The relative effectiveness of three treatment protocols in the management of temporomandibular disorder

By

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I, Elizabeth Poacher, do declare that this dissertation is representative of my own work in both conception and execution, except where acknowledgements indicate to the contrary.

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DEDICATION

I would like to dedicate this dissertation to my parents Leon and Jeanette, whose love, encouragement and patient support throughout my chiropractic journey and my life have allowed me to get to where I am today.

A special thank you to my husband Bruce, who has walked this journey with me every step of the way. I cannot thank you enough for your unconditional support, guidance and calming influence over the years.

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ABSTRACT

Background: The relationship between TMD and dysfunction in the cervical spine has been reported in the literature and there are many case studies which have shown favourable results when treatment was aimed at the TMJ, cervical spine relationship. However, the numerous TMD treatment protocols described in the literature concerning this relationship, and the effectiveness of these treatments have not been well established. In spite of this many chiropractors treat TMD. TMD is a multifactoral condition and conservative treatment options need to be further investigated in order to determine if manual interventions directed at the cercival spine in the treatment of TMD are beneficial.

Objectives: The purpose of this study was to compare myofascial trigger point therapy and manipulative therapy of either the TMJ, cervical spine or a combination of the two in order to determine their effectiveness for the TMD.

Method: Thirty participants with TMD were randomly assigned to one of three treatment groups. Participants in each group received two treatments per week for two weeks with a follow up consultation in the third week. Data were collected before the commencement of the first, second, and fourth treatments and at the follow up consultation. Outcome measures included algometer readings, CROM, Mouth opening readings, NRS and a disability questionnaire. SPSS version 15.0 was used for analysis of the data. A *p* value <0.05 was considered as statistically significant. Multivariate testing was used for intra- and inter-group comparisons. Profile plots were generated to assess the direction and trend of the effect and to visually compare the trends in the different treatment groups.

Results: Inter-group comparisons did not reveal any statistically significant different improvements between the three treatment groups.

Conclusion: All groups responded favourably to treatment and showed trends towards improvement. However, statistically analysis revealed that no one treatment protocol was superior to the other. Although no definitive inferences may be drawn regarding the effectiveness of each treatment approach, within group trends indicated that the combination of the two treatment approaches may be preferred.

Key words: Temporomandibular joint, Temporomandibular disorder, TMJ syndrome, Cervical spine manipulation, Temporomandibular joint manipulation, orofacial pain, masticatory system.

TABLE OF CONTENTS

CHAPTER SIX

LIST OF TABLES

Chapter Two:

Chapter Three:

Chapter Four:

.

LIST OF FIGURES

APPENDICES

LIST OF ABBREVIATIONS

CDC	: Chiropractic Day Clinic
CROM	: Cervical range of motion
CSD/s	: Cervical spine disorder/s
DUT	: Durban University of Technology
EMG	: Electromyographic
MFTP/s	: Myofascial trigger point/s
MRI	: Magnetic resonance imaging
NRS	: Numerical rating scale
NSAIDs	: Non steroidal anti inflammatory drugs
PNF	: Proprioceptive neuromuscular facilitation
RDC/TMD	: Research diagnostic critera for TMD
SCM	: Sternocleidomastoid
SMT	: Spinal manipulative therapy
SCM	: Sternocleidomastoid muscle
TENS	: Trans-cutaneous electrical nerve stimulation
TMD	: Temporomandibular disorder
TMDDIQ	: Temporomandibular disorder disability index questionnaire
TMJ/s	: Temporomandibular joint/s

LIST OF DEFINITIONS

BIOFEEDBACK	: Presentation of immediate visual or auditory information about usually unconscious body functions such as muscle tension. By operant conditioning a patient can learn to repeat behavior which results in a satisfactory level of body function (Brooker, 2003).
BRUXISM	: A combination of parafunctional clenching and grinding of the teeth. (Camparis, Formigoni, Teixeira, Bittencourt, Tufik and Tesseroli de Siqueira, 2006)
ISCHAEMIC COMPRESSION	: Manual application of non-painful, slowly, increasing, pressure applied over a MFTP until a barrier of tissue resistence is met. It is aimed at eliminating MFTP tension and tenderness (Travell, Simons Simons, 1999).
JOINT DYSFUNCTION	: An area where there is a disturbance in the normal function of joint mechanics without structural change (Peterson and Bergmann, 2002).
MANIPULATION	: Is characterized by a high velocity, low amplitude thrust. It is performed over a specific contact point and in a specific direction (Peterson and Bergmann, 2002).
MYOFASCIAL TRIGGER POINT	: A spot of hyperirritability within a taut band of skeletal muscle or Fascia that is hypersensitive to palpation and can bring about Characteristic reproducible reffered pain (Clark and Solberg, 1987 and Rachlin and Rachlin, 2002).
PROPRIOCEPTIVE NEUROMUSCULAR FASCILITATION	: Manual resistance using isometric muscular contraction followed by relaxation of tight muscles (Liebenson, 2007).
TEMPOROMANDIBULAR DISORDER	: A non-specific group of related musculoskeletal conditions affecting the TMJ or the muscles of mastication, or both (Jagger, Bates and Kopp, 1994) which is independent of local disease and excludes neoplastic, vascular and infectious diseases of the orofacial region (McNeil, 1993).

CHAPTER ONE

1. INTRODUCTION

The masticatory system is made up of the temporomandibular joints (TMJs), teeth, the muscles of mastication, cranial bones, mandible, and the central nervous system (Moore and Dalley, 2006). Also included, but not usually thought of as part of this system is the cervical musculature and associated cervical vertebra (Curl, 1994).

Temporomandibular disorder (TMD) is a limited term used to describe a non specific group of related musculoskeletal conditions affecting the TMJ and the muscles of mastication (Jagger, Bates and Kopp, 1994). It is the preferred term used by most North American authorities in the field when referring to disorders of the joint and muscles of the orofacial region (McNeil, 1993). This term is independent of local disease and excludes neoplastic, vascular and infectious diseases as well as any other non-musculoskeletal disorders in the orofacial region which can produce similar symptoms of pain and dysfunction (McNeil, 1993). Symptoms of TMD include: joint dysfunction noted by clicking, grinding and changes in mandibular gait with an associated decrease in joint range of motion. There may also be accompanying symptoms of otic dysfunction including tinnitus, dizziness, ear popping, ear pain and recurrent headache (Kraus, 1994). Local pain in the TMJ area or referred pain from the muscles of mastication, which is the most common presenting symptom, may be a result of macrotrauma (e.g. blunt injury), micrcotrauma (e.g. bruxism) or myofascial dysfunction (Good, Proctor, McCarthy, Hill, and Lane, 2000). It is estimated that 85% to 90% of the population will acquire one or more symptoms of TMD, at some point during their life (Souza, 1997). Previously a multidisciplinary approach to the treatment of TMD was advocated (Gelb, 1977) and this has not changed (Travell, Simons and Simons, 1999). Okeson (1993) endorses reversible treatment for the initial care of most cases of TMD as many of these patients may obtain sufficient relief of their symptoms with conservative therapy. According to DeVocht, Long, Zeitler and Schaeffer (2003:422), they state that there are many varying treatment protocols described in the literature concerning TMD but the effectiveness of these treatments have not been well established. Further to this, they state that “many chiropractors also treat patients with TMD. However, there are few articles in the peer-reviewed literature on this topic.”

It has also been shown that there is a relationship between the cervical spine and the TMJ due to muscular, ligamentous and fascial attachments (O'Shaughnessy, 1994 and Chinappi and Getzoff, 1995) and given that the mandible is attached to the cranium, hyoid bone and the clavicle via certain muscles, it can be said that the cervical spine lies between the proximal and distal attachments of some of the muscles which control the functioning of the TMJ (Hertling and Kessler, 2006). Contraction of the lateral pterygoids and digastrics, facilitated by the supra- and infrahyoid muscles, needs to take place in order for the mandible to open (Peterson and Bergmann, 2002). In addition, the muscles of the posterior cervical spine also need to contract in order to prevent flexion of the neck and thus allow the mandible to drop away from the cranium (Peterson and Bergmann, 2002). This highlights that the masticatory system is made up of components not usually considered as part of this system, for example the cervical musculature (Nelson and Ash, 2010).

De Wijer, de Leeuw, Steenks, and Bosman (1996) and Stiesch-Scholz, Fink and Tschernitschek (2003) state that the relationship between TMD and dysfunction in the cervical spine has been reported in the literature, however there are few randomized controlled trials to demonstrate the effect of chiropractic treatment on this relationship. In a report of two case studies, Nykoliation and Cassidy (1984) advocate the use of TMJ manipulation alone or in conjunction with cervical spine manipulative therapy (SMT) in alleviating the symptoms associated with TMD. This is supported by Saghafi and Curl (1995) whose findings promote the use of specific TMJ manipulations of the TMJ as a conservative approach to the treatment of an adhered anteriorly dislocated disc. Tucker, Farrell and Farrell (2008) go on to state that myofascial pain and dysfunction is the most common cause of masticatory pain and limited function in patients seeking dental consultation and in clinical practice the joint is rarely treated without the myofascial component being treated as well (Peterson and Bergmann 2002). De Laat, Meuleman, Stevens and Verbeke (1998) and Stiesch-Scholz, Fink and Tschernitschek (2003) noted that there was an increased number of myofascial trigger points (MFTP's) in the cervical musculature as well as a higher prevalence of cervical dysfunction in patients suffering with TMD. In view of that Walther and Maitland as cited in O'Reilly and Pollard (1996), suggest utilizing treatment techniques which have an effect on the muscular and myofascial symptoms as well as cervical SMT as they feel that SMT alone is not a comprehensive treatment protocol for TMD.

Alcantara, Plaugher, Klem and Salem (2002) state that treatment options such as acupuncture, therapeutic ultrasound, trigger point therapy and cryotherapy are common in the literature and have been shown to have good success rates for TMD of a myofascial nature. This is supported by several studies (Gray, Quayle, Hall and Schofeild, 1994; Crider and Glaros, 1999; and Michelotti, Parisini and Farella, 2002) which have shown that treating the myofascial component of TMD produced favorable results.

TMD is a multifactoral condition and conservative treatment options need to be further investigated in order to determine if manual interventions directed at the cervical spine in the treatment of TMD are beneficial (George, Fennema, Maddox, Nessler and Skaggs, 2007). This study aims to investigate the relative effectiveness of three treatment protocols in order to determine if manipulative and myofascial trigger point therapy of the TMJ and cervical spine would be a valuable adjunct to a multidisciplinary approach to TMD.

1.1. Aims and objectives

The aim of the study was to test and compare TMJ manipulation plus myofascial trigger point therapy, cervical spine manipulative therapy plus myofascial trigger point therapy of the cervical spine musculature, and a combination of the above two treatment approaches for TMD.

1.1.1. The first objective:

To determine the effectiveness (both clinically and statistically) of TMJ manipulation combined with myofascial trigger point therapy of the TMJ musculature in the treatment of TMD.

1.1.2. The second objective:

To determine the effectiveness (both clinically and statistically) of cervical spine manipulation combined with myofascial trigger point therapy of the cervical musculature in the treatment of TMD.

1.1.3. The third objective:

To determine the effectiveness (both clinically and statistically) of TMJ and cervical spine manipulation combined with myofascial trigger point therapy of both the cervical and TMJ musculature in the treatment of TMD.

1.1.4. The fourth objective:

To compare the outcomes of the respective treatment groups to determine which may be more effective for TMD.

1.2. Hypotheses

There are few clinical trials in the literature which have investigated the effect of manipulative therapy in conjunction with manual therapy aimed at the TMJ or cervical spine in the treatment of TMD. It is for this reason that the following null hypotheses were set, to address the objectives identified in 1.1.1 to 1.1.4.

The first null hypothesis:

There will be no significant improvement in terms of subjective and objective findings in participants with TMD who are treated with:

A. TMJ manipulation and myofascial trigger point therapy of the TMJ musculature.
B. Cervical spine manipulation and myofascial trigger point therapy of the cervical spine musculature.
C. Combined TMJ and cervical spine manipulation and myofascial trigger point therapy of the TMJ and cervical spine musculature.

The second null hypothesis:

There will be no statistically significant difference noted when comparing the three treatment groups.

1.3. Benefits and limitations

Due to the fact that TMD is a highly prevalent condition in the general population (Souza, 1997) it is important to find an effective treatment protocol. Treatment of TMD traditionally encompasses a multidisciplinary approach (Jagger, Bates and Kopp, 1994) and the Chiropractic profession has for many years been addressing the aspect of orofacial dysfunction with intra-oral and upper cervical techniques (Kalamir, Pollard, Vitiello and Bonello, 2006). However, there remains a paucity of published clinical trials demonstrating the usefulness of adding cervical manipulation and treatment of the cervical spine musculature in the management of TMD. This study will add to the body of knowledge regarding the benefit of including manipulative and myofascial trigger point therapy on the TMJ and cervical spine to conventional chiropractic treatment of TMD as an adjunct to a multidisciplinary approach to TMD.

Limitations

TMD can be due to a number of underlying conditions and the diagnosis of TMD in this study was made based on participants' presenting signs and symptoms. Through various screening questions, examination procedures and the taking of a detailed case history the researcher has for the purpose of this study attempted to retain only those participants presenting with TMD of a myofascial origin. However, as radiographs were not taken, participants with intra-articular, osseous and soft tissue pathologic conditions may have unwittingly been retained by the researcher as part of the subject group. Beyond recording obvious discrepancies in jaw size, missing teeth, crowding of teeth and other obvious tooth misalignment this study has not focused on the details of the dental examination as is recommended by Kraus (1994), this study has instead focused on the musculoskeletal aspect of TMD.

TMD is a multifactoral condition (Jagger, Bates and Kopp, 1994) and should be addressed as such, however this study did not address the psycho-physiological causes and the role that stress, anxiety and depression play in the TMD patient (Okeson, 1996). Nor did it investigate the role of postural problems on the biomechanical or kinematic chains of the craniocervical-madibular system (de Farias Neto, de Santana, de Santana-Filho, Quintans-Junior, de Lima Ferreira and Bonjardim, 2010). Manipulative lesions and myofascial pain dysfunction of the TMJ and cervical spine were thus the prime area of focus for this study.

When comparing the literature regarding TMD it becomes evident that there are several definitions to describe the same term, as well as multiple terms to convey the same clinical phenomenon (Travell, Simons and Simons, 1999). This creates difficulty when comparing studies, interpreting research data or identifying the exact condition the researcher is treating.

CHAPTER TWO

LITERATURE REVIEW

2. INTRODUCTION

Temporomandibular disorder (TMD) is a frequent cause of non dental pain in the orofacial region (McNeil, 1993 and Okeson, 1996) and is considered to be the main source of orofacial pain, affecting many individuals and interfering with activities of daily living (Kraus, 1994; Armijo-Olivo, Fuentes, da Costa, Major, Warren, Thie and Magee, 2010). The TMJ is the only bilateral joint in the human body that demands two-sided synchronized muscular action in order to function during mastication, swallowing, speech, laughing, coughing and normal respiration. This highlights its uniqueness and the significance of its extreme mobility, low stiffness and versatility of its various combined functions (Kraus, 1994).

2.1. Anatomy of the temporomandibular joint

2.1.1. Osseous structures, joint surface

The temporomandibular joint (TMJ) is classified as a complex, multiaxial, synovial, bicondylar and ginglymaoarthrodial joint (Saghafi and Curl, 1995; Malik, 2008) as it allows for both hinging and gliding movements (McNeil, 1993).

The TMJ is formed by the head of the mandibular condyle, and the mandibular fossa of the temporal bone (Moore and Dalley, 2006). Unlike most synovial joints which are lined by hyaline cartilage, the TMJ articular surfaces are lined by fibrocartilage (Moore and Dalley, 2006) which affords the TMJ the ability to regenerate, making it less susceptible to degeneration caused by repetitive compressive forces e.g. opening and closing of the mouth (Good, Proctor, McCarthy, Hill and Lane, 2000). The articular area of the temporal bone and the head of the mandible are surrounded by a thin fibrous capsule which is reinforced by the temporomandibular ligament (Moore and Dalley, 2006).

2.1.2. Ligament structures

The Temporomandibular ligament extends from the articular eminence to the external and posterior surface of the neck of the mandibular condyle (Malik, 2008). The ligament, together with the post-glenoid tubercle, helps to prevent posterior dislocation of the joint (Moore and Dalley, 2006). Two other ligaments are involved in connecting the mandible to the cranium: the stylomandibular ligament and the sphenomandibular ligament (Malik, 2008). Both of the ligaments provide passive support as the weight of the mandible is primarily carried by the tonus of the masticatory muscles (Moore and Dalley, 2006). Rocabado and Iglarsh (1991) noted that the lateral fibres of the capsule continue to the anterior ligament of the malleus and on to the malleus itself, consequently any tension on the capsular ligament may cause otic symptoms.

2.1.3. Temporomandibular disc

The TMJ is unique in that it contains a complete intra-articular disc which is made up of dense, fibrous collagen tissue which divides the joint cavity into two articular surfaces (Jagger, Bates and Kopp, 1994; Moore and Dalley, 2006; Malik, 2008). The superior surface, which articulates with the temporal bone, allows for sliding and translation between the temporal bone and the mandibular condyle, while the inferior surface facilitates rotatory movements of the mandibular condyle around the horizontal axis. The importance of this is that the infra-alveolar nerve and vessels are protected during mandibular movement (Jagger, Bates and Kopp, 1994; Moore and Dalley, 2006; Malik, 2008).

2.1.4. Blood supply and innervation

The lateral aspect of the TMJ receives its blood supply from the superficial temporal branch of the external carotid artery (Moore and Dalley, 2006). The deep auricular, posterior auricular and masseteric branches of the internal maxillary artery supply the deep and posterior aspect of the retrodiscal capsular aspect of the TMJ (Moore and Dalley 2006). The head of the mandibular condyle also receives a vascular supply via the numerous nutrient foramen vessels which branch off from the vascular supply of the lateral pterygoid muscle (Moore and Dalley, 2006 and Malik, 2008).

Sensory innervations to the face and oral structures as well as motor innervations to the muscles of mastication are supplied by the trigeminal nerve (McNeil, 1993). The TMJ is innervated by the mandibular nerve, which is a branch of the trigeminal cranial nerve (Moore and Dalley, 2006). Trigeminal nerve sensory fibres extend to synapses in the trigeminal spinal nucleus of the brain stem which extends caudally into the region where cervical nerves one through to three enter the central nervous system. This convergence of cervical and trigeminal nerves provides an anatomic and physiological explanation for the source of referred pain from the cervical region to the trigeminal region (Giunta and Kronman, 1985).

2.1.5. Muscles

Movement and stability of the TMJ is generated primarily by the muscles of mastication, namely the temporal, masseter, medial and lateral pterygoid muscles along with other muscles such as the supra and infrahyoid muscles and the platysma which act indirectly on the TMJ and the mandible (Moore and Dalley, 2006). Table 2.1, as adapted from Moore and Dalley (2006) details the attachment, innervation and main action of these muscles.

Table 2.1: TMJ muscle anatomy, innervation and action

Muscle of mastication	Proximal attachment	Distal attachment	Innervation		Main Action(s)
Temporalis	Triangular muscle with broad attachment to floor of temporal fossa and deep surface of temporal fascia	Narrow attachment to the tip and medial surface of coronoid process and anterior border of ramus of mandible	Anterior trunk of mandibular nerve (CN V3)	Via deep temporal branches	Elevates mandible, closing jaw; the more horizontal fibres are primary retractors of the mandible. Some fibers of the temporalis muscle may insert into the skeletal orbit of the eye which could be responsible for eye fatigue and posterior orbital pressure and excessive effort to focus in TMJ suffers (Rocabado and Iglarsh, 1991).
Masseter	Quadrate muscle attaching to inferior border and medial surface of maxillary process of zygomatic bone and arch	Angle and lateral surface or ramus of mandible		Via masseteric nerve	Elevates mandible closing jaw; superficial fibers make limited contribution to protrusion of jaw
Lateral Pterygoid	Triangular two-headed muscle from (1) infra-temporal surface and crest of greater wing of sphenoid (2) lateral surface of lateral pterygoid plate	Upper head attaches primarily to joint capsule and articular disc of TMJ; inferior head attaches to pterygoid fovea on anteromedialapect of neck of condyloid process of mandible		Via later pterygoid nerves	Acting bilaterally, protracts mandible and depresses chin; unilaterally, swings jaw toward contralateral side; alternate unilateral contraction produces larger lateral chewing movements
Medial Pterygoid	Quadrangular two-headed muscle from (1) medial surface of lateral pterygoid plate and pyramidal process of palatine bone (2) tuberosity of maxilla	Medial surface of ramus of mandible, inferior to mandibular foramen		Via medial pterygoid nerves	Acts synergistically with masseter to elevate mandible; contributes to protrusion; alternating unilateral activity produces smaller grinding movements

(Moore and Dalley, 2006)

Furthermore the mandible is stabilized by the dentition (Malik, 2008). To a large extent most of the force of mastication is borne by the teeth and any disparity of the dentition, will in turn, affect proper functioning of the TMJ's, as seen in the case of occlusal disharmony (Malik, 2008) and hence an understanding of the basic cervical anatomy is required.

