio. A full-length mirror in the voice studio can give the student useful information regarding orofacial muscle activation, posture, and jaw opening that allows them to adapt as they sing, a form of *simultaneous* feedback. Filming or audio recording of the voice lesson allows the student to view and reflect upon their singing choices, a form of *delayed* feedback, and Madden (2012) recommends the use of slow-motion video capture to highlight specific muscle movements. Additionally, since TMDs may impact resonance in singing, a visual representation of resonance using downloadable software such as VoceVista Video and Overtone Analyzer, may help the student observe and more easily modify the resonance patterns during singing (https://www.vocevista.com) (Madden, 2012).

While simultaneous feedback allows the singer to immediately integrate observations in real-time, there may be additional psychological benefits from delayed feedback. Kross and Ayduk (2011) suggest that emotional self-distancing in reflection of challenges, such as viewing video or audio of past singing, allows students to analyze their singing and find solutions free of the psychological and egoic pressures of the experience. This distance in turn makes it easier for the student to avoid negative self-talk or catastrophizing. Encouraging the student to self-monitor and be a part of the problem-solving discussion may also increase the student's self-efficacy in management of TMDs. While Madden (2012) cautions that singers may become overly reliant

on biofeedback in the voice studio, Angelakis et al. (2021) suggest that the additional information biofeedback provides is important for developing a deeper understanding of the mechanics of singing and recommends use of technology in the voice studio as part of a larger, holistic pedagogical approach.

A third consideration for the organization of the voice studio is the facilitation of ergonomic efficiency. Specifically, the setup of the studio should allow the singer to maintain aligned posture, since posture may be a factor in the development of TMDs (Bartley, 2011; Corrêa & Bérzin, 2004; Rockland et al., 2010). In the case of in-person lessons, it may be helpful to position the student opposite to and far enough from the voice teacher to allow the singer to make eye contact without having look down or to one side. Additionally, use of a music stand to hold sheet music closer to eye level may help the singer maintain aligned posture. Similarly, in the case of remote lessons, the student may be encouraged to position their streaming device as close to eye level as possible. In both in-person and remote situations, the voice teacher can also verbally encourage the singer to maintain aligned positioning while singing. If necessary, the singer may stand against a wall or door as an additional postural reminder.

Adaptations to voice lesson structure

The structure and flow of lessons may be impacted by a student's TMD. Since the experience of TMDs can vary day-to-day and even moment-to-moment (Aaron et al., 2006; Van Grootel et al., 2002), a dynamic lesson structure that can respond to the changing needs of the student may be useful. Both Aaron et al. (2006) and Van Grootel et al. (2002) found that patients reported higher levels of pain in the evening, a factor voice teachers might consider when scheduling weekly lessons for their students. Another significant factor that may impact lesson structure is that singers with a TMD reported reduced endurance (Amorino & Taddey, 1993), a

finding that aligns with the relationship between increased practice time and TMDs (Taddey, 1992; Van Selms et al., 2019). Thus, shorter lesson times, increased use of vocal exercises that manage vocal fatigue, or breaks within the lesson to work on aspects that do not require singing (i.e., discussing repertoire or practicing pronunciation) may be needed. It is important for the voice teacher to foster an ongoing conversation with the student to appropriately adapt the lesson structure as needed.

Additionally, voice teachers may need to adapt singing repertoire. Since jaw opening is necessary for resonance high in the range (Austin, 2007; Sundberg & Skoog, 1997) and since singers with TMDs reported limitations to their range (Amorino & Taddey, 1993), repertoire with pitches high in the singer's range may be challenging for singers with TMDs. Frey (1988) reported a higher incidence of TMDs in sopranos, compared to other voice types, suggesting that range may impact these singers more frequently. Further, voice teachers should also consider that avoiding normal singing behavior (i.e. "guarding") was found to increase pain and functional limitations in subjects with TMDs (Brister et al., 2005). While singing high in the range may be challenging and potentially painful, it may not be wise to avoid songs with high notes entirely. Choosing repertoire with one or two "high notes", that singers can access carefully and with guidance might be a possible solution. Another option might be to focus on high notes exclusively in vocal exercises, and only choose repertoire with notes that can be sung without pain as the singer becomes more confident managing symptoms with TMDs. An ongoing discussion with the student regarding repertoire choices will support the student's self-efficacy. Once repertoire is selected, the voice teacher may decide to set aside or modify songs that appear to lead to technical regression or progressively more jaw and orofacial tension.

Students may also require additional guidance in creating independent practice routines. Such routines will allow the student to have the knowledge and confidence to practice in a way that supports prevention and management of TMDs without the oversight of a voice teacher in the room. In particular, the voice teacher may instruct the student to consider the same concerns that affect the structure of a lesson, namely, limitations to endurance and range. Students may be more likely to practice past the point of vocal health in the presence of external stressors such as an upcoming performance. For that reason, the voice teacher might plan a longer period of preparation for new repertoire so that the student does not feel the need to practice more than is healthy to them. In support of self-efficacy, it may be useful for the voice teacher to work with the student to create an optimal weekly practice routine that limits the consecutive time spent singing and allows students to proactively prevent and respond to symptoms of tension and fatigue. Students should be encouraged to carefully warm their voices up into the high range, but to recognize situations of diminishing returns in vocal quality and physical tension.

Vocal technique in management and prevention of TMDs

Adaptations to vocal technique should similarly be dynamic, addressing the signs and symptoms that emerge during lessons. Managing tension, particularly in the orofacial, laryngeal, and tongue muscles, is a priority. Since singing is a highly emotional act, voice teachers may quickly need to pivot from addressing physical limitations to addressing the emotional experience of singing when a physical limitation is experienced. An empathetic, practical approach will allow the teacher to recognize the student's challenges, while promoting self-efficacy through focus on that which, in the moment, the student can change.

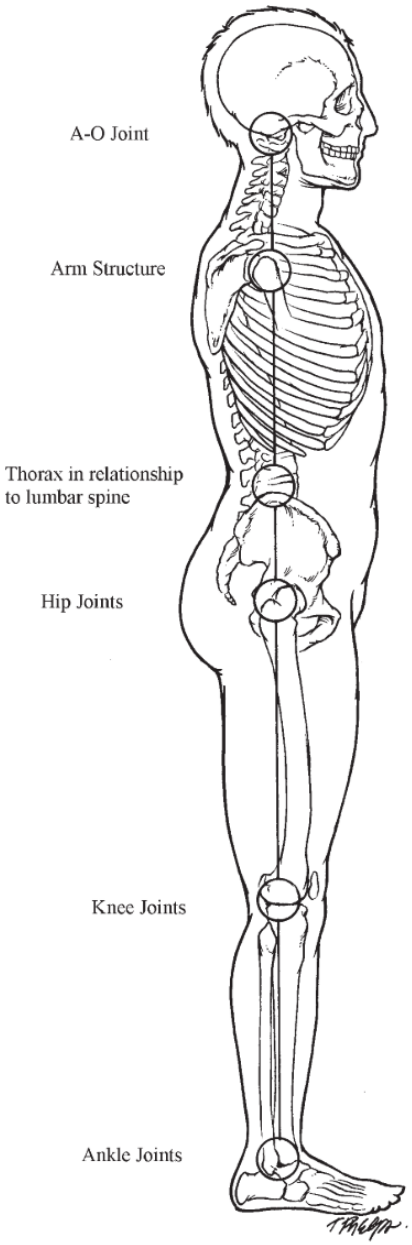
Technical adaptations to singing lessons may be related to posture and breathing, laryngeal function, resonance, and articulation. Ways that TMDs impact the singing voice are

discussed at length in Chapter 3; the following are recommendations to address specific functional limitations and technical adaptations to prevent exacerbation of TMDs. Since incorrect posture, particularly forward head posture, can negatively affect TMDs, voice teachers should be quick to correct postural imbalances (Bartley, 2010; Corrêa & Bérzin, 2004; Rockland, et al., 2010). Additionally, students should build awareness of their posture while singing and during daily life so that over time, self-correction is sufficient. Malde et al. (2020) described the six points of vertical alignment that voice teachers might use to direct correct posture: the atlanto-occipital joint, arm structure, thoracic/lumbar spine, hip joints, knee joints, and ankle joints (See Figure 1). Additionally, such posture should be maintained without excessive tension or "locking" of joints. Strengthening of postural muscles, such as through Pilates Exercises, may help students more easily maintain postural alignment without tension (Krawczky et al., 2016; Lee, 2009).

Physical tension can additionally extend into the external laryngeal, tongue, and jaw muscles. Burt and Burt (2014) reported that singers often incorrectly rely upon digastric and masticatory contraction to "support the tone", rather than breath support through expiratory muscle engagement (p. 42). Burt and Burt recommended that singers with TMDs learn *appoggio* breathing, that is, singing with a raised sternum and expanded ribcage, while Sataloff (2006) promotes abdominal breathing to promote jaw and tongue relaxation.