2.2. Anatomy of the cervical spine

The TMJ lies in close proximity to the cervical spine and its functioning is interrelated to the workings of the cervical spine (McNeil, 1993). The American Academy of Orofacial Pain suggests in its guidelines that the evaluation of cervical range of motion as well as palpation of the cervical muscles is a significant aspect of the diagnostic protocol for identification of craniomandibular disorders (Ciancaglini, Testa and Radaelli, 1999).

2.2.1. Osseous structures

The bones of the neck include the cervical vertebra, hyoid bone, manubrium of the sternum and the clavicles (Moore and Dalley, 2006). The cervical vertebra attach superiorly to the base of the skull via the occipital condyles and attach inferiorly to the first thoracic vertebrae (T1) via the facet joints (Williams, Warick, Dyson, Bannister, 1989).

The hyoid bone, which is located in the anterior aspect of the neck, lies at the level of C3 in the angle between the mandible and the thyroid cartilage. The hyoid bone is suspended by the muscles which connect it to the mandible, styloid process, thyroid cartilage, manubrium and scapulae (Moore and Dalley, 2006).

2.2.2. Joints

Joints of the cervical spine include the posterior facets, intervertebral discs, atlanto-occipital and the atlanto-axial joints. The posterior facet joints (zygopophyseal) joints account for four of the six. The last two are formed between the vertebral body and the intervertebral discs inferiorly and superiorly. This is true for all cervical vertebra except for the atlas and the axis because there is no disc between them or the atlas and the occipital bones (Williams *et al*., 1989).

2.2.3. Ligament structures

Three significant ligaments in cervical spine are described in table 2.2 and the four ligaments which connect the axis to the occipital bones (Table 2.3).

Table 2.2: Ligaments of the cervical spine

LIGAMENT	DESCRIPTION
Anterior longitudinal ligament	This is a strong ligament attaching to the anterior aspect of the vertebral body extending from the base of the occipital bone to the anterior surface of the sacrum.
Posterior longitudinal ligament	It runs in the vertebral canal and attaches to the posterior aspect of the vertebral body. Extends from the posterior aspect of the odontoid process superiorly becoming the membrane tectoria which attaches to the foramen magna of the occipital bone.
Ligamentum Nuchae	This is a continuation of the supraspinous ligament and extends from the external occipital protuberance to the spinous process of C7. Various muscles and muscle sheaths attach to this ligament. It functions to check neck flexion.

(Williams *et al*., 1989).

Table 2.3: Ligaments of the axis and occipital bones

LIGAMENT	DESCRIPTION
Membrane tectoria	A continuation of the posterior longitudinal ligament
Alar ligaments	There are two alar ligaments which begin on either side of dens and project laterally, attaching on the medial aspect of the occipital condyles. The alar ligaments are responsible for checking rotation and forward flexion of the head
Apical ligament of the dens	This ligament runs from the apex of the dens to the anterior margin of the foramen magnum

(Williams *et al*., 1989).

2.2.4. Muscles

Table 2.4 adapted from Travell, Simons and Simons (1999) and Moore and Dalley (2006) details the muscles of the cervical spine which have an effect on the TMJ.

Table 2.4: Anatomy, innervation and action of the cervical spine musculature

Muscles acting on the Mandible/ TMJ				
Muscle	**Proximal attachment**	**Distal attachment**	**Innervation**	**Main Action(s)**
Suprahyoid muscles				
Digastric	Base of cranium	Hyoid bone	Facial and mandibular nerves	Depresses mandible against resistance when infrahyoid muscles fix or depress hyoid bone
Stylohyoid	Styloid process		Facial nerve	
Mylohyoid	Medial body of manible		Mandibular nerve	
Geniohyoid	Anterior body of mandible		Nerve to genoihyoid (C1-2)	
Infrahyoid muscles				
Omohyoid	Scapula	Hyoid bone	Ansacervicalis from cervical plexus (C1-3)	Fixes or depresses hyoid bone
Sternohyoid	Manubrium of sternum			
Sternothyroid and thyrohyoid	Manubrium of sternum and thyroid cartilage			
Muscles of facial expression				
Platysma	Inferior border of mandible, skin, subcutaneous tissues of lower face	Fascia covering superior parts of pectoralis major and deltoid muscles	Cervical branch of facial nerve (CN VII)	Draws corners of mouth inferiorly and widens it. Draws skin; depresses mandible against resistance
Superficial muscle of the neck				
Sternocleidomastoid (SCM)	Lateral surface of mastoid process of temporal bone and lateral half of superior nuchal line	Sternal head: anterior surface of manubrium Clavicular head: superior surface of medial third of clavicle	Spinal accessory nerve (CN XI, motor) C2 and C3 nerve (pain and proprioception)	Unilateral: laterally flexes neck and rotates it so face is turned superiorly toward opposite side. Bilateral: extends neck at atlanto-occiptal joints. Flexes cervical vertebrae
Trapezius	Medial third of superior nuchal line, external occipital protuberance, nuchal ligament, spinous process of C7-T12 vertebrae	Lateral third of clavicle, acronium, spine of scapula	Spinal accessory nerve (CN XI, motor) C2 and C3 nerve (pain and proprioception)	Elevates, retracts and rotates scapulae

Table 2.4: Anatomy, innervation and action of the cervical spine muscle continued

PosteriorCervicals				
SemispinalisCapitis	Occipit between the inferior and superior nuchal lines	Articular processes of cervical vertebrae C4 to C6 and TVP's of thoracic vertebra T1-T6	divisions of the cervical spinal nerves	Extension of the head
LongissimusCapitis	Skull, along the posterior margin of the mastoid process	Articular processes of C4 to C7 and to T1 to T5 TVP's		
SemispinalisCervicis	Spinous process of C2 to C5	TVP's of T1 to T6		Extension of the neck
Multifidi and Rotatores	spinous processes of the C2 to C5 vertebrae	Articular processes of C4 to C7		Extension and rotation of the neck
Upper fiber of trapezius	As above, see trapezius			

(Adapted from Travell, Simons and Simons,1999 and Moore and Dalley, 2006).

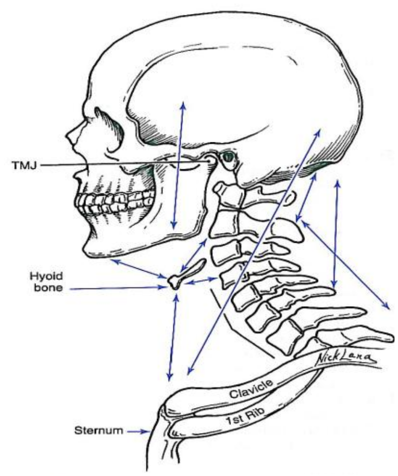
2.2.5. Deep cervical fascia

Also of importance in the neck region is the deep cervical fascia which binds the cervical spine and TMJ into a singular functional unit (Schafer and Faye, 1990 and O'Shaughnessy, 1994). It is made up of three layers namely the investing, pretracheal and prevertebral layers. The investing layer of the deep cervical fascia is the most superficial of the three layers and surrounds the entire neck. It encloses the sternocleidomastoid (SCM) and trapezius muscles. The superior attachments of the investing layer of the deep cervical attachments are: superior nuchal line of the occipital bone, mastoid process of the temporal bone, zygomatic arches, inferior border of the mandible, hyoid bone, spinous processes of the cervical vertebrae (Moore and Dalley, 2006).

2.3. Anantomical and biomechanical link between the cervical spine and the temporomandibular joint

Clark, Delcanho and Goulet (1993) and De Laat, Meuleman, Stevens and Verbeke (1998) suggest that TMD patients often present with signs and symptoms associated with CSDs and vice versa. Armijo-Olivo, Fuentes, da Costa, Major, Warren, Thie and Magee (2010) further state that dysfunction in the cervical spine as well as the accompanying changes in muscle strength, performance and endurance should be of interest to clinicians working with TMD patients as these could lead to the development and perpetuation of TMD symptoms.

When the TMJ is resting in its normal position, an intraocclusal space exists where the superior and inferior teeth do not meet (Peterson and Bergmann, 2002). This is known as the freeway space and is approximately 3 to 5 mm (Peterson and Bergmann, 2002). The space exists due to the equilibrium that is created by the muscular tone of the mandibular elevators and the effect of gravity (Peterson and Bergmann, 2002). This freeway space is influenced by the inherent elasticity of the massticatory muscles, head posture, and the condition of the anterior and posterior cervical muscles (Peterson and Bergmann, 2002). The anatomical link is formed by the various attachments and actions of the muscles, ligaments, and fascia of the mandible, cranium, hyoid bone, cervical spine and shoulder girdle (Jones, 2002). The link can be likened to a series of elastic bands which connect the TMJ to the neck and shoulders (Taddey, Schrader and Dillion, 1990), as seen in Figure 2.1. sourced from Peterson and Bergmann (2002).



*the arrows illustrate the direction of muscle pull

Figure 2.1: Biomechanical relationship between the TMJ, neck and shoulders (Peterson and Bergmann 2002: 342).

Changes in function in one “elastic band” will result in an indirect change to the other (Taddey, Schrader and Dillion, 1990). The change in function will follow a certain pattern or chain reaction which is not complete, constant or fixed but is rather dynamic and shifting (Liebenson,2007). For instance, the muscles of the orofacial region also function to maintain the alignment of the head, neck and shoulder girdle (Rocabado and Iglarsh, 1991), so increased tension in the orofacial muscles will lead to referred pain patterns which in turn lead to joint dysfunction of the TMJ or cervical spine. The Table 2.5, adapted from Liebenson (2007), presents the chain reaction which occurs in the orofacial region.

Table 2.5: Orofacial chain reaction

Increased tension in:	masticatory muscles, digastric, SCM's, trapezius, short extensors of the craniocervical junction, deep neck flexors, pectoralis and levator scapulae.
Tender attachment points (points of referred pain):	Hyoid, posterior atlas arch and transverse processes, spinous process of C2, linea nuchae, medial end of collar bone, upper margin of scapulae, angle of upper ribs.
Joint dysfunction:	TMJ, craniocervical junction, cervicothoracic junction, upper ribs.

(adapted from Liebenson, 2007)

Head and neck positioning affecting the kinematics of the TMJ is well documented (Higbie, Seidel-Cobb, Taylor and Cummings, 1999; Visscher, Huddleston-Slater, Lobbezoo and Naetje, 2000) and any changes in head posture alters the position of the mandible. Mannheimer and Rosenthal (1991) describe how head protrusion leads to mandibular retrusion and pain and state that there is a coordinated action between elevation and depression of the mandible with movements of the neck due to pre-emptive control mechanisms in the neuromuscular system of the jaw. This can be seen by the frequent presence of pain in the SCM muscle of patients presenting with TMD (Uys, 2009) which may be due to the simultaneous activation of the both the SCM and muscles of mastication (Higbie *et al*., 1999; Visscher *et al.*, 2000). Kraus (2007) proposes that the muscles of mastication contract in response to contraction of the cervical spine musculature as they are viewed as agonists and antagonists. He goes on to describe a neurophysiologic relationship where synergistic co-contraction of the jaw and neck muscles is observed in activities like talking and chewing. An example of this would be when a common daily activity requires the cervical spine musculature to be in a state of constant low level contraction in order to maintain a specific head and neck posture and, as a result, the longer the subject spends maintaining this posture, the more likely a disproportionate contraction of the muscles of mastication is to occur (Kraus, 2007). Extension at the craniocervical junction occurs during normal mouth opening and thus any restriction in the upper cervical spine may cause a decreased mouth opening capacity (Eriksson, Haggman-Henrikson, Nordh and Zafar, 2000).

This relationship can also work in reverse. Schafer and Faye (1990) and O'Shaughnessy (1994) describe how the stability of the axis and atlas are influenced by the jaw, and vice versa, due to the action of the deep cervical fascia which binds the cervical spine and TMJ into a singular functional unit. Also, the position of the mandible changes the isometric strength of the head and neck flexors because both flexion of the head and lowering of the mandible involve both the supra and infra hyiod muscles (Hagberg, 1987). Mannheimer and Rosenthal (1991); Kibana, Ishijima and Hirai (2002); Ferrario, Sforza, Dellavia and Tartaglia (2003) support the notion that occlusal changes can have an effect on the posture of the head and neck. De Laat *et al*.,(1998) noted in a single-blinded study of 61 participants that there were significantly more segmental limitations in the upper cervical spine in patients presenting with TMD than those who were asymptomatic, C0-C1 ($p < 0.001$), C2-C3 ($p < 0.001$) and that the restriction in active neck motion was most likely due to reflex splinting of the cervical muscles.

In addition, the masticatory system is closely related to cervical proprioception, vision, the vestibular system and ocular motility via the trigeminal nerve (Catanzariti, Debuse and Duquesnoy, 2005). Proprioceptive mechanoreceptors situated in the periodontal soft tissues project trigeminal afferent fibers to the sensory cortex of the fifth cranial nerve in the brainstem. From here they go on to the first three segments of the cervical spinal cord and to the nucleus of the spinal accessory nerve which contributes to innervate the trapezius and the SCM muscles along with C1 and C2 roots (Catanzariti, Debuse and Duquesnoy, 2005). In a study by Turp, Kowalski, O'Leary and Stohler (1998), of 200 female participants who presented at a university facial pain clinic, 163 had pain that extended to areas that included the C2, C3 and C4 dermatomes.

2.4. Temporomandibular disorder

TMD or craniomandibular dysfunctions are just two of the many terms which are used to encompass a group of non specific yet related clinical problems which affect the TMJ, the masticatory muscles (Lawrence, 1991; Jagger, Bates and Kopp, 1994; Okeson, 1996) and its associated structures in the head and neck region (Camparis, Formigoni, Teixeira, Bittencourt, Tufik and Tesseroli de Siqueira, 2006). As no set definition exists (Broome, 2003), the use of numerous synonyms such as TMJ pain and dysfunction syndrome, myofascial pain and dysfunction, temporomandibular joint dysfunction and mandibular stress syndrome have been utilized to refer to a "condition" which causes pain and limited mouth opening (Salvinelli, Casale, Paparo, Persico and Zini, 2003). The lack of a cohesive definition causes misunderstanding in the literature especially when evaluating the clinical efficacy and effectiveness of different treatment protocols (Broome, 2003). For most TMD sufferers their main complaint lies with the muscles of mastication and not in the TMJ and it was for this reason that the American Dental Association preferred the term temporomandibular disorder over temporomandibular joint dysfunction (Okeson and de Kanter, 1996). For the purpose of this study, TMD will be defined as a non-specific group of related musculoskeletal conditions affecting the TMJ or the muscles of mastication, or both (Jagger, Bates and Kopp, 1994). TMD is independent of local disease and excludes neoplastic, vascular and infectious diseases as well as any other non-musculoskeletal disorders in the orofacial region which can produce similar symptoms of pain and dysfunction (McNeil, 1993). However, it should be noted that it is possible to treat a patient with TMD of a muscular nature only to find that, as the myalgia and tension remit, there is articular damage where at first none was identified (Alcantara, Plaugher, Klemp and Salem, 2002).

2.5. Aetiology

The aetiology of TMD is not well established although it is regarded as a multifactoral condition (DeVocht, Long, Zeitler and Schaeffer, 2003 and Andrade, Gomes and Teixeira-Salmela, 2007) with alterations in occlusion, bruxism, stress, anxiety and head and neck postural problems all contributing to its development (de Farias Neto, de Santana, de Santana-Filho, Quinntans-Junior, de Lima Ferreire and Bonjardim, 2010). Temporomandibular disorders are often diagnosed according to the research diagnostic criteria for TMD (RDC/TMD) which is considered to be the “gold” standard for the diagnosis of TMD (de Farias Neto *et al*., 2010). The RDC/TMD is made up of two axes (Dworkin, Fricton, Hollender, Huggins, LeResche, Lund, Mohal, Ohrbach, Palla, Sommers, Stohler, Truelove, Von Korff and Widmer, 1992). An overview of the first criteria can be seen in Table 2.6 which classifies clinical TMD while the second axis uses a 31 item history questionnaire which evaluates the patient’s psychological status, severity of pain, jaw disability and other non specific symptoms (Dworkin *et al*., 1992).

Table 2.6: RDC/TMD

GROUP 1 **Muscle disorders**	**a** **b**	**Myofascial pain** **Myofascial pain with limited opening**
GROUP 2 **Disc displacement**	**a** **b** **c**	**Displaced disc with reduction** **Displaced disc without reduction, with limited opening** **Displaced disc without reduction, without limited opening**
GROUP 3 **Arthralgia, Arthritis,** **Arthrosis**	**a** **b** **c**	**Arthralgia** **Osteoarthritis** **Osteoarthrosis**

(adapted from Dworkin *et al*., 1992).

According to Uyanik and Murphy (2003) and Fricton (2004), TMD is also divided into three distinct groups: 1) internal derangement where the problem lies within the joint e.g. malpositioning of the articulating disc; 2) degenerative joint disease and 3) myofascial pain dysfunction where pain at the TMJ is due to a variety of causes of increased muscle tension and spasm without any primary disorder of the joint itself. The latter is the most common cause of temporomandibular disorders (Tucker, Farrell and Farrell, 2008) and accounts for up to 50% of all TMD (Ibsen and Phelan, 2009). George, Fennema, Maddox, Nessler and Skaggs (2007) stated that the myofascial category of TMD involves not only the muscles of mastication but also the muscles of the neck and shoulders, which supports the earlier findings of Travel, Simons and Simons (1999).

Internal derangement includes such entities as disc displacement, and ankylosis while degenerative joint disease encompasses such conditions as osteo and rheumatoid arthritis (Ibsen and Phelan, 2009).

Broome (2003) also classifies TMD into three categories which include 1) musculo-mechanical, 2) psycho-physiological and 3) occlusal mechanical dysfunction.

1) Musculo-mechanical causes are the most common causes of TMD according to Broome (2003) and are a result of either macro or microtrauma. Microtrauma encompasses pathological repetitive activities such as nail biting, bruxism, jaw clenching, the chewing of gum (Travel, Simons and Simons, 1999) and other significant occlusal disharmony. Pertes and Gross (1995) highlight the fact that microtrauma caused by the above-mentioned activities work not only as an initiating factor in TMD but also act to maintain

and perpetuate it after the onset. Macrotrauma takes into consideration issues like direct trauma due to, for example, a blow to the jaw and face (Okeson, 1996) as well as accounting for the TMD noted in patients following whiplash injury (Jagger, Bates and Kopp, 1994; Foreman and Croft, 1995; Okeson, 1996 and Friedman and Weisberg, 2000).

2) Psycho-physiological causes reflect on the role that stress, anxiety and depression play in the TMD patient (Okeson, 1996). Under raised levels of emotional stress the skeletal musculature as a whole exhibits generalized hyperfunction (Malik, 2008) and has been implicated in the development of myofascial pain and hyperactivity in the muscles of mastication in TMD patients (Travell, Simons and Simons, 1999). Travell, Simons and Simons (1999) discuss how the stressed anxious individual holds their muscles in sustained contraction which inevitably overloads them and perpetuates myofascial trigger points (MFTP's). Malik (2008) also emphasizes that emotional stress increases what he calls "persistent, tension relieving oral habits" such as pipe smoking, jaw clenching, nail biting, gum chewing and bruxism which contribute to the musculo-mechanical causes of TMD.

3) Occlusal mechanical dysfunction relates to the displacement of the articular disc of the TMJ (Lawrence, 1991) and it is thought to be due to lengthening of or torn ligaments between the disc and the condyle (Okeson, 1996). It also accounts for conditions which affect the normal resting position of the mandible. Mouth breathing, for example, causes an increase in the freeway space and alters tongue position, as mouth breathing cannot occur when the tongue is resting on the palate (Mannheimer and Rosenthal, 1991). This in turn leads to extension of the head in order to facilitate mouth breathing which produces hyperactivity of the cervical musculature and not only adds to pain referral to the craniofacial region but also contributes to the development of TMD (Mannheimer and Rosenthal, 1991).

Gelb (1977) recognized the "TMD triad" as depicted in Figure 2.2 which places the components of TMD into one of three categories: predisposition, tissue alterations and psychologic dependence.