Figure 1

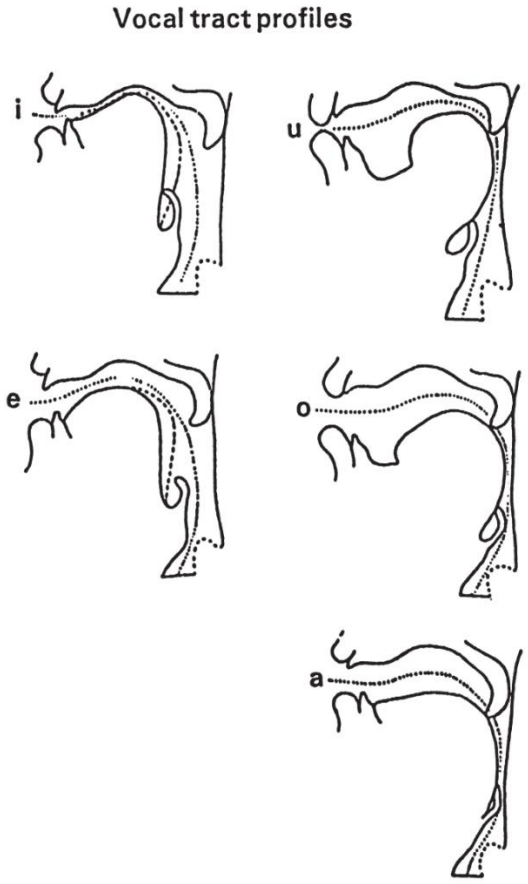
Places of balance skeleton, side view. By Tim Phelps. Copyright 2008 (Malde, et al., 2020)



Voice teachers should be particularly vigilant in identifying and managing orofacial and masticatory tension. Singers should work to become aware of areas of tension and intentionally relax those muscles while singing and throughout the day, whether speaking or at rest. Tongue tension can lead to a retracted tongue position which puts strain on both the TMJs and the hyoid

bone (Sataloff, 2017). Voice teachers should listen for excessive tongue retraction on vowels that require a tongue position that is further back, such as [u], [o], or [a] (see Figure 2), which can be heard as an excessively dark, muffled sound (Sataloff, 2017, p. 173). Miller advises singers find the optimal neutral tongue position for resonant singing by utilizing the position necessary to create a sustained [v] or [f], namely, in which the tongue is in contract with the lower teeth (Miller, 1981).

Figure 2
Tracing of x-ray profiles of the vocal tract for front vowels [i], [e], compared to back vowels [u],[o],[a]. (Sataloff, 2017).



Clenching of the masseter and temporal muscles can limit resonance during speech and singing (Sataloff, 2017; Sundberg & Skoog, 1997). Sataloff (2017) recommended intentional relaxation during vocal exercises to train freedom of jaw movement during voice tasks. Singers

with TMDs may find it challenging or even painful to open the jaw wide for higher singing. While prolonged mouth opening, such as during a dental procedure, has been observed to contribute to symptoms of TMDs (Howard, 1991; Kapos, 2020), there is no evidence that the kinds of mouth opening necessary for high singing are prolonged or wide enough to cause a TMD. Nevertheless, it may be prudent for singers to avoid mouth opening that causes open lock or acute pain.

Since resonance and voice quality are affected by TMDs, singers with TMDs may benefit from voice pedagogy methodologies that improve resonance and reduce difficulty in tone production. Resonant Voice Therapy is characterized by exercises that promote a "forward tone with vibratory sensations on the alveolar ridge and the maxillary bones", usually involving partial occlusion of the mouth (i.e. humming or buzzing) (Yiu et al., 2017, p. 18). Such exercises promote efficient, economic phonation and might reduce the level of effort necessary to sing through TMDs. Additionally, such exercises have been shown to improve outcomes of TMD comorbidities (see Chapter 3). Specifically, humming was shown to improve symptoms of Muscle Tension Dysphonia (Ogawa, et al., 2013), while Vocal Function Exercises improved symptoms of Laryngopharyngeal Reflux in singers (Bell et al., 2021).

Since these systems are interrelated, adaptations may need to address multiple systems simultaneously. Furthermore, many of the technical strategies that manage and prevent TMDs are also recommended for healthy singing. Thus, the technically proficient singer may already possess many of the skills necessary to sing through TMDs. Additional exercises that help to relax the masticatory muscles and increase range of movement, as well as several Resonant Voice Exercises are included in detail in Appendix B. While some benefit may be achieved from only using written exercises available in the literature, voice teachers may consider obtaining

additional education and instruction of such exercises from a massage therapist or physical therapist.

Section 3 : Considerations for Implementation

The student-teacher relationship

Mutual trust and respect are critical in matters of vocal health, such as when managing a TMD, (Brand, 2016; Kiik-Salupere & Ross; 2011). Furthermore, Meyer and Helding (2021) propose that "the quality of the student-teacher relationship may influence the student's vocal progress more than other single factor" (p. 361). Therefore, maintenance of a healthy student-teacher relationship founded on trust and respect is likely to support effective management of TMDs in the voice studio and increase likelihood of student cooperation with proposed adaptations. Table 1 outlines possible characteristics of a healthy student-teacher relationship.

Table 1

Characteristics of a healthy student-teacher relationship in TMD management

Voice Teacher Characteristics	Singing Student Expectations
Prioritize students' best interests	Trust in the voice teacher
Prioritize voice-related health	Cooperation with advice/ instruction
Expertise - continuing education	Honest, respectful communication
Referral beyond scope of practice	Self-advocacy (communication and education)
Honest, respectful communication	

The National Association of Teachers of Singing Code of Ethics states: "Members should offer their best instruction and career advice to every student under their supervision" (p. 1). This implies a "good faith" intent on the part of the voice teacher to teach with the student's best interests at heart, regardless of conflicting incentives such as fame, acclaim, tenure, financial gain, etc. Thus, for example, the voice teacher would not encourage the singing student to injure

themselves or exacerbate a TMD in pursuit of a high-profile singing award. Additionally, the teacher may observe closely the effects of various pedagogical techniques, not persisting in methods that appear to negatively impact the voice or student, or methods that do not appear to be beneficial to the singer. Since vocal health is an important component of singer success, student's best interests are supported through prioritization of voice-related health, specifically management of TMDs. Consistent prioritization of the student's best interests, including vocal health may help the singer feel more secure in trusting the voice teacher's recommendations for TMD management.

If, as earlier suggested, the voice teacher is "the source of all knowledge about anything vocal" (Heman-Ackah et al., 2008, pg. 583), this knowledge might reasonably be extended to encompass matters of voice-related health. Continuing education on the part of the voice teacher in all matters voice-related would ensure such knowledge remains relevant; many of these areas, including TMDs, evolve yearly with new research. In matters beyond the voice teacher's expertise or out of the voice teacher scope of practice, the voice teacher may refer to external resources, such as medical providers, to ensure the student receives appropriate assistance.

In management of TMDs, honest communication is likely an important component in building trust in the student-teacher relationship. This may include discussion of observations from the lesson, discussion of realistic singing goals, and acknowledgment of the limitations of voice lessons and of the teacher's own expertise. The voice teacher may further wish to educate the student regarding the vocal limitations that may arise from TMDs, while cautioning that such issues may not be resolved from voice lessons alone.

In return, it is reasonable to expect that the student trust the voice teacher's motives and expertise. The student should make a reasonable effort to cooperate with vocal health and

singing technique instructions, while communicating honestly any reservations or barriers towards compliance. For example, the student should incorporate practice instructions, repertoire recommendations, and self-care strategies to the best of their ability, and seek clarification or modification of instructions when necessary. The student should likewise communicate honestly regarding TMD and voice-related symptoms, inform the voice teacher when certain singing tasks exacerbate a TMD, and make the voice teacher aware of treatment plans affecting the voice (i.e., planned surgeries). Finally, the student should practice self-advocacy and agency in pursuing vocal health and excellence, taking responsibility for participation in mutually agreed-upon lesson and vocal health goals. The voice teacher may wish to outline similar expectations for the student early in the relationship in order to set the tone for all future lessons.

Challenges in working towards adaptive goals

When working in lessons towards performance goals, voice teachers may become aware of the presence of musical performance anxiety in their students. Musical performance anxiety (MPA) is a type of social anxiety disorder and is defined as "the experience of marked and persistent anxious apprehension related to musical performance" (Burin & Osório, 2017; Kenny, 2011, p. 61). MPA has been reported in 16.5% to 60% of professional musicians (Fernholz et al., 2018) and is an example of an occupational stressor that may contribute to TMDs. MPA severity is influenced by personality (self-esteem, anxiety state, or perfectionism), difficulty of task, and context (i.e. low-stakes rehearsal or high-stakes performance) (Burin & Osório, 2017). Voice teachers can reduce task-related MPA through repertoire choice and an emphasis on preparation, such as early memorization of a song.