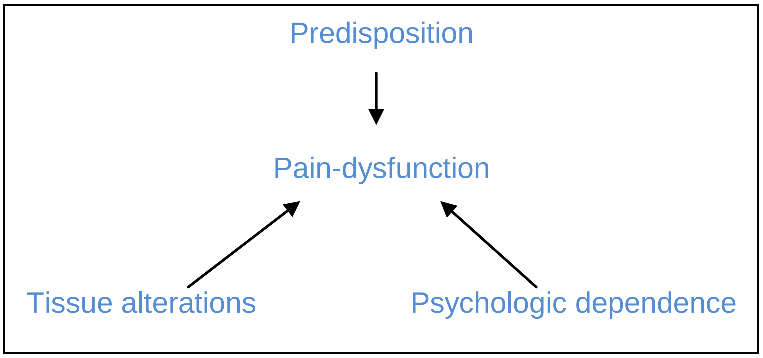


Figure 2.2: The TMD Triad (adapted from Gleb,1977).

Gelb (1977) states that all three factors need to be present to precipitate TMD. An individual may be genetically predisposed and have an altered maxillo-mandibular relationship but the patient does not have sufficient psychological stress to cause bruxism or clenching and so does not present with any clinical symptoms of pain and dysfunction.

The diagnosis of TMD is commonly based on the presenting signs and symptoms though Okeson (1996) suggests the use of investigations such as magnetic resonance imaging (MRI), radiographs (X-Rays) and arthroscopy to differentiate between the various conditions which cause TMD.

2.6. Epidemiology

There does not seem to be a greater occurance of TMD in any one racial or cultural group (LeResche, 1997; Esposito, Panucci and Farman, 2000 and Parnes, Sinert and Heffer, 2006), while it does predominate in the 20-40 year age group (Shimshak, Kent and DeFuria, 1997; Hertling and Kessler, 2006) and according to LeResche (1997) pain in the temporomandibular region occurs in approximately 10% of the North American population over the age of 18. Schiffman, Fricton, Haley and Shapiro (1990) stated that 12-25% of the general population present with TMJ symptoms and according to Okeson and de Kanter (1996) 40-75% of the adult population will have at least one sign of TMD (movement abnormalities, joint sounds, pain or tenderness to palpation) and approximately 33% will have at least one symptom of TMD in their life. Epidemiological studies carried out by De Wijer *et al*., (1996) and Ciangaglini, Testa and Radaelli (1999) found that patients with TMD and neck pain were mostly females in their 30's who were employed in the tertiary sector and who reported high levels of stress. The incidence of TMD amongst males to females has been reported as 1:2 and 1:3 (Jagger, Bates and Kopp, 1994 and McNeil, 1993). Although these figures may seem high many of the signs and symptoms are not troublesome to the patient, resulting in only 3-7% of the population seeking treatment (Dworkin, Huggins, LeResche, von Korff, Howard, Truelove and Sommers, 1990; De Kanter, Truin, Burgersdijk, van't Hof, Battistuzzi, Kalsbeek and Kayser, 1993). Epidemiological estimations of TMD are, however, problematical because of the integrated biomechanics of the muscles of the head and neck which co-ordinates mandibular and cervical movements as well as postural changes (Foreman and Croft, 1995).

2.7. Signs and symptoms

Symptoms of TMD include: joint dysfunction noted by clicking, popping (Broome, 2003), grinding or crepitus (Nykoliation and Cassidy, 1984) and changes in mandibular gait with an associated decrease in joint range of motion (Lawrence, 1991; Peterson and Bergmann, 2002; and Broome, 2003). There may also be accompanying symptoms of otic dysfunction including tinnitus, dizziness, ear popping, ear pain and recurrent headaches (Kraus, 1994; Broome, 2003 and Auvenshine, 2007). Local pain in the TMJ area or referred pain from the muscles of mastication is the most common presenting symptom (Good *et al*., 2000) and patients often describe a sensation of muscle stiffness and fatigue, which is aggrevated by movements of the jaw (Wanman and Agerberg, 1986). Local pain is usually confirmed by the presence of palpable taut bands in the muscles of mastication (Travell, Simons and Simons, 1999), most commonly the masseter muscle (Rachlin and Rachlin, 2002). TMD sufferers not only have intermittent or persistent pain and sensitivity in their masticatory muscles, but also in other groups of muscles such as the digastrics, SCM and posterior cervical muscles (Kalamir, Pollard, Vitiello and Bonello, 2006). Tension-type headaches are often present in patients with TMD which may be related to myofascial trigger points in the temporal muscle (Jagger, Bates and Kopp, 1994) or are secondary to MFTP's from the neck muscles (Okeson, 1996).

2.8. Treatment

Alcantara *et al*., (2002) suggest that three quarters of patients with moderate to sever TMD will spontaneously improve over time (approximately 2 and half years). This is supported by a review by Kalamir *et al*., (2006) where it was found that 50% of TMD cases were self-limiting, 25% were managed with the use of muscle relaxants and non steroidal anti inflammatory drugs (NSAIDs) and 20% were managed with oral appliances. Only 2% eventually required surgical correction which left 3% presumably to undergo other forms of treatment e.g. physiotherapy, chiropractic, massage, acupuncture, stress counseling and biofeedback.

Successful management of TMD depends firstly on an accurate diagnosis (Pertes and Bailey, 1995) and early treatment should be designed to be reversible, palliative and promote healing (Pertes and Bailey, 1995). It should also include patient education to make them aware of the factors associated with their condition, thus allowing them an active role in their own recovery (Tucker, Farrell and Farrell, 2008) and seeing as though both physical factors as well as psychological factors contribute to the development and perpetuation of TMD, a multidisciplinary approach should be promoted in order to assess and manage patients presenting with TMD appropriately (De Laat, 2001).

2.8.1. Pharmacological

Pharmacological treatment helps to control pain and inflammation which is often associated with TMD and includes the use of analgesics, NSAIDs, corticosteroids, muscle relaxants, anti-anxiety agents and anti-depressants (Pertes and Bailey, 1995). Pharmacological measures are more effective when used in conjunction with other treatment approaches (Jagger, Bates and Kopp, 1994 and Pertes and Bailey, 1995). NSAID medication reduces inflammation in the muscles and the joints and also acts as an analgesic providing satisfactory pain relief for most cases of TMD. It is important however to remember that TMD may be a chronic condition and long term use of analgesic medication could be addictive (Tucker, Farrell and Farrell, 2008). Anti-depressants such as Tricyclic anti-depressants prevent the reuptake of neurotransmitters and hence inhibit pain transmission. It has be shown anecdotally that the administration of these kinds of drugs in small doses may be effective in decreasing nocturnal bruxism, due to improved sleep and an overall decrease in joint and muscle pain (Tucker, Farrell and Farrell, 2008). Pharmacological treatment is a good short term measure, but should not be used for long term management (Pertes and Bailey, 1995).

2.8.2. Interocclusal appliances

TMD management is dominated by the dental field (Kalamir *et al*., 2006) and the use of interocclusal appliances is widely accepted despite the exact role of occlusion in TMD still being controversial (Morrish and Stroud, 1995). The most widely used method is the use of an intra oral plate which is fashioned on a cast and is custom fabricated for each patient and each specific type of TMD (Okeson and de Kanter, 1996 and Catanzariti, Debuse and Duquesnoy, 2005). These are used to decrease loading of the TMJ and reduce muscle hyperactivity (Morrish and Stroud, 1995) or to reposition the jaw in order to return the TMJ discs to their normal location (Catanzariti, Debuse and Duquesnoy, 2005). The use of intrerocclusal appliances distributes the forces during bruxism and assists in the prevention of wear and tear caused by bruxism (Pettingill, GrowneyJr, Schoff and Kenworthy, 1998).

Joint stabilization splints are recommended for TMD of a myogenous nature as well as those conditions where the aim of treatment is to decrease the pressure on the joint, such as capsulitis and synovitis (Morrish and Stroud, 1995). Anterior repositioning splints are most often used when the disc-condyle relationship is dysfunctional and its use is aimed at achieving a more favorable biomechanical relationship (Morrish and Stroud, 1995).

Other options include tooth reshaping, orthodontic treatment, and prostheses to replace lost posterior teeth (Catanzariti, Debuse and Duquesnoy, 2005). Proshodontic and orthodontic options are often required as a component of normal dental care but is usually not recommended for the primary management of patients with TMD (Fricton, 2004). According to Chinappi and Getzoff (1995) and Pertes and Bailey (1995) co-operation between a physical medicine practitioner and a dentist is essential in the comprehensive treatment of TMD. This is supported by a case study (Chinappi and Getzoff, 1995), where the subsequent findings promote the use of co-treatment and integrated care of both a chiropractor and a dentist. DeVocht *et al*., (2003) and Andrade, Gomes and Teixeira-Salmela (2007) also suggest that since TMD is a multifactoral condition it needs to be addressed as such in order to best benefit the patient.

2.8.3. Surgery

Surgery is performed for specific articular disorders and should only be used in selected cases such as that of TMJ ankylosis or severe degeneration of the joint or when there has been failure of reversible non-surgical treatment (Tucker, Farrell and Farrell, 2008). Care must however, be taken to ensure that the TMJ is the primary source of pain (Pertes and Bailey, 1995). It appears from the literature that arthroscopic surgery is the procedure of choice but open-joint procedures still play an important role depending on the degree of anatomic derangement within the joint (Jagger, Bates and Kopp, 1994 and Pertes and Bailey, 1995).

2.8.4. Physical medicine

Manual therapy techniques that are available include soft tissue therapy (e.g. massage), mobilization, exercise and manipulation. These are postulated to reduce local ischemia, stimulate proprioception, break fibrous adhesions, stimulate synovial fluid production and reduce pain (Travell, Simons and Simons, 1999). Physical modalities such as the application of moist heat, cryotherapy, vaporocoolant and diathermy cause temperature changes in the muscle and skin and act as a form of counter-stimulation, while the use of ultrasound, massage, acupressure and dry needling offer mechanical disruption to reduce tenderness (Fricton, 2007). Electrical stimulation devices such as transcutaneous electrical nerve stimulation (TENS), megapulse and interferential therapy provide electrical currents in order to stimulate muscles (Fricton, 2007). Megapulse, short-wave diathermy, ultrasound and laser are often used in the physical therapy practice yet the literature is devoid of formal comparative and blinded studies of these treatments (Gray, Quayle, Hall and Schofield, 1994). Other manual procedures which are commonly used include joint mobilization, gently stretching exercises, proprioceptive neuromuscular facilitation (PNF) stretching and myofascial release techniques, such as dry needling and acupressure (Mannheimer, 1995 and O'Reilly and Pollard, 1996). Rehabilitation and exercise therapy is recommended to improve tongue and mandibular function (Catanzariti, Debuse and Duquesnoy, 2005) as well as head and neck posture which helps to reduce the susceptibility of muscles to the reactivation of pain, improve circulation, and increase the durability and strength of the muscles concerned (Fricton, 2007). Passive and active stretching can improve the mandibular range of motion and decrease the pain associated with maximum mouth opening in TMD patients (Fricton, 2007). Correct tongue posture, where the tongue is placed gently on the roof of the mouth with the top and bottom teeth slightly apart, as well as correct head and neck posture decreases muscle activity and encourages healing (Fricton, 2007) but like dentistry does not claim to address the psycho-emotional aspect associated with TMD.

2.8.5. Psycho-physiological

The role that stress, anxiety and depression play in the TMD patient has been mentioned previously (Okeson, 1996). Fricton (2004) explains that emotional stress often manifests by producing hyperactivity in the muscles of the suboccipital, cervical and shoulder girdle regions.

Friction (2004) goes on to state that this hyperactivity could lead to referred pain to the craniofacial region and contribute to the development of TMD. This is supported by Kraus (2007) and Fricton (2007) who also found that patients who experience chronic pain and dysfunction often display signs and symptoms related to psychosocial factors and often exhibit changes in their approach to finding treatment. Thus, relaxation training, stress counseling and biofeedback are therefore an integral part of treating the psychological aspects of TMD and aim at changing maladaptive behaviors and habits such as bruxism, neck and shoulder tensing and nail biting (Fricton, 2007). Auvenshine (2007: 121) stated that "congnitive-behavioral therapies are effective in treating persistent distress and disability resulting from functional somatic syndromes" and this in conjunction with other psycho-physiological treatment aids in reducing the overall symptoms of TMD (Tucker, Farrell and Farrell, 2008).

2.9. Myofascial trigger point therapy

A myofascial trigger point (MFTP) is defined as a spot of hyperirritability within a taut band of skeletal muscle or fascia that is hypersensitive to palpation and can bring about characteristic reproducible referred pain and tenderness (Clark and Solberg,1987 and Rachlin and Rachlin, 2002), motor dysfunction, and autonomic phenomena such as coryza, lacrimation, salivation, erythema and changes in temperature of the overlying skin, sweating, piloerection and proprioceptive disturbances (Gatterman, 1990; Lavelle, Lavelle and Smith, 2007). Travell, Simons and Simons (1999) describe the effects of latent trigger points as causing stiffness and restriction in range of motion while active trigger points cause pain, in addition, to the motor dysfunction of latent trigger points.

MFTP's are caused by either direct or indirect stimuli (Travell, Simons and Simons, 1999). Direct stimuli includes direct trauma and nerve compression as well as acute muscle overload due to repetitive or sustained use as this allows the muscle to remain in a shortened position and causes the muscle to contract while in this shortened position (Travell, Simons and Simons, 1999). Indirect stimuli can be caused due to referred pain from an existing active trigger point and encompasses conditions such as joint dysfunction and the effect of emotional distress and anxiety on muscular conditioning (Travell, Simons and Simons, 1999).

Manolopoulos, Vlastarakos, Georgiou, Giotakis, Loizoz and Nickolopoulos (2008) findings support the review by Svensson and Graven-Nielsen (2001) that MFTP's frequently develop in the TMJ area and if left to persist are considered one of the prime causes of functional disability in the masticatory system (Manolopoulos *et al*., 2008). Fricton (2007) discusses how MFTP's in the muscles of mastication can cause a restriction in mandibular range of motion which is unrelated to joint restriction and in experimental studies by Svensson, Bak and Troest (2003) and Castrillion, Cairns, Ernberg, Wang, Sessle, Arendt-Nielsen and Svensson (2008) glutamate was injected into the masseter muscles resulting in sensory and motor disturbances which were similar to those reported by TMD patients. Fernandez-de-las-Penas, Galan-del-Rio, Alonso-Blanco, Jimenez-Garcia, Arendt-Nielsen and Svensson (2010) in a blinded, control trial of 25 females presenting with TMD and 25 healthy matched participants found that those participants with TMD had multiple active MFTP's in the shoulder, neck and masticatory muscles (active MFTP's were not found in the control group). It was also noted that on manual palpation of these active MFTP's, it reproduced the pain pattern that mimicked the TMD sufferers' usual symptoms (active MFTP's were not found in the control group). However, the study had a small sample size (n = 50) and the authors do state that owing to the fact that their study was not longitudinal they cannot establish a cause and effect relationship between TMD pain and MFTP's.

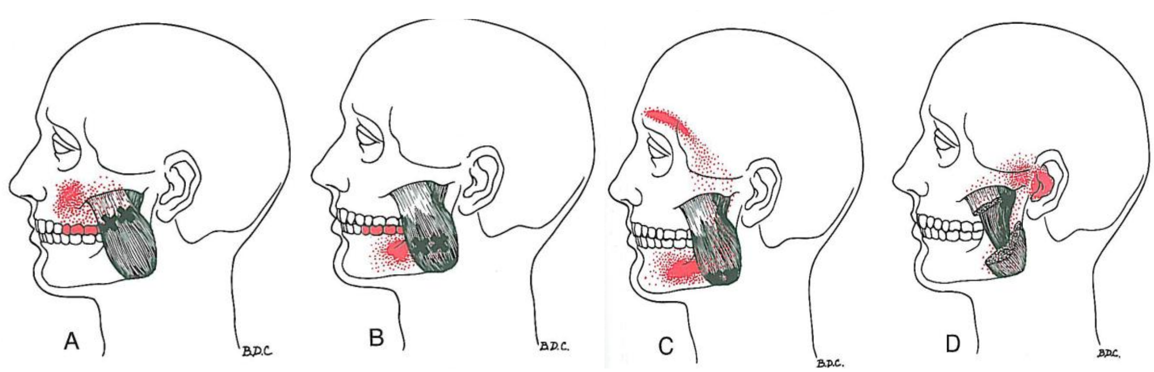
In an uncontrolled trial by Carlson, Okeson, Falace, Nitz and Lindroth (1993), 20 patients presenting with MFTP in the upper trapezius muscle as well as pain in the ipsilateral masseter muscle were injected with a local anaesthetics into the trapezius MFTP's resulting in a significant decrease in pain ($p < 0.001$) and EMG activity ($p < 0.03$) in the masseter muscle. However, given that the study was uncontrolled, firm conclusions cannot be drawn regarding the exact relationship between the injection of the trapezius and the reduction in EMG activity in the masseter. Although, similarly, Hagberg (1987) found that when there was a reduction of pain in the muscles of mastication, in both humans and animals, there was a subsequent alteration in muscle activity of the local muscles extending even to the cervical musculature. Travell, Simons and Simons, (1999) noted that the masseter and temporalis muscles often harbour satellite trigger points as a result of primary trigger points in the SCM due to these muscles lying within the pain reference zone of the SCM trigger points. According to Travell, Simons and Simons (1999), neither these muscles nor the pain in the TMJ responded to treatment until the primary trigger points in the SCM have been successfully treated.

Studies by De Laat *et al.,* (1998) and Stiesch-Scholz, Fink and Tschernitschek (2003) have shown a high prevalence of MFTPs in the masticatory muscles and in the cervical spine musculature in patients presenting with TMD. They have also shown an increased incidence of cervical spine dysfunction in the upper cervical region (C0-C3) in patients with TMD. De Laat *et al's*., (1998) study compared 31 consecutive TMD patients with 30 control patients who were free of subjective complaints of TMD and cervical dysfunction. There were significantly more tender points present in the SCM, most notably on the right, (p = 0.005) and trapezius muscle (left trapezuis p = 0.025; right trapezius p = 0.002) of the TMD sufferers than the control group. Moreover, De Laat *et al*., (1998) also noted that hyperalgesia was present in 13-16% of subjects with TMD when compared to the controls in this study. These studies highlight the notion that the masticatory system and the cervical spine are linked as a functional entity. De Laat *et al.,* (1998) concurs with Kraus (1994) and explains that dysfunction and pain in the cervical spine and its musculature in TMD patients could be as a result of changes in head posture which is often linked to a dysfunctional masticatory system as well as due to the excessive convergence of different types of afferent input on the trigeminal nuclei.

2.9.1. Muscles of mastication

Masseter muscle:

Symptoms of MFTP in the masseter muscle include restricted jaw movement and tinnitus which closely mimics TMD. The pain experienced by patients with MFTP's in this muscle follows a very similar distribution pattern to that of TMD, as can be seen in Figure 2.3 (Travell, Simons and Simons, 1999). Excessive forward head posture has been known to perpetuate MFTP in the masseter because it places the mandible in a position which puts stress on the muscle. Excessive abusive jaw habits among many other factors are also implicated in the perpetuation of MFTP in the masseter (Travell, Simons and Simons, 1999).

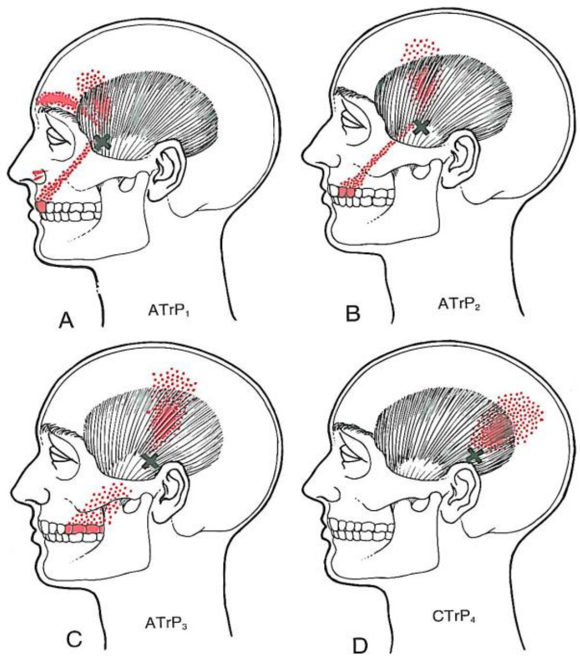


Pain may refer to the TMJ, deep in the ear, to the maxilla, mandible and upper molars. (Travell, Simons and Simons, 1999).

Figure 2.3: Masseter referral pain pattern (Travell, Simons and Simons, 1999: 331).