When context related MPA is elevated in students, such as during preparation for an important performance, voice teachers may need to refer students for treatment of their MPA.

Common treatments for MPA include Cognitive Behavioral Therapy (CBT), relaxation, exercise, and β-blockers (Fernholz et al., 2018). Coping strategies for acute MPA include breathing techniques, relaxation, and alteration of problematic narratives such as catastrophizing (Burin & Osório, 2017).

As previously mentioned, the voice lesson is a good opportunity for voice teachers to model positive narratives, and this practice may be particularly relevant in situations of performance anxiety. For example, if the student tells the teacher "I am really stressed about this upcoming performance because I don't want to make mistakes in front of a large audience" the voice teacher might help the student shift the narrative to "I am nervous, but I am excited to have the opportunity to sing in front of a large audience. Even if I make a mistake, the audience will still enjoy my performance and I will learn a lot from the experience."

As voice teachers incorporate the adaptations described in this chapter, it is possible that their students may struggle to implement changes to their technique or habit, resulting in additional stress and emotional turmoil. Meyer and Helding (2021) suggest use of *motivational interviewing* (MI), a psychological technique therapists use to help clients overcome resistance to change. This technique involves the incorporation of five principles that may be safely utilized in the voice studio setting and outlined in Table 3:

Table 3
Motivational Interviewing Principles & Applications for Singers with TMDS

Principle	Description	TMD-related voice teacher dialogue
Express Empathy	Engage in reflective listening to better understand the student's experience	"Tell me about your experiences while singing"
Develop Discrepancy	Between what students say and what they do and between the behavior and the person	"You have stated you would like to limit time spent practicing. Let's come up with a strategy to help you track your practice time."
Avoid Argument	Direct confrontation can damage student-teacher relationship	"I understand you are not comfortable seeing a dentist for your TMD. Here is some information about TMDs and some self-care strategies"
Adjust to Client Resistance	Instead, use the student as a resource to help identify the barriers to change and possible solutions	"What are the feelings that come up when you try to unclench your jaw while singing? What would make you feel more secure doing so?"
Support Self-Efficacy	Through frequent discussion of appropriate and achievable goals	"Let's choose repertoire for the upcoming recital early, so that you can prepare without over practicing"

Meyers and Helding (2021) identify "ambivalence" or conflicted feelings as barriers to change in students. If a student is ambivalent about visiting a dentist or changing practice habits, techniques like MI may help voice teachers discuss TMD management in a way that is both empathetic and effective.

Conclusions

The recommendations outlined above address the biopsychosocial components of TMDs and provide a framework through which to consider the student's learning and health needs in the context of studio lessons. The following is a summary of these recommendations:

- The support voice teachers can provide students with TMDs can be understood through the biopsychosocial model. In this model, the voice teacher can support each area of

wellbeing through education, referral, accommodations adapted to the needs of the student, and the creation of a positive environment in the voice studio.

- Adaptations to the physical space of the studio can be for educational purposes, such as with the addition of anatomical diagrams, or useful in gathering of biofeedback, such as with the presence of a large mirror.
- Adaptations to the voice lesson should be dynamic and responsive to students' changing needs. Voice teachers may make adaptations to the studio space and lesson structure to accommodate these needs that emphasize education, awareness, and regular communication about TMDs.
- While singers may find certain vocal tasks, such as singing in the high range, challenging, choosing to carefully perform normal tasks in a low-stakes environment may best promote self-efficacy and overall TMJ health.
- Voice teachers should be aware of areas particularly affected by TMDs; namely muscle tension in the masticatory muscles, tongue, and face. Techniques that reduce tension, strengthen breathing, and improve resonance and laryngeal function may help mitigate the challenges in singers with TMDs.
- Relaxation techniques may be helpful in minimizing physical distress and improving overall health. Voice teachers should consider receiving additional training or inviting a practitioner to work with the singers when addressing this component of the voice lesson.
- Factors in the effectiveness of adaptations may include the quality of the student-teacher relationship and musical performance anxiety. Facilitation of trust and respect, and techniques such as Motivational Interviewing may help the voice teacher achieve success in implementation of adaptations in the voice studio.

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Chapter VI: Conclusions and Future Research

Introduction

Rosenberg and Leborgne (2019) ask of their readers the rhetorical question: "Why would audience members pay money to sit for two or three hours for a mundane experience?" (pg. 84). This aptly put question is one that this author refers to frequently while teaching, and one that highlights both the excitement and risk of singing. The heightened physical, emotional, and, perhaps, spiritual vulnerability of the act of singing asks a similar vulnerability of voice teachers in examining their teaching methods and theories. To that end, the community of voice teachers is constantly reassessing, revising, and adding to bodies of knowledge. The evolution of the understanding of TMDs in the medical field and, more personally, that of this author's own understanding of TMDs while researching and writing this document mirror this process. It is clear that the collective understanding of the relationship between TMDs and the singing voice has ample room to grow. The following sections describe conclusions from the literature and specific directions for possible future research.

Section 1 : Conclusions for Voice Teachers

About TMDs

There are several important takeaways for voice teachers from the research. The first is that TMDs are prevalent among the general population, and particularly among singers assigned female at birth or female-identifying singers, who may comprise a majority of the singing student population. Because of this, it is likely that voice teachers will teach students with TMDs and may benefit from a foundational knowledge base when they work with these students. Furthermore, research suggests that TMDs may have a significant and potentially severe impact

upon many aspects of singing. Voice teachers can anticipate such effects and be prepared to manage signs and symptoms of TMDs in voice lessons. While research does not yet support a causal relationship between singing and TMDs, some aspects of singing, namely singing technique, singing-related stressors, and overuse, have been shown to correlate with incidence and severity of TMDs.

Biopsychosocial Model

Since the collective understanding of TMDs has evolved considerably in recent years, a review of contemporary, evidence-based theories and treatment options may aid voice teachers in providing relevant guidance to their students. It is important for voice teachers to understand the complex nature of TMDs, specifically the biopsychosocial nature of this group of disorders. Mechanistic approaches to management do not reflect the multidimensional etiology and progression of TMDs. In contrast, the biopsychosocial framework provides a way of understanding TMDs that promotes an individualized, collaborative approach to management that honors both the physical impact and the experience of singing with a TMD. In this way, students and voice teachers can work together to discover effective ways of management, and voice teachers can empower students to make healthcare decisions that are aligned with current research, specifically, pursuit of treatment options that prioritize conservative methods. Thus, voice teachers may gain a deeper understanding of their student's experiences with TMDs and find more success in implementation of adaptations within the biopsychosocial framework.

Voice teacher adaptations

Voice teachers have the responsibility to support the wellbeing of their students. They can assist students with TMDs through screening, speedy and appropriate referral, and ongoing communication with the singer and medical providers regarding their observations within voice

lessons. Furthermore, in the voice studio, the voice teacher can educate students about TMD pathophysiology, provide information for symptom management, and make adaptations to voice lesson and structure and studio space that will assist students in symptom management while singing. Finally, within the singing community, the voice teacher can facilitate a culture of positivity and support that destigmatizes TMDs, promotes student self-efficacy, and prioritizes both emotional and physical wellbeing inside the studio and out.

Moving forward

The goal of this synthesis of research is to provide information to readers so as to develop their understanding of TMDs. While working with a student with a TMD can be complicated, the information and recommendations outlined in this document provides a framework through which teachers can work more confidently and knowledgeably with students experiencing these disorders. Furthermore, voice teachers may be able to address masticatory and mental health concerns more proactively, in order to prevent TMDs in their students.

Section 2: Future Research

Improving existing body of research

This document compiled and summarized research from disciplines of voice pedagogy and medicine. Limited collaborations between researchers from two communities were found in the research; Burt and Burt (2014), Amorino and Taddey (1993), Sataloff (2017) were exceptions that featured authors from both medical and voice pedagogy disciplines. Such collaborations offer much value in areas of research that explore singer's health, and future research should include more interdisciplinary studies. Research teams that included voice

teachers, physical therapists, dentists, otolaryngologists, and psychologists might provide a more rounded perspective in observation of singers with TMDs.

While the research for this document unveiled many studies exploring the relationship between TMDs and the voice, there are several ways in which existing literature might be expanded upon and improved. Firstly, as described in Chapter 3, the literature associating TMDs and the voice included varied methodologies of data collection, varied population samples, and varied methods of assessing voice and TMJ status. While some studies gathered data from singers, others addressed the voice during speech. Replication of any of the studies described in Chapter 3 with larger sample sizes of singers and more uniform methods, such use of the DC/TMD and clinical diagnosis, would provide valuable verification of results.