Temporalis muscle:

Patients with MFTP in the temporalis muscle often complain of toothache (Gatterman, 1990; Jagger, Bates and Kopp, 1994; Travell, Simons and Simons, 1999) as seen in Figure 2.4. These TP's may develop in response to long periods of jaw immobilization, bruxism, clenching, direct trauma or due to satellite MFTP in the the SCM and upper trapezius muscles. It may also become overloaded from tension in the supra and infrahyoid muscles due to anterior head carriage (Gatterman, 1990; Jagger, Bates and Kopp, 1994; Travell, Simons and Simons, 1999).

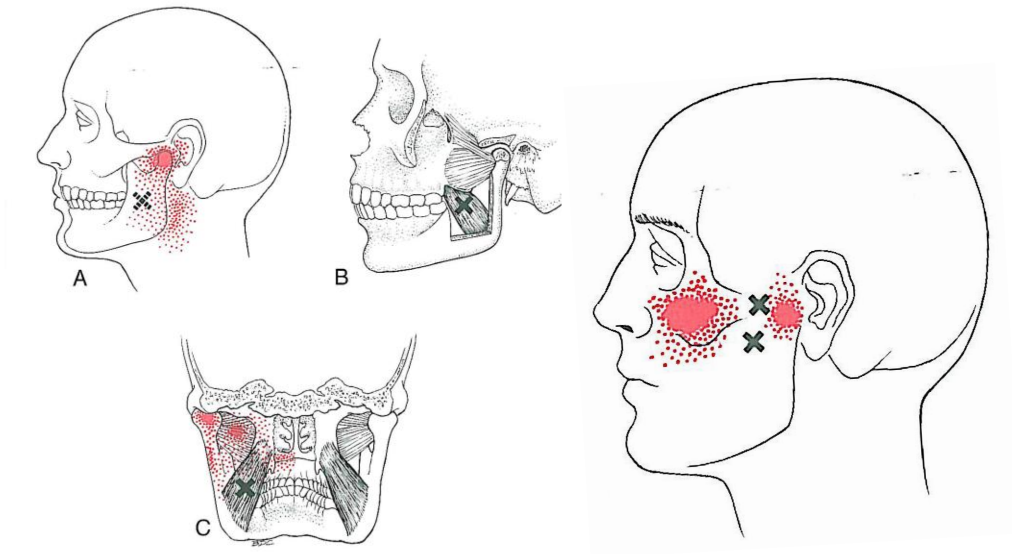


Pain may refer to occipital ridge, behind and deep into the ear and to the vertex of the skull (Travell, Simons and Simons, 1999).

Figure 2.4: Temporalis referral pain pattern (Travell, Simons and SImons, 1999: 351).

Medial and lateral Pterygoid muscle

According to Travell, Simons and Simons (1999) MFTPs in the lateral pterygoid muscle are likely to disturb the position of the mandible and cause masticatory dysfunction and tinnitus and resulting in the development of trigger points in the other muscles of mastication. The medial pterygoid produces such symptoms as difficulty swallowing, painful jaw opening with restriction and a sore throat (Travell, Simons and Simons, 1999). Like the other muscles of mastication, MFTP's in the medial and lateral pterygoids may result from bruxism and excessive abusive oral habits and have been known to develop in response to primary MFTP in the neck muscles (Travell, Simons and Simons, 1999).



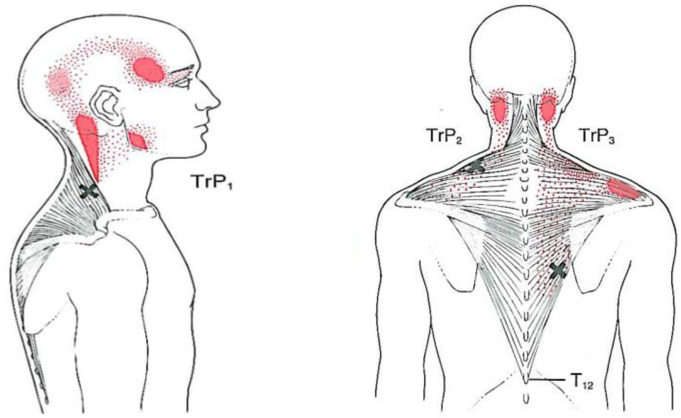
Medial Pterygoid Lateral Pterygoid

Figure 2.5: Medial and lateral pterygoid muscle referral pain patterns. (Travell, Simons and Simons, 1999: 366 and 380).

2.9.2. Muscles of the cervical spine that have a role in TMD

Upper fibres of the Trapezius

The trapezius is one of the most common muscles affected by MFTP's and when present these MFTP's are often a cause of temporal and cervicogenic headaches (Okeson, 1996 and Travell, Simons and Simons, 1999) as well as vertigo (Travell, Simons and Simons, 1999) both of which are common symptoms in the TMD patient (Kraus, 1994 and Broome, 2003). The pain referral pattern can be seen in Figure 2.6. The upper fibres of the trapezius muscle acts as a synergist with the SCM and as a result a functional unit between the two muscles is formed. This is significant because an active myofascial trigger point in one muscle increases the likelihood of other muscles, within the functional unit, of developing satellite trigger points. Travell, Simons and Simons, (1999) describe certain key trigger points in the upper fibres of the trapezius muscle and the SCM which correspond to satellite MFTP's in the masseter and temporalis muscles, as well as the semispinalis capitis (Travell, Simons and Simons, 1999).

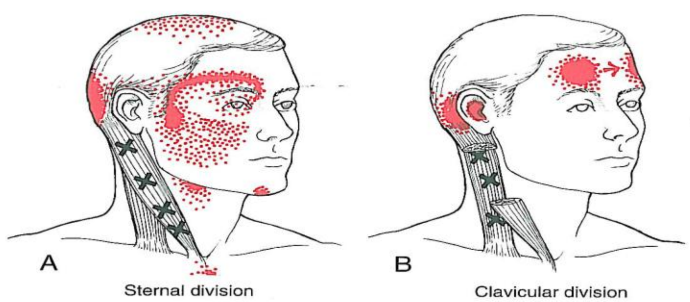


When severe, pain occurs at the temporal region, back of the orbit and occasionally around the angle of the jaw. Rarely pain refers to the occiput and lower molars (Gatterman, 1990; Jagger, Bates and Kopp, 1994; Travell, Simons and Simons, 1999; Rachlin and Rachlin, 2002).

Figure 2.6: Trapezius muscle referral pain pattern (Travell, Simons and Simons, 1999: 279-280).

The Sternocleidomastoid

According to Uys (2009), the SCM is commonly taut in TMD patient sufferers. Figure 2.7 depicts the pain referral pattern of the two divisions (starnal and clavicular) of the muscle (Moore and Dalley, 2006). MFTP's in the SCM have been known to cause such phenomena as excessive lacrimation, visual disturbances, coryza, sinus congestion, unilateral deafness, dizziness, vertigo and nausea (Travell, Simons and Simons, 1999). As mentioned earlier, the SCM acts as a synergist with fibres of the upper trapezius and, as well as being associated with satellite TP's in the temporalis and masseter, the SCM is linked to the development of satellite TP's in the lateral pterygoid, digastrics, frontalis, orbicularis oculi and platysma muscle (Gatterman, 1990 and Travell, Simons and Simons, 1999).



Occasionally pain referrs to the pharynx and the back of the tongue (Gatterman,1990 and Travell, Simons and Simons, 1999). Sternal division TP's may refer to the vertex of the head (Travell, Simons and Simons, 1999). Clavicular division TP's may refer pain across the forehead and ipsilateral ear (Gatterman,1990 and Travell, Simons and Simons, 1999).

Figure 2.7: SCM referral pain pattern (Travell, Simons and Simons, 1999: 310).

Posterior Cervical muscles

TPs in the Upper fibres of the semispinalis capitis projects pain above the orbit and over the posterior occiput. TPs in the Longissimus capitis refers pain around the ear. Multifidi MFTP's refers pain to the suboccipital region and posterior aspect of the neck and upper part of the shoulder girdle (Travell, Simons and Simons, 1999).

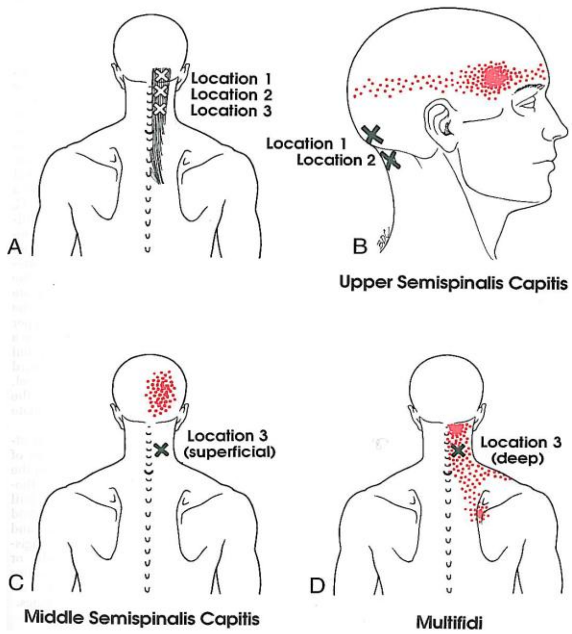


Figure 2.8: Posterior cervical referral pain patterns (Travell, Simons and Simons, 1999: 447).

2.9.3. Ischaemic compression

Ischaemic compression is just one of many terms used to describe the use of deep manual pressure applied over tender muscular nodules (Perterson and Bergmann, 2002). Terms such as receptor tonus, neuromuscular technique, trigger point therapy and acupressure are all used to describe varying therapeutic approaches to the same technique (Perterson and Bergmann, 2002). Trigger point therapy or ishcaemic compression is thought to work on the barrier release model (Travell, Simons and Simons, 1999) and works to reduce tenderness by mechanical disruption (Fricton, 2007) by generating a concentrated stretch of the contracted sarcomeres within the TP, thus separating the actin and myosin heads (Peterson and Bergmann, 2002). Travell, Simons and Simons (1999) and Peterson and Bergmann, (2002) also state that ischaemic compression works through the neurological mediation of reflex pathways as well as bringing about local ischaemia which induces a sensory nerve block due to the lack of oxygen. Another explanation is that once the pressure is released there is a reflex vasodilation which increases circulation, thus lessening the effects of metabolites and chemical irritants as well as conveying oxygen and adenosine triphosphates to the area (Peterson and Bergmann, 2002). Peterson and Bergmann (2002) go on to explain that ischaemic compression also generates pain in the area which causes hyper-stimulation of the interneurons in the dorsal horn which in turn releases endorphins and thus inhibits pain perception.

To perform ischaemic compression non-painful slowly increasing pressure is applied over the MFTP until a barrier of tissue resistance is met. When the tissue barrier releases, pressure is increased to reach a new barrier until the trigger point tension and tenderness is eliminated (Travell, Simons and Simons, 1999).

O'Reilly and Pollard (1996) state that myofacial trigger point therapy applied to the masticatory musculature is frequently used to treat the symptoms of TMD. Cohen and Pertes, Ferguson and Gerwin and Greenfeild as cited in Kalamir *et al*., (2006) state that there are many case studies and technique manuals that describe static ischaemic compression as a common form of treatment for TMD, however, according to Kalamir *et al*., (2006) there are few published clinical trials which describe the exact technique of massage used in the treatment of TMD. Mootz, Djami, Hess, Cook and Schorr (1994) treated eleven chronic and episodic tension-type headache patients with spinal manipulative therapy (SMT), ischaemic compression and moist heat packs, to the cervical and thoracic musculature, and the results showed a statistically significant change ($p < 0.01$) in the mean pre-treatment to post-treatment headache frequency from 6.4 episodes per two-week period to 3.1. This indicates that combined SMT and trigger point therapy, in the form of ischaemic compression, is beneficial in the treatment of episodic tension-type headache and thus could be indicated in the treatment of TMD.

2.9.4. Prorioceptive Neuromuscular Facilitation

PNF involves manual resistance using isometric muscular contraction followed by relaxation and stretching of the tight muscle (Liebenson, 2007). It is most commonly used to either stretch shortened muscles or to aid relaxation of overactive muscles and thus reduce pain originating from these muscles (Lewitt and Simons, 1984). PNF achieves these objectives by making use of two physiological phenomena: post-contraction inhibition and reciprocal inhibition (Liebenson, 2007). Post-contraction inhibition is the brief automatic relaxed state that muscles are in following muscle contraction (Liebenson, 2007). Reciprocal inhibition is the phenomenon where when one muscle contracts, its antagonists are automatically relaxed (Liebenson, 2007). PNF also allows for varying proprioceptive stimulation when used to enable weak and inhibited muscles (Liebenson, 2007). Lewit and Simons (1984) in a study treated 351 muscle groups in 244 patients with musculoskeletal pain using PNF and found that PNF produced immediate relief of pain in 94% and lasting pain relief in 63% of all the sites treated. However, the only muscles investigated which are pertinent to this study were the upper trapezius, suboccipital and SCM muscles with 100%, 91% and 78% relief respectively; indicating that PNF is an effective means of restoring full stretch length and relieving pain commonly associated with MFTP's. There are also other studies (Cornelius, Ebrahim, Watson and Hill, 1992; McCarthy, Olsen and Smeby, 1997; MacDougall, 1999; Kofotolis and Kellis, 2006) which demonstrate the effectiveness of PNF, thus indicating that PNF could be a suitable form of treatment for TMD caused by dysfunction in the masticatory muscles.

Travell, Simons and Simons (1999) recommended techniques that elongate the muscle and restore the muscles to full stretch length for other chronic musculoskeletal pain conditions. Travel, Simons and Simons (1999) also stated that PNF techniques directed toward the muscles of mastication can release trigger point tension and pain in these muscles and they suggest the use of PNF, as an adjunct to ischaemic compression, to enhance the effectiveness of ischaemic compression. This is supported by Wilson (2002, unpublished) who found PNF of the cervical musculature to decrease pain and increase range of motion in the cervical spine in patients with chronic mechanical neck pain. Gray (2002), in an unpublished study, found that PNF was more effective in improving patients TMJ range of motion and masticatory muscle MFTPs when compared to ultrasound therapy in the management of TMD caused by myofascial pain and dysfunction (n = 60), but this study is subject to researcher bias as it was an un-blided study and little can be said regarding the effectiveness of each repective treatment group (i.e. within group analysis, because there was no placebo group.

In a study by Michelotti, Steenks, Farella, Parisini, Cimino and Martina (2004) where patients were assigned to either an education group or an education and home physical therapy group it was shown that the participants in the education and home physical therapy group showed a significantly greater (p = 0.017) improvement in pain free maximal jaw opening and the researchers attributed this improvement to the stretching exercises which this group received. This is congruent to the findings by Travell, Simons and Simons (1999) and indicates that PNF is an effective treatment.

2.10. TMJ and cervical spine manipulation.

TMJ and cervical joint dysfunction is commonly noted in TMD patients as a result of the increased tension in the orofacial musculature (Liebenson, 2007). Chiropractic manipulation is most often applied to the spine (DeVocht *et al*., 2003) and is intended to alleviate vertebral dysfunction and restore normal range of motion (Peterson and Bergmann*,* 2002) and improve biomechanical functioning (DeVocht *et al*., 2003). Curl (1994) explains that high velocity, low amplitude manipulations work mechanically by causing stimulation of the mechanoreceptors, stretching muscle spindles and breaking joint adhesions which result in an increase in active and passive joint range of motion as well as stimulating the autonomic nervous system which causes reflex inhibition of pain and muscle spasm. Peterson and Bergmann (2002) go on to state that manipulation re-establishes correct biomechanics and corrects altered neurological reflexes which are associated with joint dysfunction.

DeVocht *et al*., (2003: 424) state that "chiropractic clinicians use well-established protocols to treat other structures, including hands, feet, knees, and even cranial bones" and they go on to suggest that it is reasonable to assume chiropractic manipulation of these other structures will have the same beneficial effect. Schafer and Faye (1990) reported that particular manipulations of the TMJ may be suitable for an adherent anterior disc displacement. In a single subject case study (Saighafi and Curl, 1995) of a patient reporting with unilateral adherent disc displacement where the patient first received cervical manipulation alone and later received cervical manipulation and specific TMJ manipulation, it was concluded that specific TMJ manipulation of the TMJ may be appropriate in the conservative management of an adherent anterior disc displacement.

De Wijer *et al*., (1996) and De Laat *et al*., (1998) found that TMD sufferers often had clinical signs and symptoms of cervical dysfunction and their findings are supported by Stiesch-Scholz Fink and Tschernitschek (2003) who investigated patients (n = 60) with and without internal derangement of the TMJ, and found considerably more restrictions in the range of movement of the cervical spine in patients with TMD than those without ($p < 0.5$). The dysfunction was most prominent in the upper cervical spine. Similarly, De Laat *et al*., (1998) (n = 61) found that there were significantly ($p < 0.001$) more segmental limitations noted in the upper cervical spine (C0-C3) in TMD patients than control subjects and that more MFTP's were present in the SCM (p = 0.005) and trapezius muscles (p = 0.025 left; p = 0.002 right) in TMD patients. Travell, Simons and Simons (1999) also state that manipulation is a valuable tool in treating MFTP's as manipulation also produces stretching of the surrounding muscles (Schafer and Faye, 1990).

In a study by O'Reilly and Pollard (1996) 12 TMD patients were assigned to either a chiropractic manipulation group or a control group. The chiropractic group received diversified cervical SMT and the control group received trigger point therapy to the cervical and thoracic musculature. Due to the small sample size the results were unclear, however, the quantitative analysis suggested that the chiropractic group benefitted slightly more and had greater pain reduction. High velocity, low amplitude cervical spine manipulation was also used to treat a single TMD patient in a study by Alcantara *et al*., (2002) and it was reported that the patient's symptoms improved after nine visits. This is supported by DeVocht *et al.,* (2003) where the activator method of treatment for TMDs was utilized; it was found that this protocol had a statistically significant beneficial effect (median improvement in VAS was 45mm and the median increase in maximum mouth opening was 9mm) in the case of articular TMD. In contrast George *et al*., (2007) did not find that manual therapy (high velocity, low amplitude cervical spine manipulation and active release technique) applied to the upper cervical spine improved mouth opening measurements. However, this study was conducted on an asymptomatic population whose initial mouth opening measurements were within the normal reference range. The researchers go on to state that manual therapy may require several sessions for improvements to occur and participants in their study only received one treatment application between measurements. An unpublished pilot study by Jones (2002) compared cervical spine and TMJ manipulations to cervical spine manipulation alone in the treatment of TMD. It was found that both groups improved in terms of subjective measurements; however, the combination treatment was more successful than manipulating the cervical spine alone. Jones' (2002) identified that a limitation of his study was that it only concentrated on manipulation and he recommended that future studies include the treatment of the related musculature.

The use of manual therapy according to Kalamir *et al*., (2007) is a widely accepted treatment modality in the management of TMD; especially TMD of a myofascial nature, but like dentistry does not claim to address the psychoemotional aspect. This study, therefore, aims to determine the effect of TMJ manipulation and myofascial trigger point therapy alone or in combination with cervical spine manipulation and myofascial trigger point therapy on TMD.

CHAPTER THREE

RESEARCH METHODOLOGY

3. INTRODUCTION

This chapter describes the setting and design of the study. It includes a description of the recruitment of participants, sampling technique, data collection and the processing of the collected data.

3.1. Design

This research study was an un-blinded quantitative randomized clinical trial. The study was approved by the Durban University of Technology, Faculty of Health Sciences Research and Ethics committee (Appendix A). This approval declared that the research conformed to the standards set by the Declaration of Helsinki1975.

3.2. Advertising

Advertisements (Appendix B) were placed on the notice boards of the Chiropractic Day Clinic (CDC), around the Durban University of Technology (Berea and City) campuses, local universities, libraries, schools, pharmacies, and chiropractic, dental and maxillofacial practices who were willing to advertise for this study. Pamphlets were handed out at various sporting events and a local pamphlet distributing company was utilized to distribute pamphlets around the Berea area of Durban.

3.3. Sample method

Any prospective participants who contacted the researcher underwent a telephonic or face to face interview to determine participant eligibility. The prospective participant was asked the following questions:

1. Are you between the ages of 18 and 50?

2. Where is your pain, or area of concern? Symptoms had to be localised to the area around the temporomandibular joint.
3. Do you have a recent history of trauma or surgery to the head, neck or TMJ? Participants were excluded if they had any recent history of trauma or surgery to the area of concern.
4. Are you currently being treated for pain in your jaw? Participants were excluded from the study if they were currently being treated for temporomandibular disorder.
5. Do you currently have any dentures, braces, bite appliances? Participants were also excluded if they had any functional appliances fitted or adjusted 12 weeks prior to participation in the study as Melson (1991) states that there is a stimulation of the orofacial musculature following the use of functional appliances.

If the potential participant met the telephonic criteria, he or she was scheduled for an appointment at the CDC where permission to use the facility for research purposes had been obtained.

3.4. Sample size

Participants were selected through a process of participant self selection (Mouton, 1996) as they responded to the advertisements. A minimum sample size of 30 participants with 10 participants per subgroup was required for the study. This is in Keeping with other studies done at the DUT. The research protocol was amended (September 2010) increasing the quota of chiropractic students allowed to partake in the study from three to nine students i.e. an increase from 10% to 30% of the sample size. This facilitated the recruitment of the sample for the study.

3.5. Sample characteristics

The following inclusion and exclusion criteria were utilized in order to further assess eligibility.

The inclusion criteria for the study were as follows:

1) Participants had to be between the ages of 18 and 50 years of age. This is because the highest prevalence of TMD is found in the 18-50 age groups (Hertling and Kessler, 2006 and Nunez, Garcez, Suzuki and Ribeiro, 2006).

2) Participants had to present with two or more of the following signs or symptoms (Jagger, Bates and Kopp, 1994):

- Constant/ periodic dull ache over the joint, ear, temporal fossa, angle of mandible or around/behind the eye. Pain is usually elicited or intensified by mandibular movement;
- Palpatory tenderness of the TMJ or muscles of mastication;
- Deviation of the mandible on mouth opening;
- Limitation of mandibular movement and mouth opening measured by the number of proximal interphalageal joints the participant could insert comfortably between their upper and lower incisors;
- Audible TMJ sounds (e.g. clicking, popping, crepitus);
- Bruxism or habitual clenching activities;
- Tension-type temporalis muscle contraction headaches which occur mainly on the pre-auricular, temporal and frontal regions of the head (Okeson and de Kanter, 1996).
- Subjective ear symptoms (tinnitus, vertigo, itching in the ear or a blocked feeling).

3) Symptoms of TMD for at least six weeks duration.

4) On initial examination participants had to present with asymptomatic cervical spine dysfunction and at least one MFTP in the cervical region, which was determined on the cervical spine regional orthopaedic examination (Appendix F).

5) Participants had to read and sign a letter of information and consent (Appendix C).

The exclusion criteria for the study were as follows:

1. Recent history of jaw or neck trauma or surgery, within the last six months (Foreman and Croft, 1995).
2. Neurological deficits e.g. Bells palsy, Trigeminal neuralgia. Although these do not mimic TMD directly, participants suffering from these conditions may present with minor headaches which could cause confusion and misdiagnosis (Jagger, Bates and Kopp, 1994).
3. Recent infections (with in the last six months) affecting the head and neck e.g. bone infections, meningitis, encephalitis, malaria, ear infection as these can mimic signs and symptoms of TMD but are not of TMD origin (Jagger, Bates and Kopp, 1994).

4. Contraindications for cervical high velocity low amplitude (HVLA) manipulation including but not limited to acute fracture, vascular insufficiency or cervical spine instability, disc prolapse with neurological deficit and or dislocation(George, Fennema, Maddox, Nessler and Skaggs, 2007).
5. Neoplasms (Jagger, Bates and Kopp, 1994).
6. Participants that were currently taking analgesics for their TMD. However a withdrawal period of 48 hours was allowed (Poul, West, Buchannan and Grahame, 1993).
7. Participants that were currently undergoing treatment for their TMD were required to stop treatment for the duration of the study.
8. Participants who were using any functional appliances e.g. dentures, braces, bite appliances which had been adjusted or fitted in the last 12 weeks prior to the commencement of this study (Melson, 1991).

3.6. Participant screening

At the first consultation (treatment session one) participants received a Letter of Information and Consent, (Appendix C) which the participants were required to read and sign. Participants were then given the opportunity to ask the researcher any questions and were informed that they were free to withdraw from the study at any point.

During the initial scheduled appointment (treatment session one) the participants were evaluated for further compliance with the inclusion criteria by means of a standardized

- Case history (Appendix D);
- Physical evaluation (Appendix E);
- Cervical spine regional orthopaedic examination (Appendix F) and
- TMJ regional orthopaedic examination (Appendix G).

Once the participant had been accepted into the study the participant was allocated, by the researcher, into one of three groups by means of a non-probability, convenience sampling method with a computer generated random allocation chart (Mouton, 1996).

3.7. Interventions

<u>**Group A:**</u>**TMJ manipulation and ischaemic compression and PNF to the muscles of mastication.**

Group A received manipulation to the TMJ according to the technique outlined by Saighafi and Curl (1995). The participant was supine and the researcher was standing on one side of the participant, facing him/her. Using sterile gloves, a unilateral or bilateral contact was made over the participant lower molars. With the practitioner's thumbs intraorally, a high velocity, low amplitude manipulation was performed distracting the mandible anteroinferiorly. Figure 3.1 depicts one of the techniques used.

Figure 3.1: TMJ manipulation

Participants also received ischaemic compression to the masseter and the temporalis myofascial trigger points (MFTP's). Ischaemic compression was performed by applying; non-painful slowly increasing pressure over the MFTP until a barrier of tissue resistance was met. When the tissue barrier released, pressure was increased to reach a new barrier until the trigger point tension and tenderness was eliminated (Travell, Simons and Simons, 1999).

In addition to the above, participants also received proprioceptive neuromuscular fascilitation (PNF) to the muscles of mastication, as described by Adler, Beckers and Buck (1993) and Nook (1997). This was done to target those muscles that could not receive effective ischemic compression due to their intraoral position. This technique was used to strengthen neurologically weakened muscles with the focus on releasing muscle spasticity associated with these muscles (Chaitow, 1996). The PNF was administered as follows in Figure 3.2.

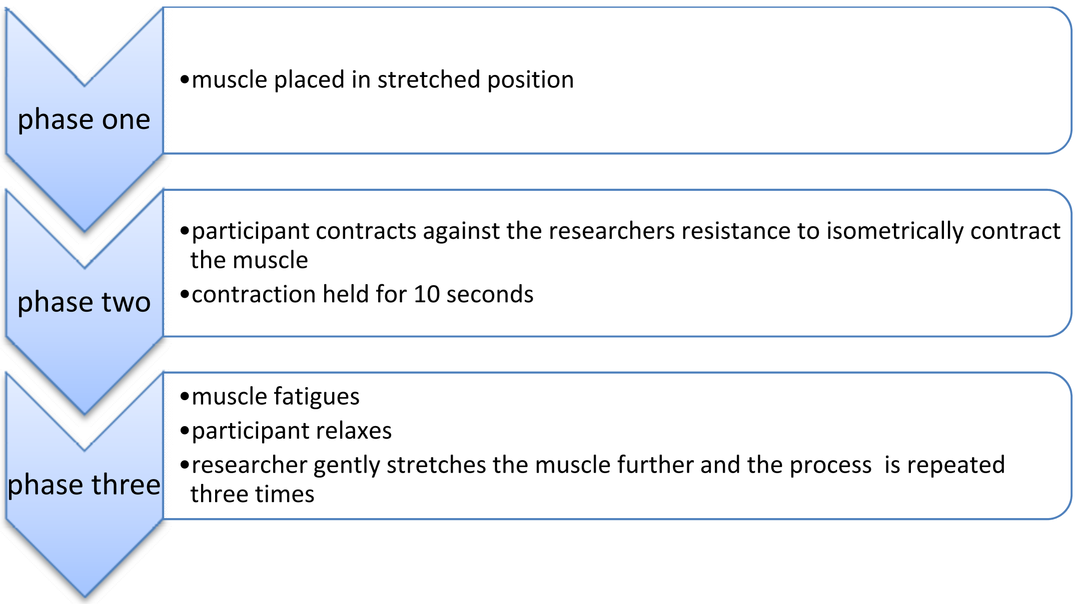


Figure 3.2: Phases of PNF stretching (adapted from Chaitow, 1996)

PNF was performed on the following muscles of mastication: masseter, temporalis, and the medial and lateral pterygoids whilst ischaemic compression was applied to the masseter and temporalis. The techniques used are detailed in Table 3.1 and Figures 3.3; 3.4 and 3.5.

Table 3.1 PNF stretching of the muscles of mastication

Muscle	Stretch position	Contract phase	Relaxation and antagonist contraction phase
Masseter and Temporalis	Participant supine with researcher standing on one side of the participant. Using sterile gloves, a unilateral/bilateral contact was made over the participants lower molars. The jaw was distracted, stretching the muscle until a resistance to further movement was felt or to the point just before the onset of pain.	The participant then closed his/her jaw against the resistance of the researcher's fingers.	The participant was then instructed to relax. The researcher then gently distracted the jaw, hence further stretching the muscle, to the point of new resistance and the process was then repeated.
Lateral pterygoid	The same stance for the above procedure was adopted The jaw was gently pushed posteriorly superiorly with the web of the researcher's hands over the participant's mental protuberance with the fingers resting on the angle of the mandible on either side.	The participant was asked to protrude his/her chin against the resistance of the researcher.	The muscle fatigued and the participant then relaxed before the researcher gently pushed the jaw further, to a point of new resistance. Repeating the procedure three times.
Medial pterygoid	The researcher stood behind a seated participant. The participant turned their head to the left. The researcher stabilised the participants head against their chest. The participant opened their mouth slightly and the researcher stretched the left ptyergoid by placing his/her left hand over the mandible with the fingers directed toward the participant's right ear and pulled the jaw into left laterotrusion until resistance was met.	The participant was then asked to push their jaw to the right against the resistance generated by the researcher's hand.	The participant was then asked to relax before the researcher again placed the participant in the stretch position and repeated the process.

(Chaitow, 1996 and Travell, Simons and Simons, 1999).

Figure 3.3: PNF of the masseter and temporalis muscles

Figure 3.4: PNF of the lateral pterygoid muscle

Figure 3.5: PNF of the medial pterygoid muscle

In terms of PNF and TMJ manipulation participants were treated bilaterally regardless of whether or not they were symptomatic unilaterally or bilaterally. This was done because the mandible is connected across the midline and when using the PNF technique on the masseters, temporalis and the medial and lateral pterygoids the muscles from both sides are stretched.

<u>Group B:</u> Cervical spine manipulation and ischaemic compression and PNF to the cervical spine musculature.

Group B received cervical spinal manipulative therapy (SMT) to the fixations found according to the diversified technique outlined by Schafer and Faye (1990) and Peterson and Bergmann (2002). All manipulative therapy involved a passive, carefully controlled thrust directed toward the involved joint, with a controlled velocity and amplitude, at or near the end of the physiological range of motion of the joint concerned but not exceeding the anatomical limit (Sandoz, 1969).

Ischaemic compression was performed on the cervical musculature: the SCM, upper trapezius, posterior and suboccipital cervical muscles and followed the process outlined for group A. PNF was performed on the cervical musculature and was done bilaterally regardless of symptomatic side (DeLaat, Meuleman, Stevens and Verbeke, 1998; George *et al*., 2007 and Uys, 2009).The muscles being stretched and the altered doctor and participant positions required in order to perform each of the PNF stretches are detailed in Table 3.2 and Figures 3.6 to 3.8.

Table 3.2: PNF stretching of the cervical spine musculature

Muscle	Stretch position	Contract phase	Relaxation and antagonist contraction phase
Posterior cevicals	The participant was supine with the researcher at the head of the bed. The participant lifted their head while the researcher placed his/her hands on the participant's shoulders; left hand to right shoulder and right hand to left shoulder, in such a way that the researcher's hands were crossed below the participant's head. The participant rested their head on the researchers crossed forearms. The researcher then lifted the participant's head into flexion until a point of resistance was met.	The participant was then asked to push their head backwards against the resistance of the researcher's crossed forearms.	The participant relaxed and their head was lifted further by the researcher until a new point of resistance was met and then the process was repeated
Trapezius	The participant was seated with the researcher standing behind the participant. The participant laterally flexed their neck to the left until they felt a mild stretch. The researcher placed his/her left hand on the participant's right shoulder while the other hand gently cupped the participant's right ear (the researcher's arms were in a crossed position). The researcher gently pushed the head and neck into further lateral flexion until resistance was met.	Then the participant was then asked to push their head to the right against the resistance of the researcher's hand which was cupping the participant's ear.	The participant relaxed and then the researcher again laterally flexed the participant's head until a mild stretch was felt. The researcher then gently pushed the participant's head and neck a little further until a new point of resistance was met and the process was repeated.
SCM	The participant was supine with the researcher at the head of the bed. The participant's head was rotated away form the involved side and extended slightly. The researcher cradled the participant's head with one hand while the other hand was placed on the participant's forehead.	The participant was then asked to raise their head (without rotation) against the researchers hand.	The muscle fatigued and the participant relaxed before the researcher placed the head and neck into further stretch and repeated the process.

(Moreau and Nook, 1995).

Figure 3.6: PNF of the posterior cervical muscles

Figure 3.7: PNF of the trapezius

Figure 3.8: PNF of the SCM

<u>Group C:</u> TMJ and cervical spine manipulation and ischaemic compression and PNF to both the cervical and masticatory musculature.

Group C received a combination of both group A and B's treatment protocols i.e. TMJ manipulation, cervical spine manipulative therapy as well as ischaemic compression and PNF stretching to the musculature of both the TMJ and the cervical spine.

3.8. Research procedure

Following acceptance into the study and group allocation each participant was measured for subjective and objective baseline measurement prior to treatment. Subjective and objective data was collected on a SOAP note and on a data collection sheet (Appendix I and Appendix J) before the commencement of the first, second, and fourth treatment sessions and at the follow up consultation session (session 5) in the third week as seen in Figure 3.9. The Data was collected by the researcher involved in the treatment of the participant. Participants were seen for treatment twice a week for two weeks. A follow up consultation took place in the third week (DeVocht, Long, Zeitler and Schaeffer, 2003).

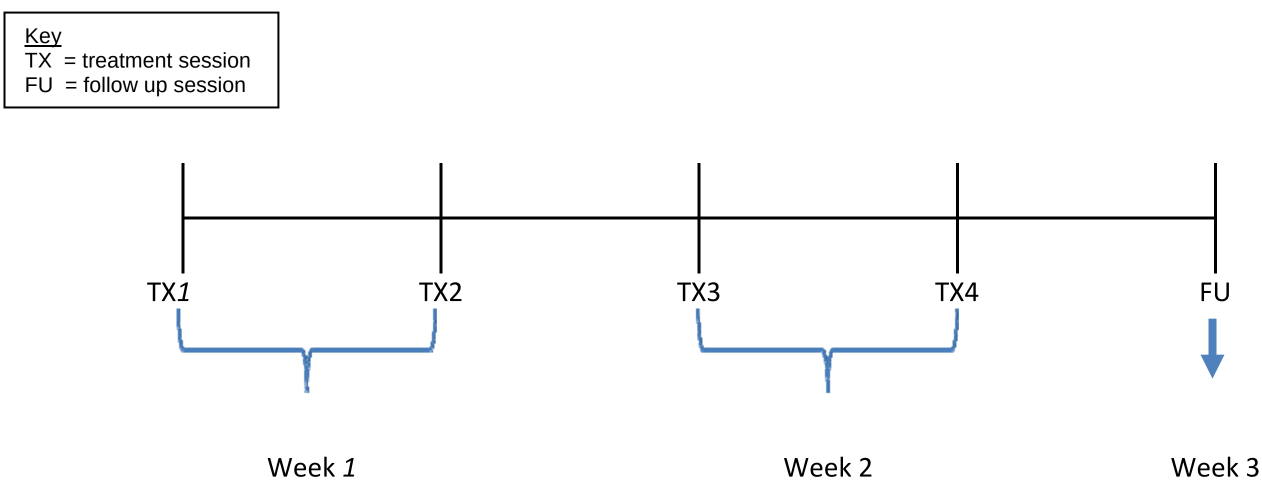


Figure 3.9: Treatment schedule

3.9. Measurement Tools

Objective Data:

- A pressure algometer was used as it is useful in assessing pain thresholds and the improvement thereof (Fischer, 1987) and in a study by Maixner, Fillingim, Sigurdsson, Kincaid and Silva (1998) it was shown that patients with TMD have lower pain thresholds in the masticatory muscles and it is assumed that by treating the muscles of mastication there will be an improvement in algometer readings. The algometer used in this study was the FDK20 force dial and it had a pressure range of 11 kilograms (manufactured by Wagner Instruments: PO Box 1217, Greenwich, CT 06836). The algometer was used to measure changes in the trigger point sensitivity in all groups on the masseter, temporalis, and involved cervical musculature as it is a valid and reliable assessment tool when assessing changes in temporomandibular muscle tenderness (Kraus, 1994). The method of use and the procedure to be followed was first described to the participant. With the algometer set at zero, the MFTP in the muscle concerned was located by palpation, and the rubber stylus was then placed over this area in such a way that the dial was perpendicular to the skin surface. Gentle, steady pressure was then applied until the participant indicated to the researcher that they detected pain. Pressure was applied at a rate of 1 kilogram per square centimeter. The value was then recorded (Fischer, 1987). The most tender MFTP in each muscle was used. Initially the same spot on the muscles was identified with the use of a henna mark, however many of the participants strongly opposed this method of marking and as a result other landmarks (freckles, moles dimples) were used to identify the same MFTP.

- Mouth opening measurements were taken using a TheraBite Range of Motion Scale illustrated in Figure 3.10 (Atos Medical AB: Box 183,24222Horby, Sweden). Maximum mouth opening is a common measurement which is used by the dental profession to assess proper functioning of the TMJ and it has been shown to be reliable (DeVocht *et al*., 2003). The normal range of motion vertically is around 45 mm (George *et al*., 2007 and Tucker, Farrell and Farrell, 2008) and according to Feteih (George *et al*., 2007), a mouth opening measurement of less than 40mm is considered restricted. Maxmimum mouth opening is a measure of the opening distance between the incisal edges of the maxillary and mandibular central anterior teeth. This measurement is a reliable and “reproducible clinical measure and represents the gold standard for evaluating mandibular movement" according to Clark, Delcanho and Goulet (Travell, Simons and Simons, 1999). This measurement was taken during maximum comfortable opening and again during maximum mouth opening regardless of pain (Travell, Simons and Simons, 1999). The notch on the TheraBite Range of Motion Scale was placed on the mandibular dental midline. For the purpose of this study, the measurement was taken with the patient seated. The participant was asked to open their mouth as wide as was comfortably possible without causing any discomfort (Figure 3.11). The participant was then asked to open their mouth again as wide as possible regardless of pain. Both measurements were taken in millimetres. Each participant was issued their own TheraBite Range of Motion Scale, which was chosen for the purpose of this study as the expanded curve of the scale provides an accurate and reliable measurement with the added benefit of being disposable for hygiene purposes. In an unpublished conference paper by Saund, Kazi, Sayeed, Choudri, McDonagh, Pearson and Dietrich (2010) it was shown that measurements taken using the TheraBite Range of Motion Scale correlated well with those measurements taken with a steel ruler.

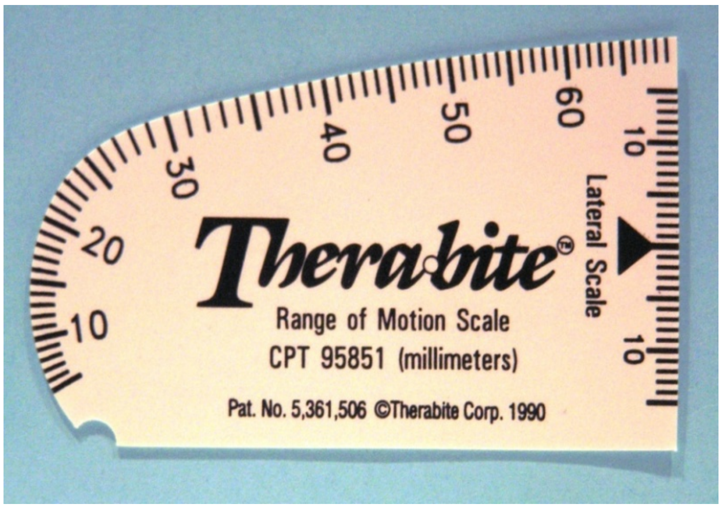


Figure 3.10: TheraBite Range of Motion Scale

Figure 3.11: TheraBite Range of Motion Scale in use

- Lateral deviation was measured using a vernier calliper, as prior to the commencement of the study, it was found to be more accurate when compared to the vertical axis of the TheraBite Range of Motion Scale. The vernier calliper is an accurate way of measuring mandibular end range of motion (Travell, Simons and Simons, 1999). The maxillary dental midline was used as the starting position of neutral and the mandibular dental midline was measured at neutral to indicate the lateral deviation of the mandible to the left or right. This was also done at maximal lateral deviation to the right and left to indicate lateral range of motion.