Research to improve understanding of the jaw and singing

Future research should focus on obtaining a better understanding of the relationship between jaw function and the singing voice. While some researchers (Austin, 2007; Nair, et al., 2018: Sundberg & Skoog, 1997) observed that jaw function is an important part of resonance in singing, and recorded some consistency in jaw opening strategies between subjects, such research was limited to small sample sizes and classical singing genres. Since resonance strategies differ between genres (Bozeman, 2013), observation of jaw movements during non-classical singing might provide useful information to voice teachers specializing in non-classical or multiple genres. Also, observations that were correlated with spectrographic analysis of voice quality and resonance could verify the functional effects of such strategies. While wide opening for high pitched singing has been observed, the use of jaw tracking technology during singing to observe laryngeal/jaw coordination might also reveal more subtle differences, particularly if comparing speech and singing or comparing different genres (Bandini & Yunusova, 2017).

Furthermore, Cookman and Verdolini (1999) observed that stronger vocal fold adduction was associated with wider jaw opening during speech. Replication of this finding in the singer population might suggest that strategies that improved jaw function might increase control over vocal fold closure in singing. Firm adduction has some historical precedence; Manuel Garcia II (1847) describes the *coup de la glotte,* or "stroke of the glottis", as necessary for classical singing. While, historically somewhat controversial, Stark (1999) argues that such a technique, which he understands to mean firm vocal fold closure, encourages efficient and powerful phonation, particularly for classical or operatic singing. Voice teachers seeking to teach the *coup de la glotte* technique might find that jaw opening impacts its implementation; however more research to verify this is needed.

Additional studies that could deepen understanding of the relationship between laryngeal and TMJ function in singing should be considered. Electromyography (EMG), or the measurement of electrical muscle activity, could measure the association between engagement of laryngeal or respiratory muscles with masticatory muscles in subjects with TMDs, compared to controls. It seems plausible that elevated laryngeal activity in conjunction with masticatory inflammation or tension might contribute to the limited stamina experienced by singers with TMDs (Amorino & Taddey, 1993; Howard, 1991; Van Selms et al., 2019).

Laryngeal movements in conjunction with jaw opening might also be observed externally and through functional magnetic resonance imaging (fMRI). This author has observed relaxation of the suprahyoid muscles and a lower larynx in singers upon wider jaw opening in conjunction with reported "increased ease" particularly in the higher range. Measurement of the mechanical relationship between laryngeal movement and jaw opening could improve the understanding of this relationship and its effects on singing.

Research to improve understanding of the TMDs and singing

While no research was found to suggest singing causes TMDs, some aspects of poor vocal technique and hygiene, such as overuse, stress, muscle tension, and inappropriate breath support were shown to be possible factors in TMD incidence and severity (Amorino & Taddey, 1993; Burt & Burt, 2014; Howard, 1991; Van Selms et al., 2019). Research associating these factors with TMDs in larger samples of singers could strengthen these associations. Conversely, it would be useful to see if singing technique associated with healthy singing also alleviated symptoms of TMDs. Additionally, research observing the intersection of comorbidities, such as GERD or Muscle Tension Dysphonia in singers with TMDs could contribute to an understanding of such relationships.

Studies using objective voice measures, such as fMRI, spectrographic analysis, aerodynamic measures, electromyography, and electroglottography would provide better information on the impact of TMDs on singers. Subjective measures, such as the vocal health index, or more in-depth qualitative questionnaires could provide information about singers' experiences with TMDs. Such information would perhaps be even more impactful were it observed in subjects with chronic TMDs over time. Furthermore, uniform identification of TMDs in singers using the DC/TMD and combining clinical diagnosis with self-described symptoms would provide more accurate information describing prevalence, severity, and impact of TMDs in singers.

Research to understand the impact of voice teachers on singers with TMDs

One conclusion from this research was that one of the most important responsibilities a voice teacher can assume is that of speedy screening and referral. Despite this, no research observing the impact of voice teacher screening and referral was found. Future research in this

area could encompass interviews with singers, voice teachers, and medical professions who have experienced the referral/treatment process together. For example, a short answer, qualitative survey of dentists who have treated singers with TMDs might reveal useful information about severity, prognosis, treatment, outcome, impact on singing, and impact of singing lessons throughout the treatment process. It would additionally be useful to determine whether some treatments are more effective in singers than others.

While voice teachers frequently work with singers diagnosed with TMDs, no research was found exploring the effectiveness of pedagogical methods in managing symptoms during singing. Thus, this is an area for research with much potential in development and testing of management methods. A research team comprised of both a voice teacher and dentist or physical therapist might develop a self-care plans and vocal exercises specifically for singers with TMD, that could be tested in a research setting through lesson observations, clinical exam, voice measurements, and questionnaires. Numerous strategies for managing signs and symptoms of TMDs in the voice studio, such as vocal technique, lesson pacing, repertoire choices, biofeedback methods, education, and self-care were discussed in Chapter 5; it might be useful to test the effectiveness of any of these strategies in controlled settings and to measure voice and TMD-related parameters over time.

Section 3: Broader Conclusions for the Field of Voice Pedagogy

Knowledge of vocal health

When taken as a whole, this synthesis points to broader implications for the field of voice pedagogy. The first is an expectation that voice teachers have a general knowledge of health topics and their application in the voice studio. Since singing is both and art form and an athletic

activity (Rosenburg & Leborgne, 2019), there are medical factors and associated risks while singing worth considering. Furthermore, some authors suggest that voice teachers may be held liable for voice-related injuries incurred while students are working with them (Brand, 2016; Jaworek & Sataloff, 2015), suggesting that such consideration also benefits the voice teacher.

The evolution of conceptual theories surrounding TMDs aptly illustrates the dynamic nature of knowledge development, which, in the medical field, is accomplished through continuing education requirements. The expectation of voice teachers to have knowledge of vocal health may well extend to a normalization of required continuing education. Voice teachers who regularly read scientific journals, enroll in teacher training courses, attend conferences, or obtain other voice pedagogy and vocal health information as part of their practice may find themselves better prepared to respond to the evolving needs of the field. Furthermore, it is possible that in the future, a formal accreditation or licensure for voice teachers may be established.

The critique outlined in Chapter 4, proposed by several authors, of the unclear effectiveness of treatment modalities from non-standardized specialties, is applicable to voice teachers (Desai et al., 2016; Reid & Greene, 2013; Sharma et al., 2019). A voice teacher certification or licensure with required continuing education might ensure that singers have access to voice teachers with a standardized body of knowledge and who engage in evidence-based practice. Such requirements are standard in the fields of medical and public school teaching, but the field of voice pedagogy is largely unregulated. To an extent, various institutions have proposed certifications such as "Singing Voice Specialist" or "Vocologist", but no state, national, or global standards exist (Loar, 2020; Pan American Vocology Association, n.d.). It

seems possible, however, that an optional accreditation or licensure for voice teachers will become mainstream in the future.

Biopsychosocial vocal health

As our collective understanding of the singing voice develops, it becomes clear that vocal health should be viewed holistically, as encompassing multiple systems and as influenced by many factors. It seems likely that, in the future, voice teachers will more frequently adopt this more holistic approach, viewing singers as individuals whose subjective, emotional experiences of singing and vocal health are a critical part of their development as artists.

The biopsychosocial model was revolutionary because it included psychosocial factors in the conception of disease and disorder. Voice teachers who focus on the biological components of the voice to the exclusion of the psychosocial factors involved may find their teaching ineffective for many students. Knowledge of vocal health through the biopsychosocial model might allow voice teachers to recognize more clearly the psychosocial barriers preventing "good" singing, increasing both their empathy towards singers' struggles and their pedagogical effectiveness.

Burt and Burt (2014) and Amorino and Taddey (1992) described scenarios in which singers with TMDs suffered from a lack of understanding and empathy from teachers and colleagues. Singers can be discouraged by stigma of voice disorders or poor technique, finding themselves unable to adopt changes towards healthy technique and self-care. Communication techniques that promote positivity and self-efficacy in change can mitigate the negative emotional effects of voice disorders. The biopsychosocial model suggests that physical and emotional well-being are equally important in the voice studio, however, to date much voice pedagogy literature emphasizes the physicality of singing. It seems clear that an increase in focus

on psychosocial health, particularly mental health and stress management, in the voice studio is crucial in maintaining vocal health and in training the singing voice.

Integrative Voice Pedagogy

Another important conclusion for the field of voice pedagogy is the importance of collaborative and integrative research and application. This document represents the synthesis of information from multiple fields of research from the point of view of a voice teacher. The diverse disciplines represented have much to offer the field of voice pedagogy on the topic of TMDs and, likely, on many other topics. Rather than "reinventing the wheel" in scientific research or development of pedagogical theories, voice teachers should work collaboratively with professionals from other disciplines. Indeed, research points to an intertwining relationship or perhaps a blurring of lines between disciplines in the context of the singing voice. The most effective voice teacher may be one who recognizes the entire network of disciplines that pertain to the singing voice and who is able dynamically integrate those disciplines as the situation requires.