- Cervical range of motion (CROM) goniometer (The Performance Attained Associates Model CROM 3600 Labore Road, Suite 6, St. Paul, MN 55110-41144)was used to measure active cervical spine range of motion including flexion, extension, right and left lateral flexion and right and left rotation. The CROM has been shown to be a reliable tool, producing good to excellent intra-tester and inter-tester reliability (Youdas, Carey and Garrett, 1991). The CROM is used with the participant seated in an upright position. The frame was then placed on the participant's head in such a way that it touched the participant's ears and the bridge of their nose. The velcro straps were then fastened at the back of the participant's head. The dials, which were arranged in an orthogonal fashion, were set to zero. Active range of motion through left and right rotation, left and right lateral flexion, flexion and extension were then measured.

Subjective Data:

- The severity of the intensity of the participant's pain was quantified using the numerical pain rating scale (NRS) on a scale of 0-10 NRS. The NRS is easy to administer and score (Jensen, Karoly and Braver, 1986) and is preferable to traditional visual analogue scales (Mannion, Balague, Pellise and Cedraschi, 2007). For the NRS, a minimum difference of 2.5 was considered as a clinically significant change (Mannion *et al.,* 2007).

- The extent of the participants TMD was assessed using the TMD Disability Index Questionnaire (TMDDIQ) (Appendix H) adapted from Yeomans (2000). With the use of the TMDDIQ the researcher was able to record symptoms and note limitations with which the participant presented and from which clinically useful information was quantified (Yeomans, 2000). The Questionnaire had nine questions with five possible answers for each question. Each possible answer was rated 0 to 4 and the points of each question were then added. The maximum score possible was 36 and a reduction in the total score was regarded as an improvement in the participant's symptoms.

3.10. Statistical analysis:

SPSS version 15.0 was used for analysis of the data. A *p* value <0.05 was considered as statistically significant. Multivariate ANOVA testing was used for intra- and inter-group comparisons of all subjective and objective measures over time. Multivariate testing is where there is more than one dependant variable. This occurs for instance when you have repeated measurements of the outcome over time. Therefore multivariate testing was necessary in order to assess the changes in the outcome variables over time and to assess whether this change over time was associated with the treatment they received. Outcome variables like algometer etc are the dependant variables; they were not tested at the same time, rather at the different time points. The effect of time was controlled for by using "time" as an independent variable as well as treatment group. For intra-group analysis, the effect of the change over time was assessed for each group separately and for the inter-group comparisons, the effect of the time versus group interaction was assessed. A significant interaction indicated a significant change over time according to treatment group. Profile plots were generated to assess the direction and trend of the effect and to visually compare the trends in the different treatment groups. In order to compare the change over time, according to the side affected, univariate ANOVA tests were performed on the change in each outcome over the four time points, using treatment group and side affected as independent variables (Esterhuizen, 2010). As a result of the large quantity of readings taken, only the pertinent tables and graphs have been included in Chapter Four. The remainder of the graphs are available in Appendix L.

CHAPTER FOUR

RESULTS

4. INTRODUCTION

This chapter presents the patient demographic data. It also presents the results obtained from the statistical analysis of the collected data.

4.1. Demographic data

The researcher had difficulty in recruiting participants for various reasons: There was prolonged student unrest at DUT, the Soccer World Cup fell over the period of recruitment resulting in a 6 week holiday. Forty-five people contacted the researcher to enquire about the study. Of those, 35 met the inclusion criteria. Five of these participants dropped out of the study. The reasons were that:

- Two of the participants had transport problems and could not get to the Chiropractic Day Clinic on the required days;
- One participant went on holiday;
- One participant arrived for his follow up outside of the three week period and
- It was discovered that one participant was currently also undergoing another form of treatment for her TMD.

Participants who dropped out were replaced to ensure 30 participants completed the study. Of the 30 participants that completed the study 21 (70%) were female and 9 (30%) were male and all groups were homogenous as there was no statistically significant difference between the groups in terms of gender ($p = 0.621$). The sample consisted of 53.3% Whites ($n = 16$); 36.7% Indians ($n = 11$) and 10% Blacks ($n = 3$). The groups were comparable as there was no statistically significant difference between the groups in terms of the ethnic distribution ($p = 0.360$). The mean age of the sample was 28.9 years (sd ± 7.89 years) with an age range of 18 to 48 years. ANOVA comparison of mean age by group showed no significant differences between the groups ($p = 0.826$). Of the participants, half (50%) were symptomatic bilaterally ($n = 15$), 30% ($n = 9$) only had right sided symptoms while 20% ($n = 6$) only had symptoms on the left. However, on statistical analysis there was a similar distribution of symptomatic side in each of the treatment groups as there was also no statistically significant difference between the groups ($p = 0.844$).

4.2. Baseline measurements

Statistical analysis of the baseline readings for the objective and subjective measurements revealed that all groups were comparable and that there was no statistically significant difference between the groups for any of the readings except for CROM rotation to the left ($p = 0.025$).

4.3. Objective One

Objective One was to determine the effectiveness of TMJ manipulation combined with myofascial trigger point therapy of the TMJ musculature in the treatment of TMD. The results of the objective and subjective data of group A are as follows.

4.3.1. Algometer readings

Algometer readings were taken at the commencement of treatment sessions one, two, four and five. The readings were taken bilaterally at five sites namely: the temporalis, masseter, posterior cervical, SCM, trapezius muscles.

Multivariate tests showed no significant improvement in algometer readings over time in any of the muscle readings for this group: right and left temporalis ($p = 0.154$; $p = 0.519$); right and left masseter ($p = 0.271$; $p = 0.065$); right and left posterior cervical ($p = 0.277$; $p = 0.408$); right and left SCM ($p = 0.201$; $p = 0.563$); and the right and left trapezius muscles ($p = 0.354$; $p = 0.446$). However, it should be noted that although not statistically significant the algometer readings over the left masseter muscle did show a mild improvement as can be seen in Table 4.1 and Figure 4.1.

Table 4.1 Multivariate tests: Algometer - left masseter for the four time periods, Group A

Effect		Value	F(a)	Hypothesis df	Error df	Sig.
Time	Pillai's Trace	0.622	3.842	3	7	0.065
	Wilks' Lambda	0.378	3.842	3	7	0.065
	Hotelling's Trace	1.647	3.842	3	7	0.065
	Roy's Largest Root	1.647	3.842	3	7	0.065

a Exact statistic

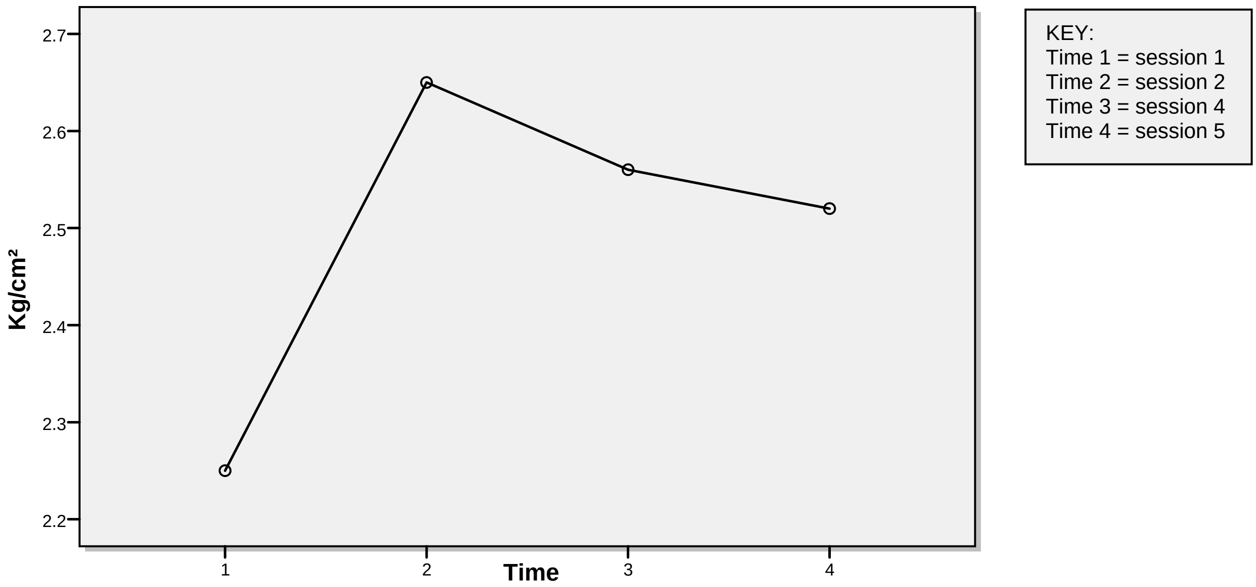


Figure 4.1 Profile plot: Algometer - left masseter for the four time periods, Group A

4.3.2. CROM readings

The CROM was used to measure active cervical spine range of motion including flexion, extension, right and left lateral flexion and right and left rotation.

Multivariate testing showed no significant improvement in the range of motion over the four time periods (i.e. treatment session one to the final follow up session) in the following directions: right and left rotation (p = 0.332; p = 0.400); left lateral flexion (p = 0.305); and flexion (p = 0.217). However, a significant improvement in range of motion over time was noted in right lateral flexion (p = 0.006) and extension (p = 0.005). As shown in Table 4.2 and Figure 4.2 the increase in right lateral flexion over the four time periods was highest at time point four (follow up session), and extension increased steadily from treatment session two to the final follow up session as illustrated in Table 4.3 and Figure 4.3.

Table 4.2 Multivariate tests: CROM - right lateral flexion for the four time periods, Group A

Effect		Value	F(a)	Hypothesis df	Error df	Sig.
Time	Pillai's Trace	0.812	10.047	3	7	0.006
	Wilks' Lambda	0.188	10.047	3	7	0.006
	Hotelling's Trace	4.306	10.047	3	7	0.006
	Roy's Largest Root	4.306	10.047	3	7	0.006

a Exact statistic

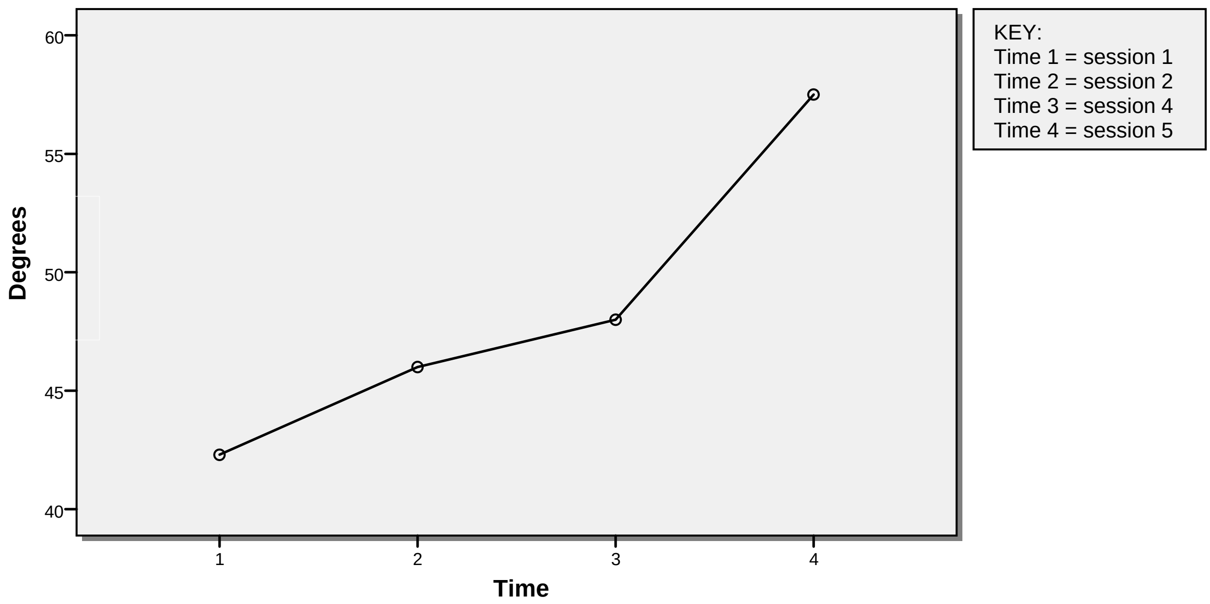


Figure 4.2 Profile plot: CROM – right lateral flexion for the four time periods, Group A

Table 4.3 Multivariate tests: CROM - extension for the four time periods, Group A

Effect		Value	F(a)	Hypothesis df	Error df	Sig.
Time	Pillai's Trace	0.820	10.658	3	7	0.005
	Wilks' Lambda	0.180	10.658	3	7	0.005
	Hotelling's Trace	4.568	10.658	3	7	0.005
	Roy's Largest Root	4.568	10.658	3	7	0.005

a Exact statistic

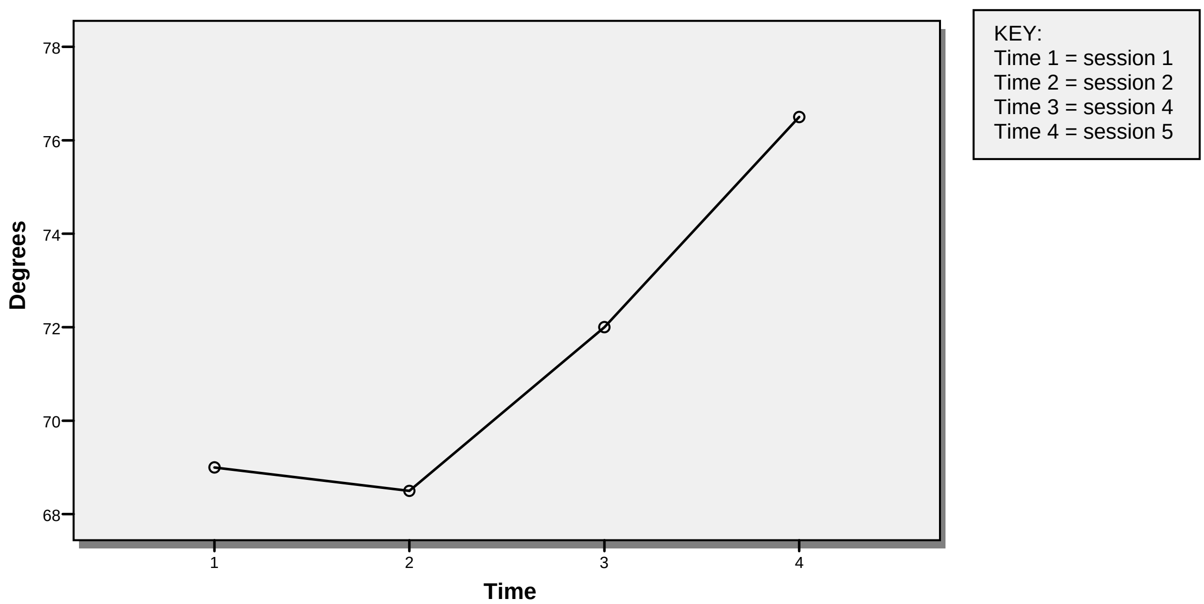


Figure 4.3 Profile plot: CROM - extension for the four time periods, Group A

4.3.3. Mouth opening readings

Although not statistically significant, Group A, showed a slight improvement over time with regards to maximum comfortable mouth opening without pain (p = 0.098) (Table 4.4 and Figure 4.4). There was, however, a statistically significant effect over time in Group A (p = 0.001) on maximum mouth opening regardless of pain. The increase was almost linear with the most improvement shown at the follow up session (Table 4.5 and Figure 4.5). Multivariate testing showed no significant change over time with regards to deviation of the jaw (p = 0.388). There was no significant change over time for active lateral deviation of the jaw to the right (p = 0.306). There was a mild improvement on active lateral deviation to the left (p = 0.062), although it was not statistically significant which can be seen in Table 4.6 and Figure 4.6.

Table 4.4 Multivariate tests: maximum mouth opening (no pain) for the four time periods, Group A

Effect		Value	F(a)	Hypothesis df	Error df	Sig.
Time	Pillai's Trace	0.572	3.115	3	7	0.098
	Wilks' Lambda	0.428	3.115	3	7	0.098
	Hotelling's Trace	1.335	3.115	3	7	0.098
	Roy's Largest Root	1.335	3.115	3	7	0.098

a Exact statistic

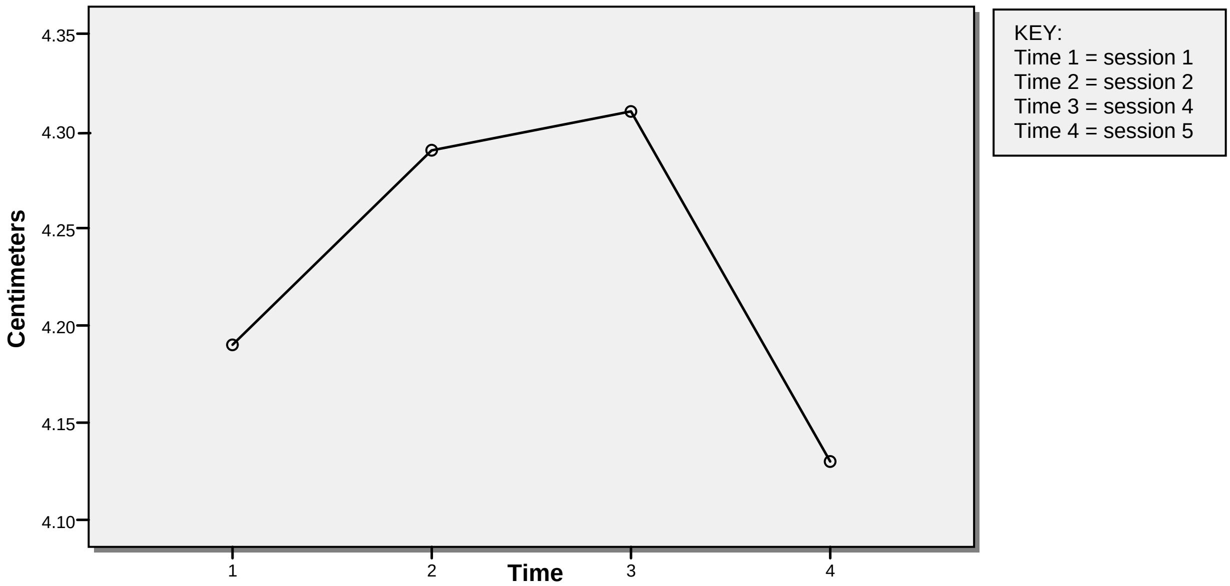


Figure 4.4 Profile plot: maximum mouth opening (no pain) for the four time periods, Group A

Table 4.5 Multivariate tests: maximum mouth opening (with pain) for the four time periods, Group A

Effect		Value	F(a)	Hypothesis df	Error df	Sig.
Time	Pillai's Trace	0.878	16.817	3	7	0.001
	Wilks' Lambda	0.122	16.817	3	7	0.001
	Hotelling's Trace	7.207	16.817	3	7	0.001
	Roy's Largest Root	7.207	16.817	3	7	0.001

a Exact statistic

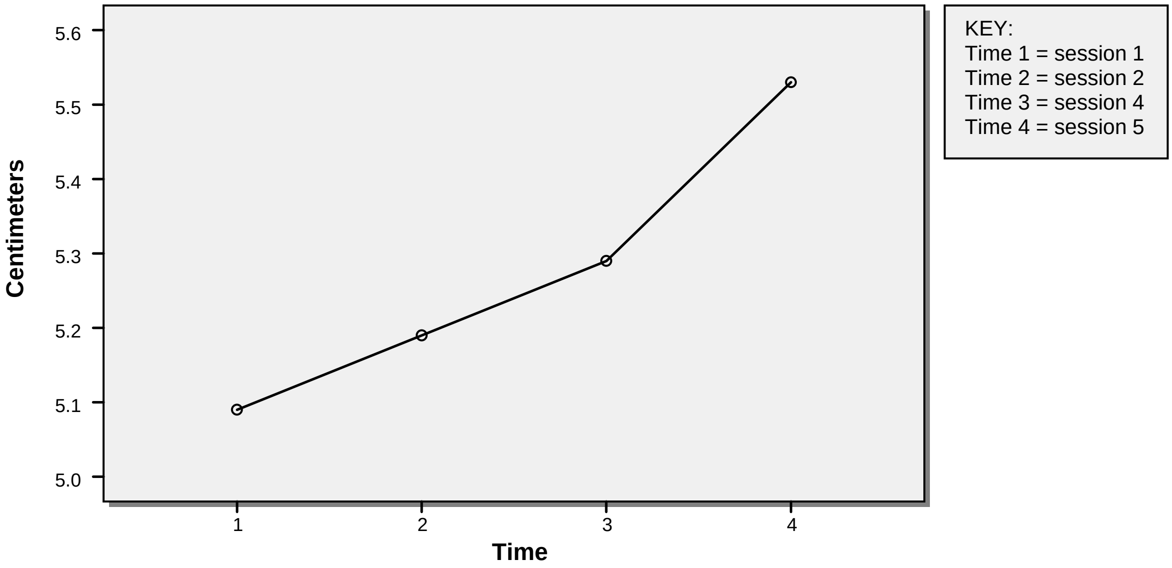


Figure 4.5 Profile plot: maximum mouth opening (with pain) for the four time periods, Group A