Section 4: Final Thoughts

The primary purpose of voice teaching may best be summarized as "to assist students in achieving beautiful and artistic singing". Towards this end, voice teachers should, first and foremost, consider the needs of the singer. Rather than asking the question "what and how do I want to teach?", voice teachers should ask "what is needed from me as a teacher?" Perhaps, as medical knowledge progresses and the interrelatedness of voice and medical disciplines becomes increasingly apparent, the expectations of voice teachers to be able to support the health of their students will increase proportionally. If this is the case, voice teachers should work both to

educate themselves in voice-adjacent disciplines and to learn the limits of their own knowledge. Temporomandibular Disorders are not yet well understood in the voice community. It is hoped that this document will provide a deeper understanding that challenges preconceptions regarding vocal health. In turn, perhaps this document will be foundational to future research on a commonly experienced disorder and lead to a better conceptualization of vocal health and pedagogy.

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Appendix A

List of Abbreviations

AFAB	Assigned Female At Birth
ATM	Awareness Through Movement
BTX	Botulinum toxin (Botox)
CAM	Complementary and Alternative Medicine
CBD	Cannabidiol
CBT	Cognitive Behavioral Therapy
CNS	Central Nervous System
CSS	Central Sensitization Syndrome
DC/TMD	Diagnostic Criteria for Temporomandibular Disorders
EGG	Electroglottograph
GERD	Gastroesophageal Reflux Disease
GI	Gastrointestinal
IBS	Irritable Bowel Syndrome
LMM	Low Mandible Maneuver
LPR	Laryngopharyngeal Reflux
MART	Muscle Awareness Relaxation Therapy
MI	Motivational Interviewing
MPA	Musical Performance Anxiety
MRI	Magnetic Resonance Imaging
MTD	Muscle Tension Dysphonia
NSAIDs	Non-Steroidal Anti-Inflammatory Drugs
OPPERA	Orofacial Pain: Prospective Evaluation and Risk Assessment
RDC/TMD	Research Diagnostic Criteria for Temporomandibular Disorders
ROM	Range of Motion
SLP	Superior Lateral Pterygoid
SM	Self-Management

SSRI	selective serotonin reuptake inhibitor
TCA	Tricyclic antidepressant
TMJ	Temporomandibular Joint; sometimes used in place of TMD or TMDs
TMDs	Temporomandibular Disorders (collective term)
TMD	Temporomandibular Disorder (term for individual and specific TMD)
VFEs	Vocal Function Exercises

Glossary of Terms

Adduction (Laryngeal)	*Closing pressure of the vocal folds*
Arthrocentesis	*The insertion of two large needles above and below the TMJ, acting as an inlet and outlet for irrigation fluids, lubricating fluids, or medications*
Arthroscopy	*The insertion of two large needles above and below the TMJ subsequent insertion of a camera for the purpose of surgical interventions*
Avascular	*Characterized by or associated with a lack of blood vessels*
Articulation	*Movement of a joint, or "articulatory", where movement occurs*
Articular disc	*Cartilaginous disc upon which the mandibular condyle moves against the mandibular fossa - part of the TMJ (see meniscus)*
Arthralgia	*Joint Pain*
Biofeedback	*The technique of making unconscious or involuntary bodily processes perceptible to the senses in order to manipulate them by conscious mental control*
Biomedical Model	*Medical model that understands all disease and disorder processes to be the result of biologically measurable variables*
Biopsychosocial Model	*Medical model that recognizes a combination of biological, psychological, and social factors in disease and disorder processes*
Burnout	*Fatigue and diminished interest caused by long-term stress*
Bruxism	*Unconscious grinding, gnashing, or clenching of the teeth (see Parafunction)*
Catastrophic thinking	*Ruminating about irrational, worst-case outcomes, which can increase anxiety and prevent action*

Central Sensitization Syndrome *Disorder characterized by chronic pain not proportional to the type of injury/ damage and accompanied by the presence of neurophysiological/ neuoropathological phenomena*

Complementary and Alternative Medicine *Medical products and practices that are not part of standard medical care, such as hypnosis, dietary supplements, massage, reiki, or Traditional Chinese Medicine*

Compressive Forces *When a physical force presses inward on an object, causing it to become compacted.*

Condyloid joint *Joint comprised of condyle (ball) and fossa (socket)*

Conservative management *a type of medical treatment defined by the avoidance of invasive measures such as surgery or other invasive procedures, usually with the intent to preserve function or body parts*

Conversational Pitch *Average pitch frequency used during normal speech*

Craniocervical *Relating to the head and the neck*

Crepitus *The grinding, crackling, or grating sensation or sound in a joint, possibly an indication of joint degeneration*

Delayed feedback *Biofeedback that is experienced out of real time or after the fact (See biofeedback)*

Dysfunction *Impaired or abnormal functioning (as of an organ of the body)*

Degenerative Joint Disease *(or Osteoarthritis) Degeneration of joint cartilage and the underlying bone, causing pain and stiffness*

Eustress *Moderate or normal stress interpreted as being beneficial for the experiencer*

Electromyography *The recording of the electrical activity of muscle tissue, or its representation as a visual display or audible signal, using electrodes attached to the skin or inserted into the muscle*

Electroglottography *Used for the noninvasive measurement of the degree of contact between the vibrating vocal folds during voice production*

Spectrographic analysis *Analysis of a visual representation of frequencies of a signal over time, such as sound frequencies*

Formant *Frequency range naturally amplified by a space, i.e., the range amplified by the throat or mouth*

Fundamental Frequency (speaking) *Average pitch or frequency of the speaking voice*

Gastroesophageal reflux disorder *When stomach acid frequently flows back into the tube connecting your mouth and stomach (esophagus). This acid reflux can irritate the lining of your esophagus.*

Guidance *The means by which movements are directed and limited*

Ginglymoarthrodial joint *A joint that can both rotate and translate forward*

Histology *The study of the microscopic structure of tissues*

Hypermobility *An increase in the range of movement of a joint is capable, which can lead to instability of the joint*

Ligament *Joint stabilizing structures comprised of nonelastic fibers*

Low Mandible Maneuver *Singing technique involving a low mandibular position*

Maladaptive *Not providing adequate or appropriate adjustment to the environment or situation*

Mandibular depressors *Muscles that lower the mandible to open the jaw*

Mandibular elevators *Muscles that raise the mandible to close the jaw*

Masticatory system *A system of bones, teeth, joints, neurovascular elements, and muscles responsible for moving the mandible for speech, singing, and chewing*

Mechanistic *Determined or characterized by physical properties*

Meniscus *Cartilaginous disc upon which the mandibular condyle moves against the mandibular fossa - part of the TMJ (see articular disc)*

Motivational Interviewing *A psychological technique therapists use to help clients overcome resistance to change*

Motor Behavior *Any kind of movement in any part of the body and in any physical or social context*

Muscle Tension Dysphonia *The pathological condition in which an excessive tension of the (para)laryngeal musculature, caused by a diverse number of etiological factors, leads to a disturbed voice*

Mutational Falsetto *Also called puberphonia. Is characterized by the habitual use of a high-pitched voice after puberty*

Multifactorial etiology *Several factors can work congruently to cause and progress a disease*

Myalgia *Muscle pain*

Obstructive Sleep Apnea	*A sleep disorder in which the muscles that support the soft tissues in your throat, such as your tongue and soft palate, temporarily relax, closing the airway and preventing breathing*
Occlusion	*The way the teeth meet when the lower jaw (mandible) and upper jaw (maxilla) come together*
Orofacial	*Relating to the mouth and face*
Pain Guarding	*Behavior that is aimed at preventing or alleviating pain" and which includes stiffness, hesitation, and bracing*
Parafunction	*Abnormal function or behavior of the body*
Palpation	*Examination by pressing on the surface of the body to feel the organs or tissues underneath.*
Predisposing factors	*Etiological factors present prior to onset of disease*
Infrahyoid Muscles	*External laryngeal muscles below and attached to the hyoid bone, contracting to lower the larynx. Including omohyoid, sternohyoid, and sternothyroid*
Initiating factors	*Etiological factors that precipitate the onset of the disease*
Laryngopharyngeal Reflux	*A classification of GERD directly affecting the pharynx and larynx*
Manual Therapy	*The skilled application of passive movement to a joint either within ('mobilization') or beyond its active range of movement ('manipulation')*
Open Joint Surgery	*Also known as arthrotomy. Involves the opening of an incision a few inches long over the joint so the surgeon may operate on the joint itself*
Perpetuating factors	*Etiological factors that impact or complicate the progression of the disease*
Prognosis	*The likely outcome or course of a disease; the chance of recovery or recurrence.*
Protrusive movements	*Forward movements*
Proliferation	*New growth*
Radiate	*To spread out from a central area, i.e., radiating pain*
Reinke's Edema	*Swelling in the deep, non-muscular portion of the vocal fold, known as Reinke's space.*
Remittance	*To become less severe for a time without absolutely ceasing*

Resonance *The tendency of a space to amplify specific frequencies introduced into the space, i.e. the vocal tract resonates the voice*

Retrodiscal *Behind the disc, i.e., retrodiscal tissue*

Self-Efficacy *An individual's belief in their capacity to execute behaviors necessary to achieve specific goals*

Self-Management *Treatment focusing on an individual's role in managing chronic disease. Often associated with self-care, SM includes an array of activities needed to effectively manage a chronic condition*

Sign *Any objective evidence of disease, as opposed to a symptom, which is, by nature, subjective*

Singer *A person who sings professionally or for pleasure, or a student of singing*

Somatic *Relating to the body, as distinguished from the mind or psyche (see mechanistic)*

Stress *Physical, mental, or emotional factor that causes bodily or mental tension*

Subluxation *Self-reducing joint dislocation*

Suprahyoid muscles *External laryngeal muscles above and attached to the hyoid bone, contracting to raise the larynx. Including digastric, stylohyoid, mylohyoid, and geniohyoid*

Symptom *Any subjective evidence of disease, as opposed to a sign, which is, by nature, objective*

Synovial fluid *Secretions that lubricate the movements of a synovial joint*

Tinnitus *Medical condition in which the patient experiences ringing or other noises in one or both ears, or perception of sound when no actual sound is present*

Tongue retraction *A strong, pulling back of the tongue into the posterior portion of the oral cavity, associated with abnormal increased muscle tone*

Translation *Movement of a joint in a linear, non-rotational direction*

Temporomandibular Disorders *Umbrella term for group of disorders affecting the TMJs and surrounding structures including muscle, tissue, and ligaments*

Temporomandibular Joint (TMJ) *Bilateral condylar joints that articulate the mandible with the temporal bone*

Tensile force	*The stretching force acting on a material*
TMJ Capsule	*Fibrous membrane that surrounds the joint and attaches to the articular eminence, the articular disc and the neck of the mandibular condyle*
TMJ Internal Derangement	*Displacement of the disc from its normal functional relationship with the mandibular condyle and the articular portion of the temporal bone*
Shearing force	*A force acting in a direction parallel to a surface or to a planar cross section of a body, as for example the pressure of air along the front of an airplane wing*
Voice Care Team	*A group of proximate professionals who can provide care for the voice beyond the scope of the voice teacher*
Vocal Fold Nodules	*Benign, callus-like growths or lesions that form on the vocal folds after repeated vocal misuse*
Vocal Fold Polyps	*Fluid filled lesions located on the vocal folds*
Voice Pathology	*Voice disorder or pathology. Vocal deficit that affects functional or daily communication needs*
Voice Pedagogy	*The study of the art and science of voice instruction*
Voice Teacher	*An expert professional who teaches singing or other high level voice use*
Voice Turbulence	*A component of voice quality related to the energy level of high frequency noise (non-pitched sound) during phonation*

Appendix B

Exercises for TMJ function

The following exercises are by no means exhaustive. As mentioned in Chapter 4, voice teachers may wish to study specific techniques with their respective practitioners to better understand and explain the procedures.

Vocal Function Exercise Protocol

First described by Dr. Barnes and modified by Dr. Stemple (Stemple et al., 2010), Vocal Function Exercises (VFEs) have been used to improve voice parameters in professional voice users, disordered voices, and aging voices (Angadi & Stemple, 2017). This protocol has been shown to improve symptoms of Laryngopharyngeal Reflux and improve resonance and tone quality in voice users (Bell, 2021).

Table 1

Vocal Function Exercise Protocol

1. (warm-up) Sustain an extremely bright, forward /i/ for as long as possible on the musical note (C3) for bass/baritone, (F3) for tenors, (C4) for altos and (F4) above middle C for Sopranos. Goal = increase time in seconds
2. (stretching) Glide from your lowest note to your highest note on the word "knoll" without the "kn." There should be vibration at the lips. Goal = no voice breaks.
3. (contracting) Glide from a comfortably high note to your lowest note on the word "knoll" without the "kn." There should be vibration at the lips. Goal = no voice breaks.
4. (power) Sustain the musical notes C-D-E-F-G (starting at middle C for sopranos and mezzo-sopranos starting one octave below middle C for baritones and basses) E-F-G- A-B for tenors for as long as possible on the word "knoll" without the "kn." There should be vibration at the lips. Goal = increase time in seconds

Frequency:	Tone Quality Goals:	Technique:
1. Complete exercises 1-4 twice, two times a day 2. There should be at least one hour between practice times	1. Softly as possible 2. Clear quality of tone 3. No breaks, wavering, or breathiness 4. Forward focus without tension 5. Balanced onsets without breathiness or glottal attack	1. Low abdominal breathing 2. Excellent singing posture 3. The pharynx should be very large, and the lips should be very small when completing Exercises 2- 4.

Angadi, V., Croake, D., & Stemple, J. (2017). Effects of Vocal Function Exercises : A Systematic Review. Journal of Voice, 33(1), 124.e13-124.e34. https://doi.org/10.1016/j.jvoice.2017.08.031

Bell, K. (2021). *The Utility of the Vocal Function Exercise (VFEs) Protocol as an Adjunct Therapy for Voice Disorders in Singers with Suspected Laryngopharyngeal Reflux (LPR) Kathleen*. Shenandoah University.

Stemple, J. C., Roy, N., & Klaben, B. K. (2018). Clinical voice pathology: Theory and management (6th ed.). Plural Publishing.

Rocabado's 6X6

The following six exercises, created by Dr. Mariano Rocobado, are to be performed six times a day. The purpose of the exercises is to normalize range of motion and relieve soft tissue tension within the jaw, neck, and head. These exercises may be attempted while singing or as part of a vocal warmup routine. Wording edited for clarity.

Table 2
Rocabado's 6X6 Exercise Program

Exercise	Purpose	Procedure
1. Rest position of tongue	Rest the tongue and jaw, promoting diaphragmatic breathing to decrease activity of the accessory muscles.	Student should keep lips together and teeth apart. Student should put the anterior 1/3 of the tongue against roof of their mouth with slight pressure as if trying to make a "cluck" sound with the tongue. The student should not touch the tongue to the teeth. Next, the student should breathe through the nose by using the diaphragm and intercostal muscles.
2. Shoulder posture correction	Correct the abnormal scapular protraction through shoulder girdle retraction.	Student should draw the shoulders backward and downward by pulling the shoulder blades together.
3. Stabilization of head flexion	Distraction of the upper cervical spine alleviates mechanical compressions, allowing the posterior cervical muscles to elongate.	Student should stabilize the upper cervical spine by clasping hands together behind the neck over C2-C7 cervical vertebrae. Student should then keep the head straight and nod the head forward. This is not a neck flexion exercise; rather it is flexion of the head on the cervical spine.
4. Axial extension of the neck	To return the sternocleidomastoid muscles to normal posterior angulation. This reduces stress and unnecessary muscle activity to maintain the position.	Student should perform all the following motions simultaneously; "nod your head, glide the neck backward and stretch the head upward." The student should think of the chin as being comfortably close to the neck.
5. Controlled TMJ rotation	Reduction of initiating jaw movements with translatory component (ie, protrusive movement in opening, talking or chewing), therefore reducing masticator muscle activity and joint overload.	Student should place the anterior 1/3 of the tongue against roof of mouth with slight pressure as if trying to make a "cluck" sound with the tongue and monitor TMJ by placing both the index fingers over the joints. Student should then open and close the mouth until they feel the condyle of the joint moving forward against the fingers. Student should keep tongue on roof of mouth and refrain from any chewing motions.

6. Rhythmic stabilization technique	To relax muscles through the principle of reciprocal inhibition (i.e. when a muscle is actively contracted, its antagonists are consequently relaxed). Rhythmic stabilization also promotes the proper jaw rest position through proprioception.	Student should place the anterior 1/3 of the tongue against roof of mouth with slight pressure as if trying to make a “cluck” sound with the tongue and grasp the chin by placing the index fingers over the chin and thumbs under the chin. The student should then apply gentle resistance sideways to the right and then to the left. Thereafter the subject should apply gentle resistance to mouth opening and closing. The student should not apply excessive force; the jaw should remain stable and unmoved from its position.