Table 4.6 Multivariate tests: active left lateral deviation of the jaw for the four time periods, Group A

Effect		Value	F(a)	Hypothesis df	Error df	Sig.
Time	Pillai's Trace	0.500	4.005	2	8	0.062
	Wilks' Lambda	0.500	4.005	2	8	0.062
	Hotelling's Trace	1.001	4.005	2	8	0.062
	Roy's Largest Root	1.001	4.005	2	8	0.062

a Exact statistic

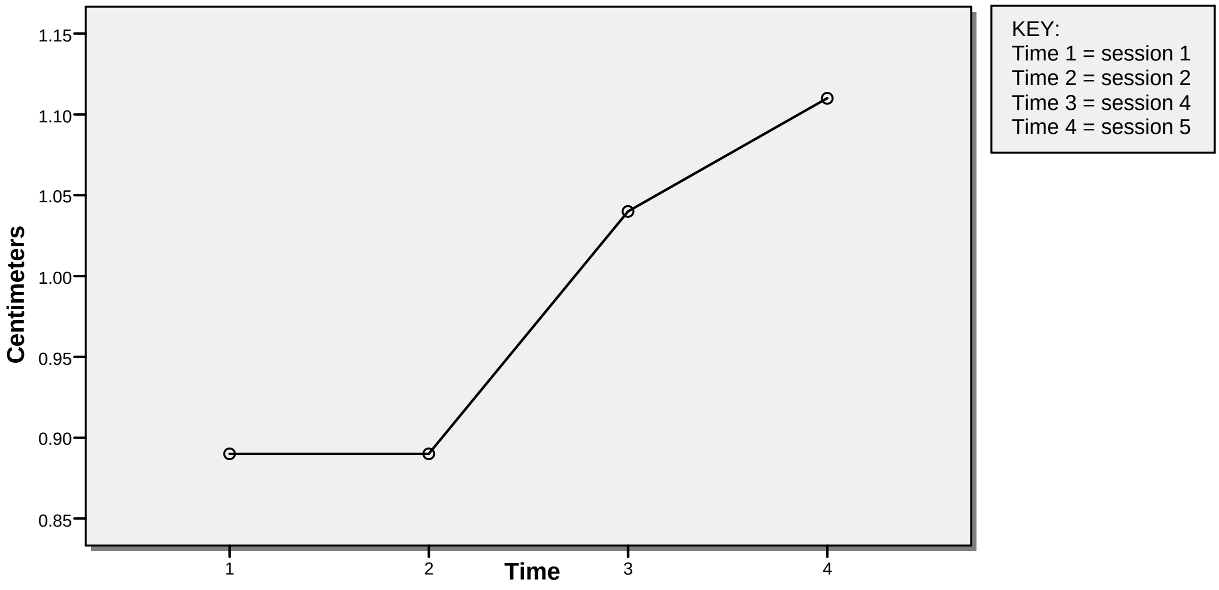


Figure 4.6 Profile plot: active left lateral deviation of the jaw for the four time periods, Group A

4.3.4. Numerical rating scale

Although not statistically significant multivariate testing showed a slight improvement over time (p = 0.063) in this group with regards to the NRS (0-10) as can be seen in Table 4.7 and Figure 4.7. This was however considered as a clinically significant improvement as the change was greater than 2.5. The average values at each time point were as follows:

Time point 1= 5.65

Time point 2= 3.90

Time point 3= 3.15

Time point 4= 2.80

Table 4.7 Multivariate tests: NRS for the four time periods, Group A

Effect		Value	F(a)	Hypothesis df	Error df	Sig.
Time	Pillai's Trace	0.626	3.908	3	7	0.063
	Wilks' Lambda	0.374	3.908	3	7	0.063
	Hotelling's Trace	1.675	3.908	3	7	0.063
	Roy's Largest Root	1.675	3.908	3	7	0.063

a Exact statistic

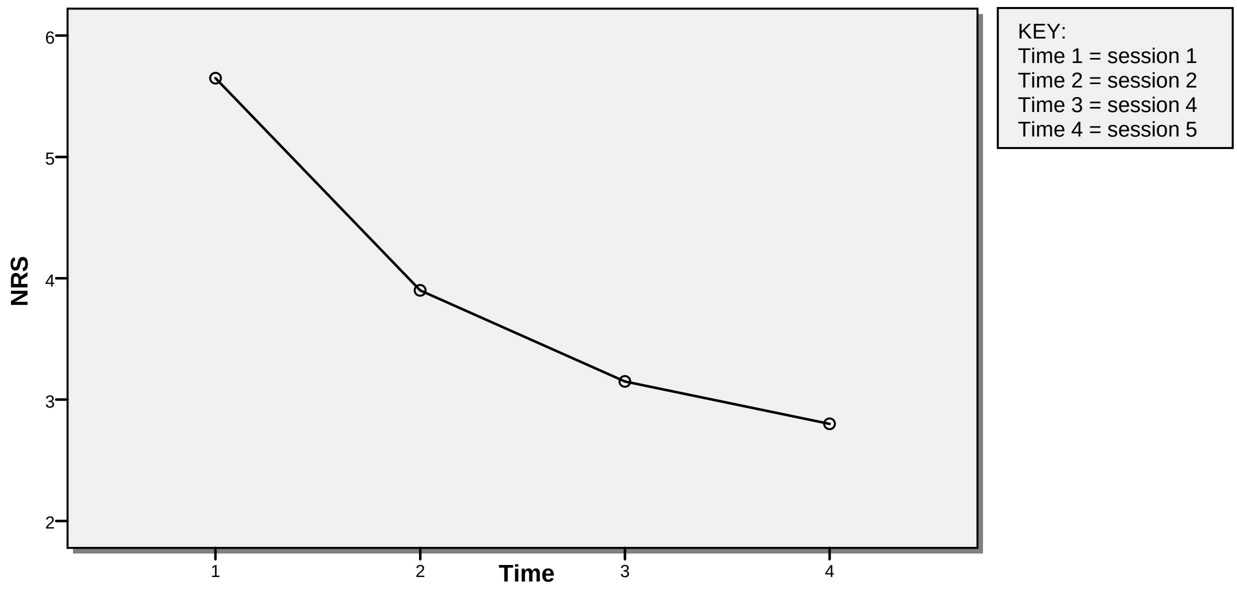


Figure 4.7 Profile plot: NRS for the four time periods, Group A

4.3.5. TMD disability index questionnaire (TMDDIQ)

Multivariate testing showed a significant improvement over time in Group A (p = 0.003). There was a decrease over time with time four (follow up session) showing the lowest score (Table 4.8 and Figure 4.8).

Table 4.8 Multivariate tests: TMDDIQ for the four time periods, Group A

Effect		Value	F(a)	Hypothesis df	Error df	Sig.
Time	Pillai's Trace	0.846	12.831	3	7	0.003
	Wilks' Lambda	0.154	12.831	3	7	0.003
	Hotelling's Trace	5.499	12.831	3	7	0.003
	Roy's Largest Root	5.499	12.831	3	7	0.003

a Exact statistic

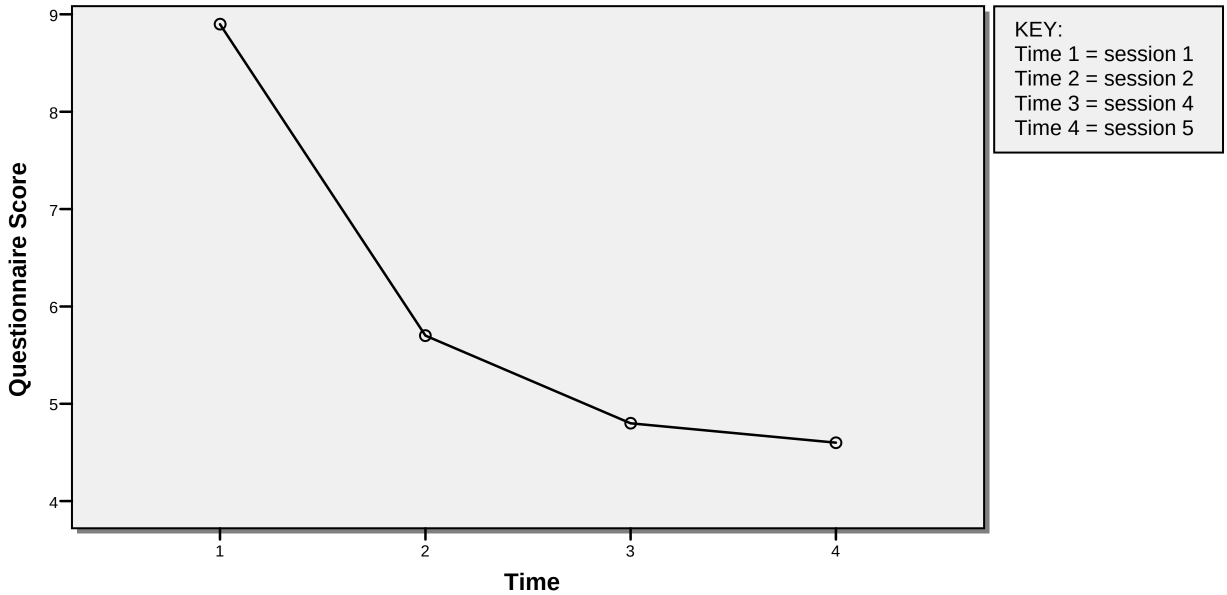


Figure 4.8 Profile plot: TMDDIQ for the four time periods, Group A

4.4. Objective Two

Objective Two was to determine the effectiveness of cervical spine manipulation combined with myofascial trigger point therapy of the cervical musculature in the treatment of TMD. The results of the objective and subjective data of Group B are as follows.

4.4.1. Algometer readings

Multivariate tests showed no statistically significant improvement in algometer readings over time in the following muscles: right temporalis (p = 0.126); right and left masseter (p = 0.846; p = 0.919); right and left posterior cervical (p = 0.399; p = 0.501); right and left SCM (p = 0.436; p = 0.532) and the right trapezius (p = 0.281). There was, however, a mild improvement in the algometer readings over the left temporalis muscle (p = 0.062) and the left trapezius muscle (p = 0.074) although these values were not statistically significant. This is depicted in Table 4.9 and Figure 4.9 and Table 4.10 and Figure 4.10 respectfully.

Table 4.9 Multivariate tests: Algometer - left temporalis for the four time periods, Group B

Effect		Value	F(a)	Hypothesis df	Error df	Sig.
Time	Pillai's Trace	0.627	3.918	3	7	0.062
	Wilks' Lambda	0.373	3.918	3	7	0.062
	Hotelling's Trace	1.679	3.918	3	7	0.062
	Roy's Largest Root	1.679	3.918	3	7	0.062

a Exact statistic

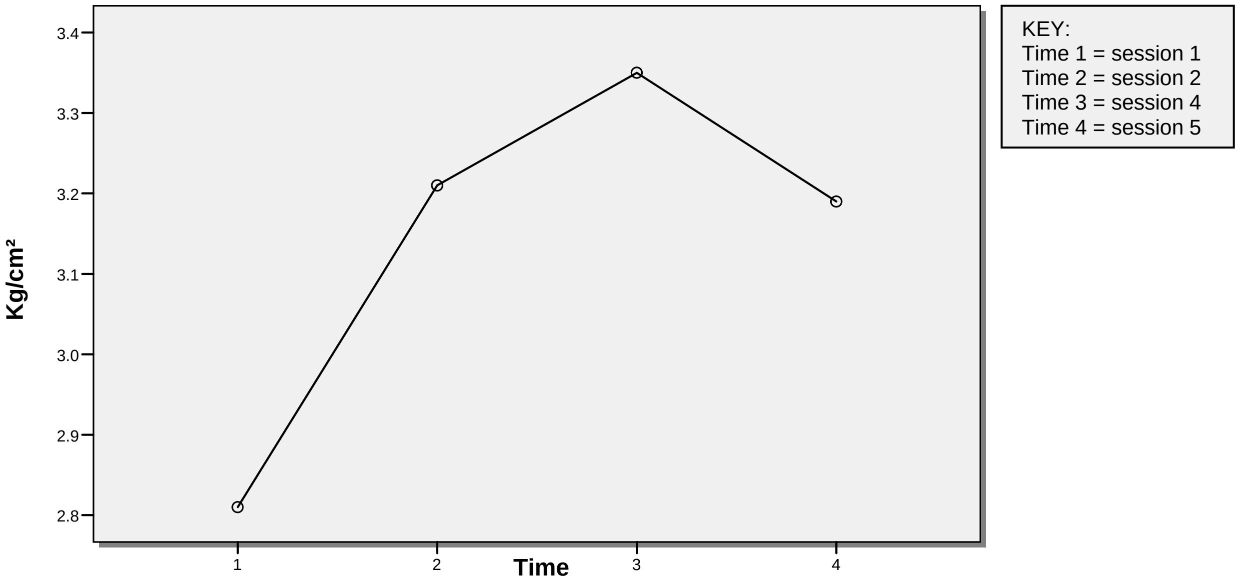


Figure 4.9 Profile plot: Algometer - left temporalis for the four time periods, Group B

Table 4.10 Multivariate tests: Algometer- left trapezius for the four time periods, Group B

Effect		Value	F(a)	Hypothesis df	Error df	Sig.
Time	Pillai's Trace	0.607	3.596	3	7	0.074
	Wilks' Lambda	0.393	3.596	3	7	0.074
	Hotelling's Trace	1.541	3.596	3	7	0.074
	Roy's Largest Root	1.541	3.596	3	7	0.074

a Exact statistic

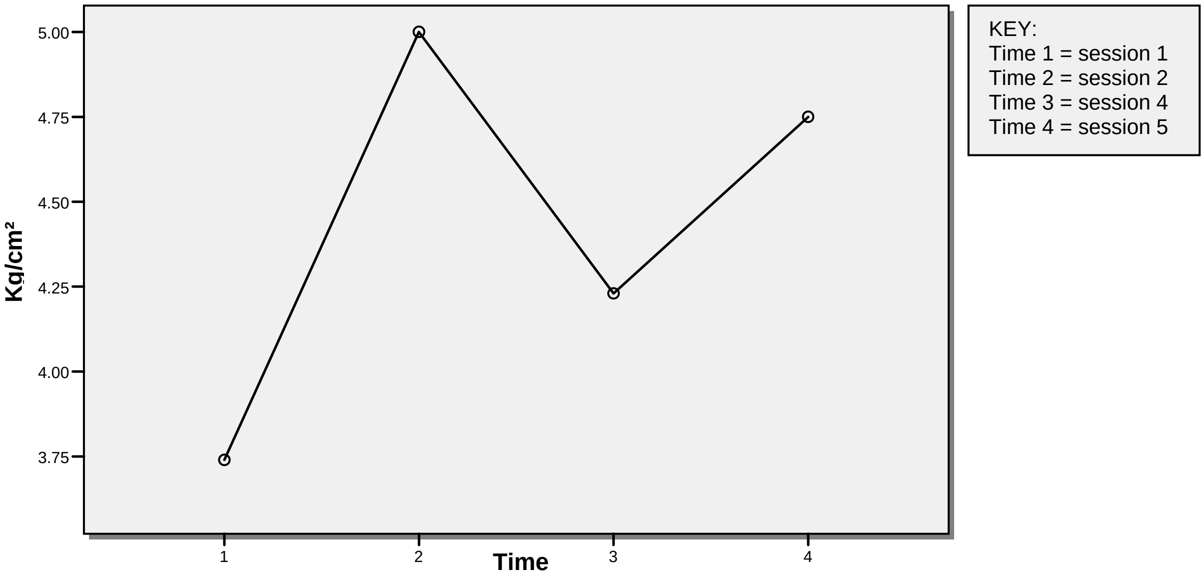


Figure 4.10 Profile plot: Algometer - left trapezius for the four time periods, Group B

4.4.2. CROM readings

Although the values were not statistically significant Multivariate testing showed a mild improvement over time in cervical rotation to the right (p = 0.069) (Table 4.11 and Figure 4.11). There was, however, no significant improvement over the four time periods for rotation to the left (p = 0.607) in group B. There was also no significant improvement to the range of motion over time on right lateral flexion (p = 0.166). Conversely there was a significant improvement in the range of motion over time on lateral flexion to the left (p = 0.034) as seen in Table 4.12 and Figure 4.12 where the values for left lateral flexion increased until reaching a peak at time four (follow up session). There was no significant improvement in the range of motion over time with regards to flexion (p = 0.148) and extension for this group (p = 0.332).

Table 4.11 Multivariate tests: CROM – right rotation for the four time periods, Group B

Effect		Value	F(a)	Hypothesis df	Error df	Sig.
Time	Pillai's Trace	0.615	3.720	3	7	0.069
	Wilks' Lambda	0.385	3.720	3	7	0.069
	Hotelling's Trace	1.594	3.720	3	7	0.069
	Roy's Largest Root	1.594	3.720	3	7	0.069

a Exact statistic

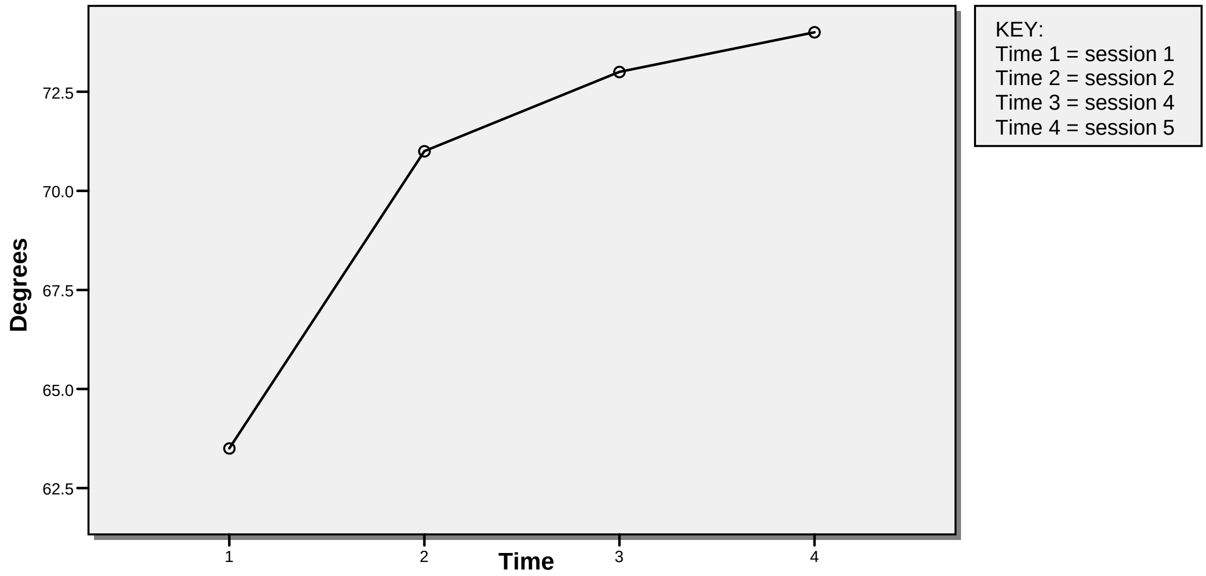


Figure 4.11 Profile plot: CROM – right rotation for the four time periods, Group B

Table 4.12 Multivariate tests: CROM - left lateral flexion for the four time periods, Group B

Effect		Value	F(a)	Hypothesis df	Error df	Sig.
Time	Pillai's Trace	0.688	5.157	3	7	0.034
	Wilks' Lambda	0.312	5.157	3	7	0.034
	Hotelling's Trace	2.210	5.157	3	7	0.034
	Roy's Largest Root	2.210	5.157	3	7	0.034

a Exact statistic

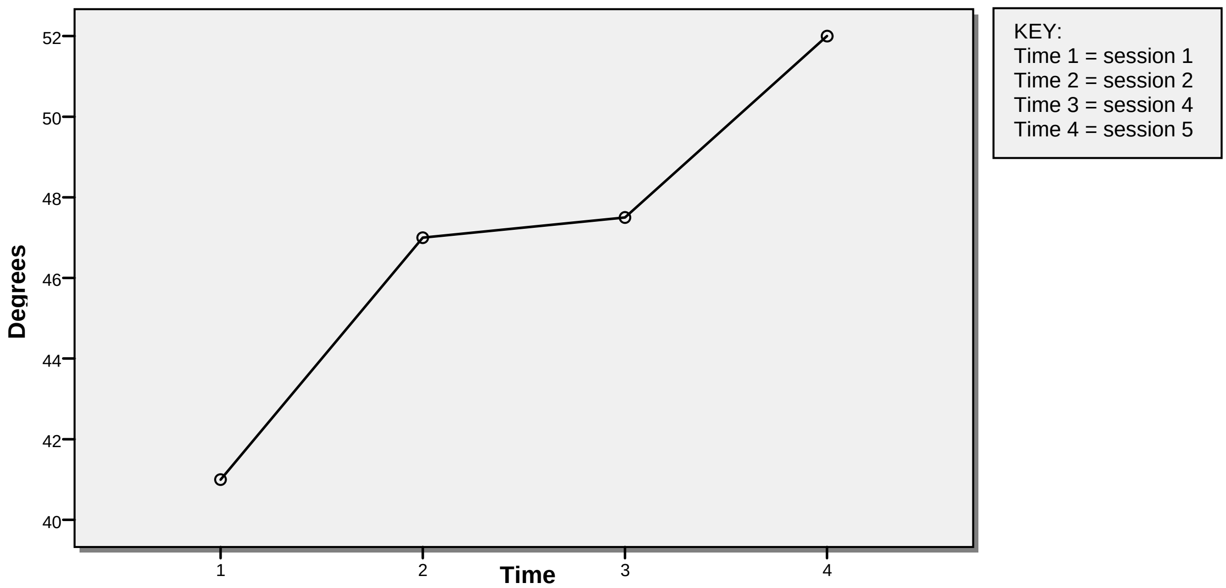


Figure 4.12 Profile plot: CROM - left lateral flexion for the four time periods, Group B

4.4.3. Mouth opening readings

Group B showed no significant improvement over time on multivariate testing with regards to maximum mouth opening without pain (p = 0.152) or on measurements for maximum mouth opening regardless of pain (p = 0.121). There was also no significant improvement over time with regards to deviation of the jaw (p = 0.410) nor was there any significant change over time for active lateral deviation of the jaw to the right (p = 0.715) or the left (p = 0.288).