Mulla, N. S., Vinod Babu, K., Sai Kumar, N., & Rizvi, S. R. (2015). Effectiveness of Rocabado’s Technique for Subjects with Temporomandibular Joint Dysfunction - A Single Blind Study. *International Journal of Physiotherapy*, *2*(1), 365. https://doi.org/10.15621/ijphy/2015/v2i1/60050

Emotional Freedom Technique

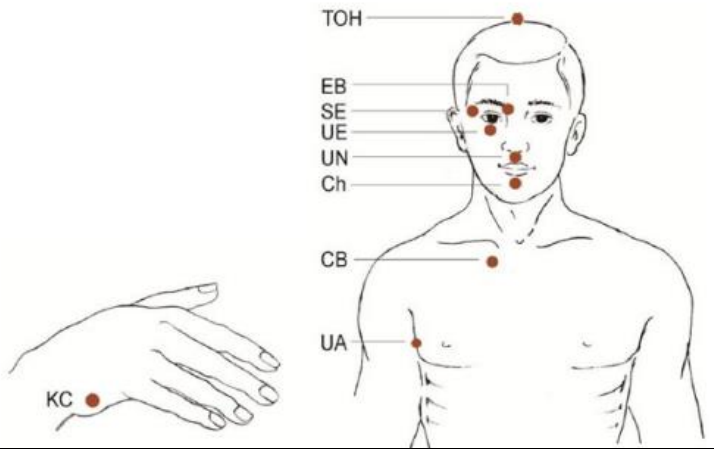
This alternative medicine technique is derived from traditional Chinese Medicine that involves focus of awareness on a specific issue (i.e. pain or stress) while tapping with the fingertips selected acupoints along meridians in the body. Research has shown positive impact on a variety of emotional and health-related problems and significantly reduced cortisol levels post-treatment (Rancour, 2016). Wording edited for clarity.

Table 3

Procedure for EFT

The patient is asked to rate the presenting problem on a scale of 0 to 10 so that testing of effectiveness can proceed throughout the administration of the intervention. The patient is then asked to hold the troubling symptom or condition in his/her conscious awareness while developing a set-up phrase during the initial tapping at the karate chop acupoint, as shown below. The basic statement sounds like: "Even though I (name the problem), I completely and deeply accept myself."
Each time the tapping procedure is concluded, the patient is asked once again to retest the intensity of the symptom by rating it on the 0 to 10 scale.

Anatomical Landmarks for EFT



KC: The Karate Chop (KC) point is located at the center of the fleshy part of the outside of your hand (either hand) between the top of the wrist and the base of the baby finger or . . . stated differently . . . the part of your hand you would use to deliver a karate chop.

TOH: On the top of the head. If you were to draw a line from one ear, over the head, to the other ear, and another line from your nose to the back of your neck, the TOH point is where those two lines would intersect.

EB: At the beginning of the eyebrow, just above and to one side of the nose. This point is abbreviated EB for beginning of the eyebrow.

SE: On the bone bordering the outside corner of the eye. This point is abbreviated SE for Side of the Eye.

UE: On the bone under an eye about 1 inch below your pupil. This point is abbreviated UE for Under the Eye.
UN: On the small area between the bottom of your nose and the top of your upper lip. This point is abbreviated UN for Under the Nose.

Ch: Midway between the point of your chin and the bottom of your lower lip. Even though it is not directly on the point of the chin, we call it the chin point because it is descriptive enough for people to understand easily. This point is abbreviated Ch for Chin.

CB: The junction where the sternum (breastbone), collarbone and the first rib meet. To locate it, first place your forefinger on the U-shaped notch at the top of the breastbone (about where one would knot a tie). From the bottom of the U, move your forefinger down toward the navel 1 inch and then go to the left (or right) 1 inch. This point is abbreviated CB for Collar Bone even though it is not on the collarbone (or clavicle) per se. It is at the beginning of the collarbone and we call it the collarbone point because that is a lot easier to say than "the junction where the sternum (breastbone), collarbone and the first rib meet.

UA: On the side of the body, at a point even with the nipple line. It is about 4 inches below the armpit. This point is abbreviated UA for Under the Arm.

Rancour, P. (2016). The Emotional Freedom Technique. Journal of Holistic Nursing, 089801011664845. Retrieved from http://journals.sagepub.com/doi/10.1177/0898010116648456

Feldenkrais Method® Awareness Through Movement (ATM)

The Feldenkrais Method® is used to improve physical function and body awareness through slow, intentional movements. Step-by-step lessons, called Awareness Through Movement (ATM) may be performed as a group or solo. Nelson & Blades-Zellar (2002) propose the usefulness of such sessions in improving body awareness and function in the voice studio. The purpose of this exercise is to bring awareness to the connection between the shoulders, neck, and jaw and to bring freedom from tension to all three. Used with permission.

Table 4

ATM: relating shoulders, neck, and jaw

This lesson may be done on the floor or in a chair. The version here is for a chair, to facilitate its use in many places. To do it on the floor, lie with your legs bent when doing the movements and with the legs stretched out when resting.
1. Sit forward in your chair. **Open and close your mouth a couple of times.** Notice how much effort this takes. How comfortable is this? **Gently move your right shoulder forward and back to the starting point.** Repeat this 4 to 6 times. Each time allow yourself to use less effort to make this movement. **Place your left hand on your forehead and, using the arm itself, begin to move the head to the left about one to two inches.** Repeat another 4 to 6 times. Pause.
2. **Again place your left hand on your forehead. Move your head about one to two inches to the left as you move your right shoulder forward.** Repeat 3 or 4 times. **Continue with this movement, but remove your left hand and allow the impetus for the head movement to be provided by the neck muscles.** Repeat this 4 to 6 times. Pause. Compare the way your left and right sides feel. Do you notice any differences?
3. **Gently move your left shoulder forward a little and then back to the starting point.** Repeat this 4 to 6 times. Allow the movement back to the starting point to be very soft, slow, and relaxed. Feel how much of your back is involved in this movement. **Place your right hand on your forehead and, using only the arm, move the head one to two inches to the right and then back again.** Repeat 3 to 4 times and then rest.
4. **Place your right hand on your forehead. Move your head about one to two inches to the right, using your arm, as you bring your left shoulder forward.** Repeat this movement 3 or 4 times, continuing as you add the next instruction. **As you continue the movement, remove your right hand and let the movement of the neck come from the neck and shoulder muscles.** Does the head lead the shoulder in doing this movement, or is it the other way around? Repeat 4 or more times until it is clear as to whether you initiate the movement with the neck or shoulder muscles. Rest.

This is the end of this module. It is a logical place to stop if you cannot do the lesson in one sitting. Resume at step 5.

---

5. **Sit forward in your chair. Open and close your mouth slowly and gently several times. Add the movement of the right shoulder forward as you open your mouth; as the shoulder returns to neutral, close your mouth.** Repeat this combination 6 to 8 times. Aim to make this movement more gently each time. Pause.

---

6. **Place your left hand on your forehead and move your head to the left once. Continue this movement, adding in opening your mouth as you move your head to the left and closing it as the head returns to the center.** Repeat 4 to 6 times. Put your hand down and pause.

Now combine opening the mouth, turning the head left, and moving the right shoulder forward. Repeat 5 to 7 times. Pause and compare your left and right sides.

---

7. **Move your left shoulder forward as you open your mouth, and close your mouth as your shoulder returns to neutral.** Repeat 4 to 6 times.

Place your right hand on your forehead and move your head to the right as you open your mouth. Repeat 4 to 7 times until this feels easy and relaxed. Pause and put your hand down.

---

8. **Now open your mouth as your left shoulder moves forward and you turn your head to the right.** Repeat this movement combination 4 to 6 times. Pause and compare the two sides.

Move your head to the left as you open your mouth and move your right shoulder forward. Let your head return to the center as your mouth closes and your right shoulder returns to the floor. Then move your head through the center to the right while moving your left shoulder forward and opening your mouth. Return to the neutral position. Repeat this combination 3 or 4 times. Pause and compare the two sides now.

This is the end of this module. It is a logical place to stop if you cannot do the lesson in one sitting. Resume at step 9.

9.
Sit forward in your chair. Place your left hand on your forehead and turn your head to the right as you move your right shoulder forward. Repeat this movement 4 to 6 times.

Continue this combination, adding in opening your mouth as you move your head toward the center and closing it as you move your head to the right. Repeat at least 5 times until this combination feels comfortable. Remember to reduce the range if it is not comfortable to make this movement. Pause and compare sides.

---

10. **Put your right hand on your forehead and turn your head to the left as you move your left shoulder forward.** Repeat this movement 4 to 6 times.

Continue this combination; as you move your head toward the center, pen your mouth, and as you move your head to the left, close it. Repeat until this feels comfortable or at least 3 times. Pause.

---

11. **Turn your head to the left as you open your mouth, and move the right shoulder forward. When you get back to the middle, continue to the right, open the mouth, and move your left shoulder forward.** Repeat 5 to 7 times and then pause.

---

12. **Move your right shoulder forward several times.** How does it feel now?

Now move your left shoulder forward and note how it feels. Move your head left and right. Repeat 3 times. How far does it move now? How easily?

O**pen and close your mouth several times.** How easy is it? Can you feel the connection between the jaw and the shoulders? Pause.

This is the end of this module. It is a logical place to stop if you cannot do the lesson in one sitting. Resume at step 13.

---

13. **Move your right shoulder back a little. Do this gently, sensing the connection both to the back and the neck.** Repeat 3 or 4 times.

Now add in the movement of the head to the right with the right shoulder going back. Repeat 4 times and pause.

---

14. **Combine opening your mouth with moving the shoulder and head to the right. Close your mouth on the return to the center.** Repeat 4 to 6 times, allowing the movement to soften with each repetition. Pause.

---

15. **Move your left shoulder back a little. Repeat 3 or 4 times. Now move your head to the left as you move your left shoulder back slightly.** Repeat 4 times and pause.

Finally, open your mouth as you move the left shoulder back and the head to the left. Repeat 4 to 6 times and pause.

---

16. **Turn your head to the right as you open your mouth and move the left shoulder forward. When you get back to the middle, continue to the left, opening the mouth and moving the left shoulder forward.** Repeat 5 to 7 times and then pause.

---

17. **Move your right shoulder forward several times.** How does it feel now?

Now move your left shoulder forward and note how it feels. Moe your head left and right. Repeat 3 times. How far does it move now? How easily?

Open and close your mouth several times. How easy is it? Can you feel the connection between the jaw and the shoudlers? Stop. Slowly stand up. Notice how you feel standing. Walk a little and notice how this feels.

End of Lesson

Nelson, S. H., & Blades-Zeller, E. (2002). *Singing with your whole self: The Feldenkrais Method and voice*. Scarecrow Press.

Self-Massage Exercise for Singing

Singers may gain awareness and release of tension in the masticatory muscles through self-massage. The book from which this exercise is drawn, The Vocal Athlete: Application and Technique for the Hybrid Singer (Rosenburg & Leborgne, 2019), contains several other exercises for managing jaw and tongue tension. Used with permission from Plural Publishing, Inc.

Table 5
Self-Massage Exercise

Masseter Muscle
Support the opposite side of your head with your entire hand from the same side (Figure 4–1).
With your thumb from the other hand, glide down from the cheek bone to the jaw line around the angle of the jaw (Figure 4–2).

Do this four or five times, moving back toward your ear.

Now using your index finger from the same hand, find the back of the upper cheek bone (Figure 4–3).

Using short sweeps, glide across the lower part of your cheek bone toward your nose.
Do this four or five times.

Figure 4–1. Masseter muscle—Step 1. Photograph courtesy of Regina Dentzman.

Figure 4–2. Masseter muscle—Step 2. Photograph courtesy of Regina Dentzman.

Figure 4–3. Masseter muscle—Step 3. Photograph courtesy of Regina Dentzman.

Temporalis Muscle

Support the opposite side of your head with your entire hand from the same side. With your first and second finger from the other hand, find the temporalis muscle (the fan-like muscle on your temples and adjacent hairline), gently use a circular motion, and begin massaging upward from the level of the eye (Figure 4–4).

Fan outward to cover the entire muscle. Do this for 10 to 15 times.

With short strokes, glide across the tendon fibers above the cheek bones (Figure 4–5). Do this 4 or 5 times.

Open the mouth slightly and glide across the fibers below the cheek bones

Figure 4–4. Temporalis muscle—Step 1. Photograph courtesy of Regina Dentzman.

Figure 4–5. Temporalis muscle—Step 2. Photograph courtesy of Regina Dentzman.

Medial Pterygoid Muscle

Support the opposite side of your head with your entire hand from the same side.

Hook your index finger from the other hand underneath the back part of the corner of the jaw (Figure 4–6). Glide inward four or five times.

Figure 4–6. Medial pterygoid muscle. Photograph courtesy of Regina Dentzman.

Lateral Pterygoid Muscle

Support the opposite side of your head with your entire hand from the same side.

With your mouth slightly open, find the jaw hinge (condyle) right in front of the tragus of the ear.

Pressing rather firmly with your first and second finger, move up and down without gliding.

Do this four or five times.

To maneuver around the masseter muscle, you might want to move the jaw slightly to the opposite side to find a deeper muscle (Figure 4–7).

Figure 4–7. Lateral pterygoid muscle. Photograph courtesy of Regina Dentzman.

LeBorgne, W. D., & Rosenberg, M. (2019). The vocal athlete: Second edition. Plural Publishing, Incorporated.

Postural Exercises for Temporomandibular Disorders

Exercises to strengthen and improve cervical posture have been shown to improve symptoms of TMDs. The following exercises, while taught in the research setting by a physical therapist, may be used at home (Figure 1, Table 6)

Figure 1
Simple Diagram of Exercises

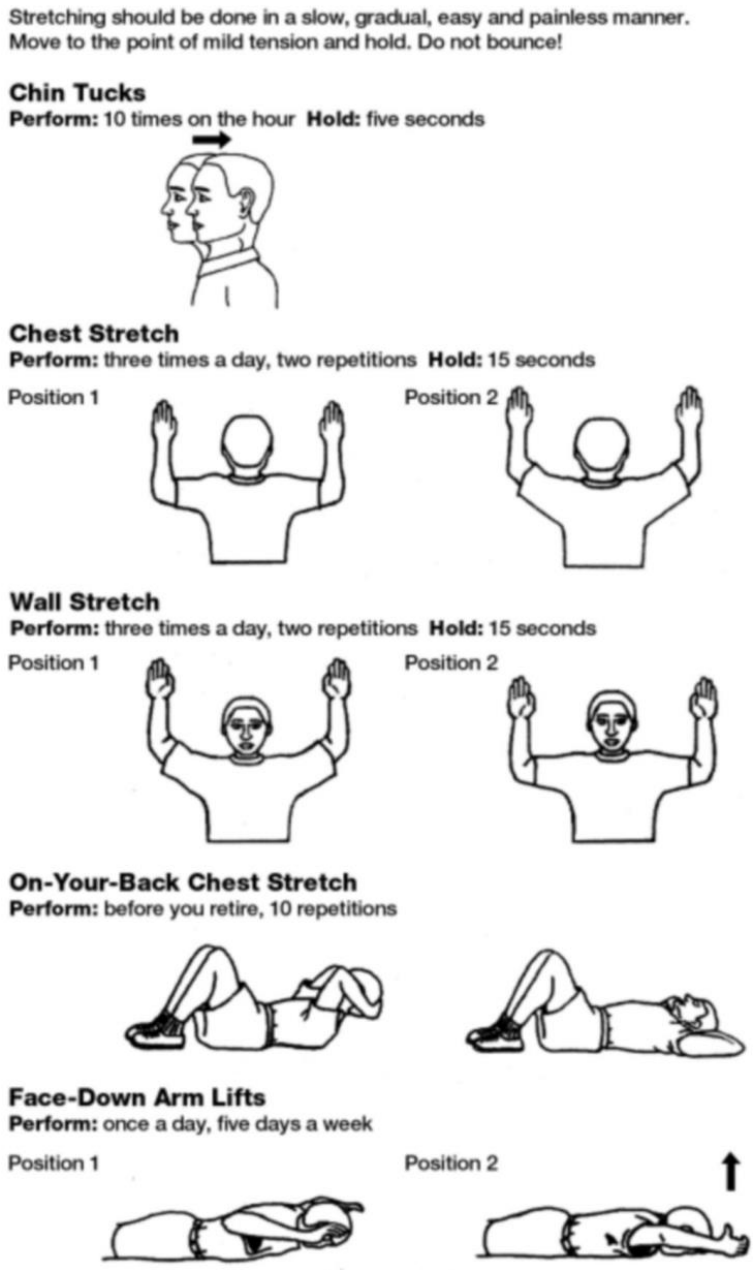


Table 6 *Exercise Instructions*	
Chin Tucks	Tuck your chin back over the notch above your sternum, so that your ear is in line with the tip of your shoulder.
Chest Stretch	Stand in a doorway or the corner of a room. Lean forward, with your hands on the wall, until you feel significant stretching across the front of your chest. Do this exercise as requested in both positions.
Wall Stretch	Stand with your back against the wall and your arms positioned as shown in the drawing. Straighten your upper back and flatten your lower back against the wall. Press your head back with your chin down and inward, and pull your elbows back against the wall. Do this exercise as requested in both positions.
On-Your-Back Chest Stretch	Lie on your back with your hands clasped behind your head. As you exhale, slowly bring your elbows together, touching in front of your face. As you inhale, slowly draw the elbows apart until they touch the floor.
Face-Down Arm Lifts	Lie on your stomach as shown in the drawings (position 1 has the elbows at shoulder level and bent at 90 degrees, while position 2 has the elbows at ear level). Lift your arms, head and chest off the floor and repeat until you move only 50 percent through the range or until you are fatigued; do this in both positions.