4.4.4. Numerical rating scale

There was a significant improvement over the four time periods, on multivariate testing with regards to the NRS in Group B (p = 0.005). Table 4.13 and Figure 4.13 shows a decrease in the NRS value over time with the most effect being at time four (follow up session).

Table 4.13 Multivariate tests: NRS for the four time periods, Group B

Effect		Value	F(a)	Hypothesis df	Error df	Sig.
Time	Pillai's Trace	0.824	10.919	3	7	0.005
	Wilks' Lambda	0.176	10.919	3	7	0.005
	Hotelling's Trace	4.679	10.919	3	7	0.005
	Roy's Largest Root	4.679	10.919	3	7	0.005

a Exact statistic

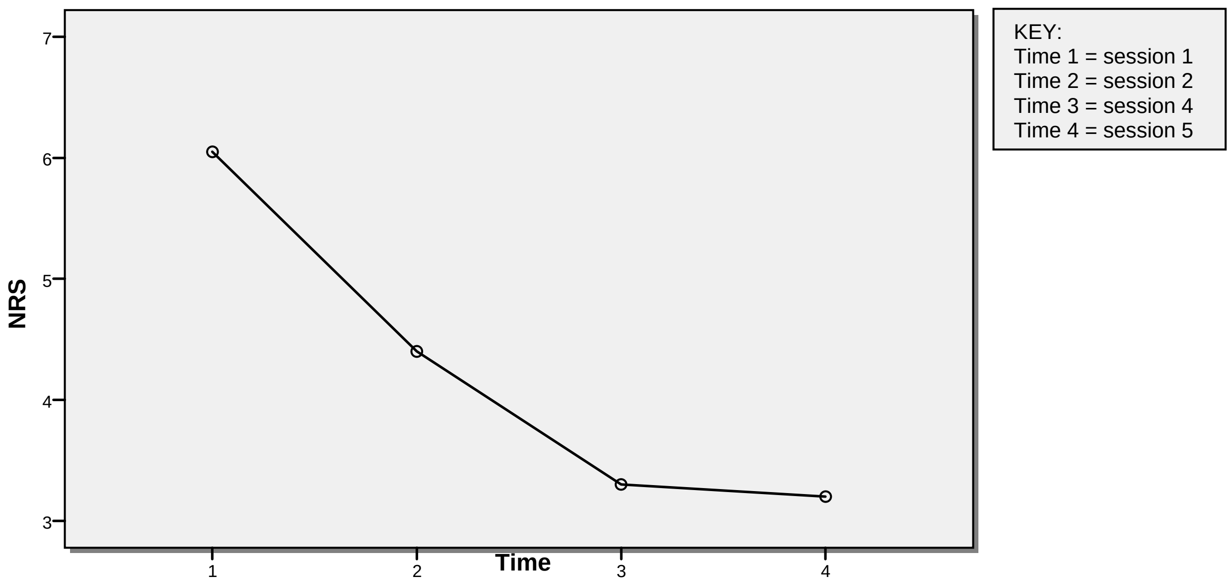


Figure 4.13 Profile plot: NRS for the four time periods, Group B

4.4.5. TMD disability index questionnaire (TMDDIQ)

Multivariate testing showed no significant improvement over the four time periods in Group B (p = 0.164).

4.5. Objective Three

Objective three was to determine the effectiveness of cervical SMT and TMJ manipulation combined with myofascial trigger point therapy of the cervical and TMJ musculature in the treatment of TMD. The results of the objective and subjective data of Group C are as follows.

4.5.1. Algometer readings

Group C had a single statistically significant improvement. Multivariate tests shown no significant improvement in the following muscles: right and left temporalis (p = 0.178; p = 0.253); left masseter (p = 0.247); right and left posterior cervical (p = 0.257; p = 0.117); right and left SCM (p = 0.355; p = 0.178) and the right trapezius muscle (p = 0.260). A mild improvement in the left trapezius muscle (p = 0.062) was noted; however, the values were not considered statistically significant (Table 4.14 and Figure 4.14). The greatest improvement, and consequently the only improvement for any of the algometer readings over the four time periods was noted in the right masseter muscle and multivariate testing showed a significant change over time to Groups C's algometer readings for this muscle (p = 0. 046). Table 4.15 and Figure 4.15 show a general increase in algometer readings until time three (session four) which was then followed by a slight decrease at time four (follow up session).

Table 4.14 Multivariate tests: Algometer - left trapezius for the four time periods, Group C

Effect		Value	F(a)	Hypothesis df	Error df	Sig.
Time	Pillai's Trace	0.628	3.936	3	7	0.062
	Wilks' Lambda	0.372	3.936	3	7	0.062
	Hotelling's Trace	1.687	3.936	3	7	0.062
	Roy's Largest Root	1.687	3.936	3	7	0.062

a Exact statistic

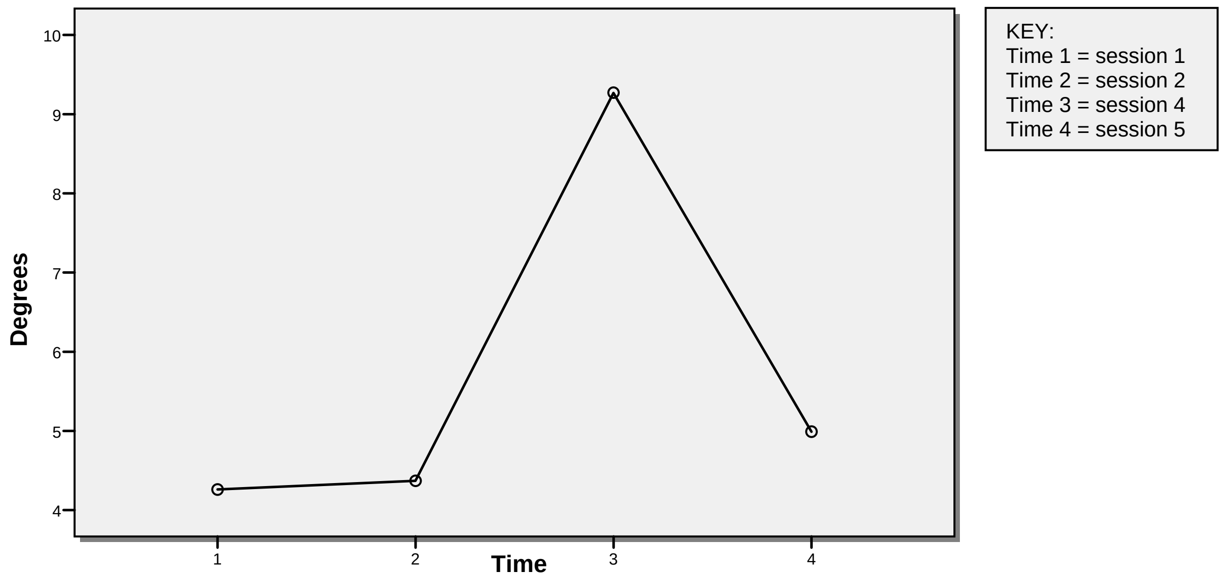


Figure 4.14 Profile plot: Algometer- left trapezius for the four time periods, Group C

Table 4.15 Multivariate tests: Algometer - right masseter for the four time periods, Group C

Effect		Value	F(a)	Hypothesis df	Error df	Sig.
Time	Pillai's Trace	0.659	4.506	3	7	0.046
	Wilks' Lambda	0.341	4.506	3	7	0.046
	Hotelling's Trace	1.931	4.506	3	7	0.046
	Roy's Largest Root	1.931	4.506	3	7	0.046

a Exact statistic

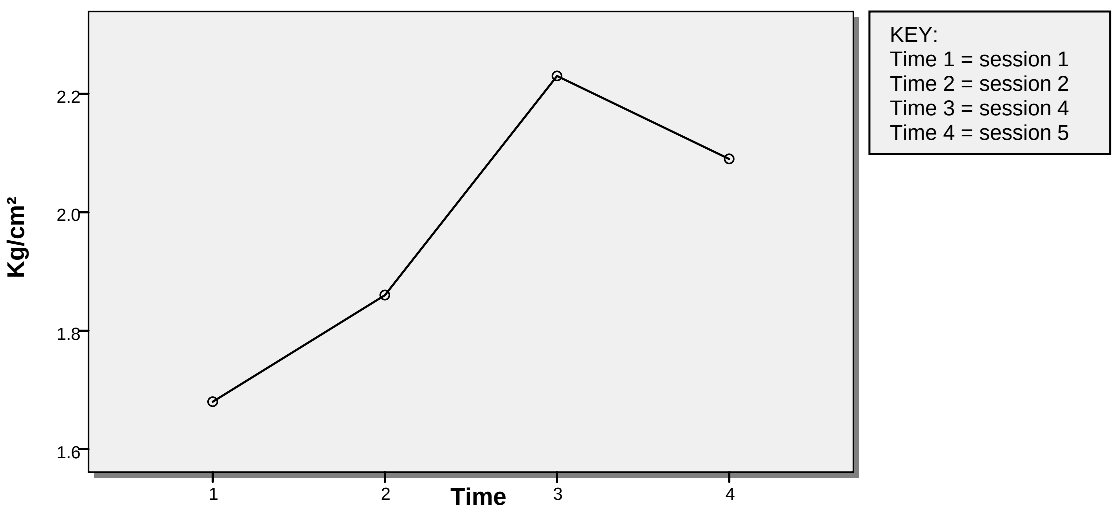


Figure 4.15 Profile plot: Algometer - right masseter for the four time periods for Group C

4.5.2. CROM readings

Multivariate testing showed a mild improvement in range of motion over time in cervical rotation to the right (p = 0.089), although these values were not statistically significant (Table 4.16 and Figure 4.16). There was, however, a significant improvement over time in this group with regards to cervical rotation to the left (p = 0.001). Table 4.17 and Figure 4.17 show an increase in the range of motion with regards to cervical rotation to the left until time three (session four) followed by a leveling off. Multivariate tests showed that on lateral flexion there was also a mildly significant improvement in range of motion over time on the right (p = 0.056) and on the left (p = 0.081). However, statistically the values were not significant (Tables 4.18 and 4.19 and Figures 4.18 and 4.19 respectively). There was no significant change over the four time periods in Group C with regards to flexion (p = 0.259) or extension (p = 0.133).

Table 4.16 Multivariate tests: CROM - right rotation for the four time periods, Group C

Effect		Value	F(a)	Hypothesis df	Error df	Sig.
Time	Pillai's Trace	0.583	3.267	3	7	0.089
	Wilks' Lambda	0.417	3.267	3	7	0.089
	Hotelling's Trace	1.400	3.267	3	7	0.089
	Roy's Largest Root	1.400	3.267	3	7	0.089

a Exact statistic

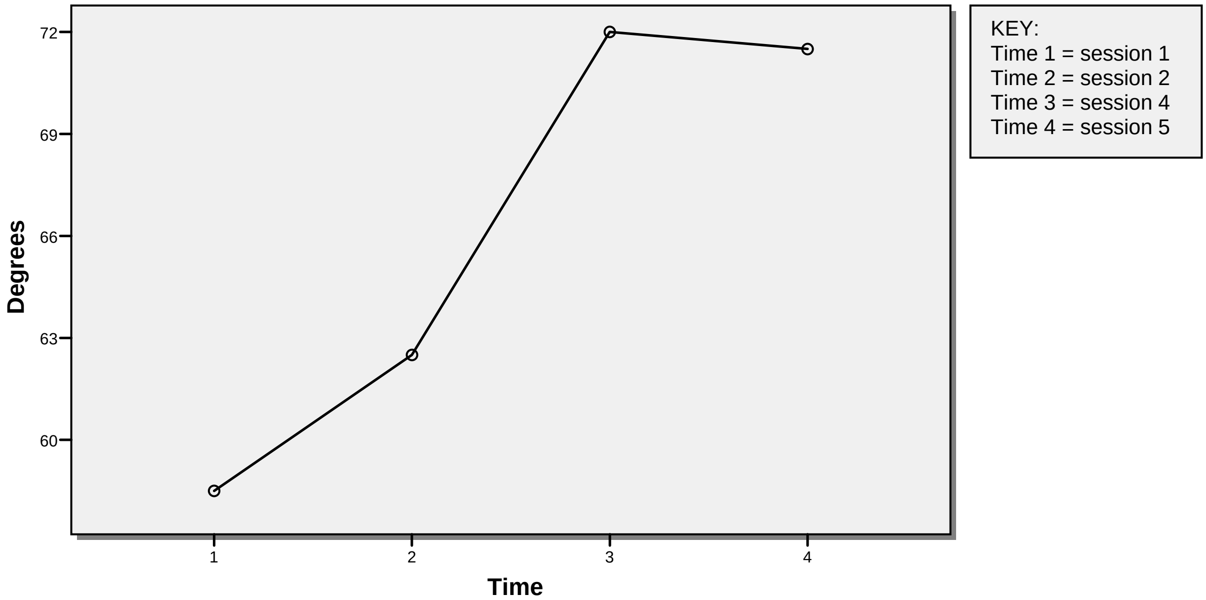


Figure 4.16 Profile plot: CROM-right rotation for the four time periods, Group C

Table 4.17 Multivariate tests: CROM - left rotation for the four time periods, Group C

Effect		Value	F(a)	Hypothesis df	Error df	Sig.
Time	Pillai's Trace	0.904	22.088	3	7	0.001
	Wilks' Lambda	0.096	22.088	3	7	0.001
	Hotelling's Trace	9.466	22.088	3	7	0.001
	Roy's Largest Root	9.466	22.088	3	7	0.001

a Exact statistic

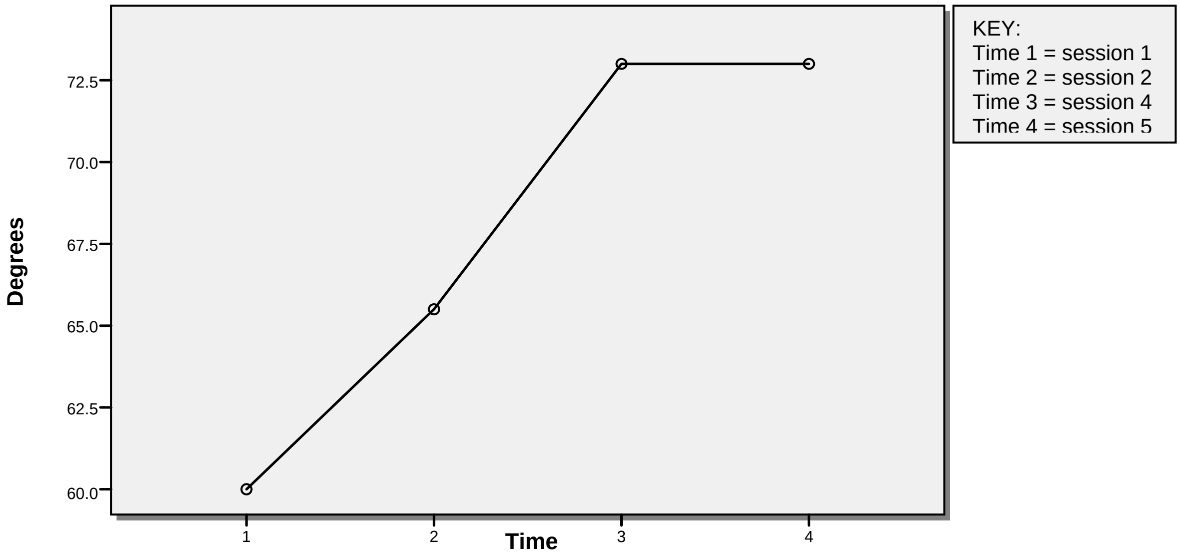


Figure 4.17 Profile plot: CROM - left rotation for the four time periods, Group C

Table 4.18 Multivariate tests: CROM - right lateral flexion for the four time periods, Group C

Effect		Value	F(a)	Hypothesis df	Error df	Sig.
Time	Pillai's Trace	0.638	4.107	3	7	0.056
	Wilks' Lambda	0.362	4.107	3	7	0.056
	Hotelling's Trace	1.760	4.107	3	7	0.056
	Roy's Largest Root	1.760	4.107	3	7	0.056

a Exact statistic

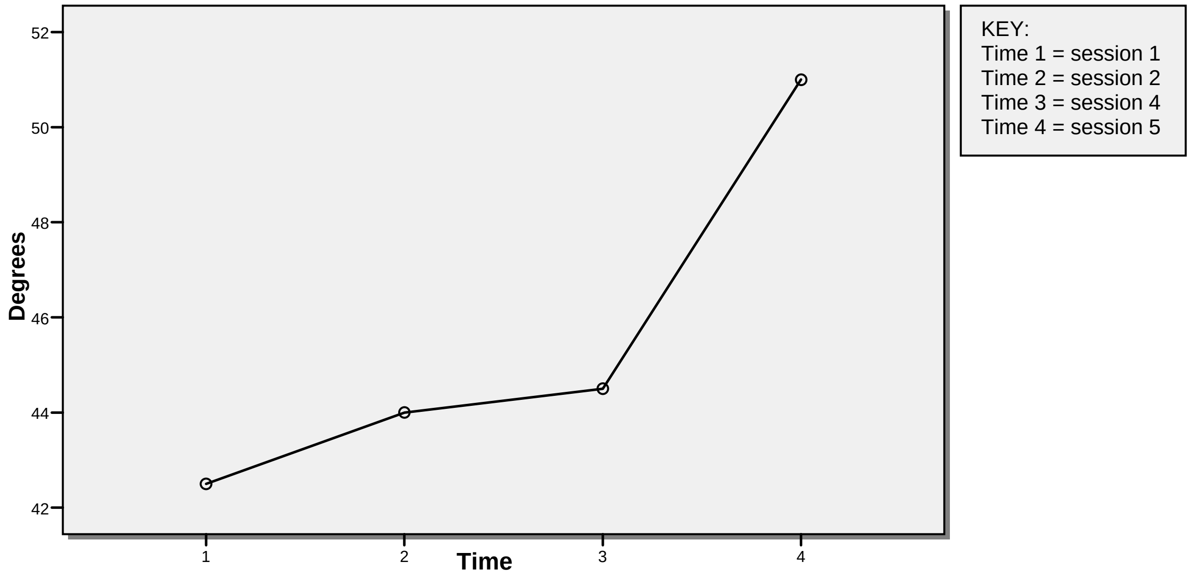


Figure 4.18 Profile plot: CROM - right lateral flexion for the four time periods, Group C

Table 4.19 Multivariate tests: CROM- left lateral flexion for the four time periods, Group C

Effect		Value	F(a)	Hypothesis df	Error df	Sig.
Time	Pillai's Trace	0.596	3.441	3	7	0.081
	Wilks' Lambda	0.404	3.441	3	7	0.081
	Hotelling's Trace	1.475	3.441	3	7	0.081
	Roy's Largest Root	1.475	3.441	3	7	0.081

a Exact statistic

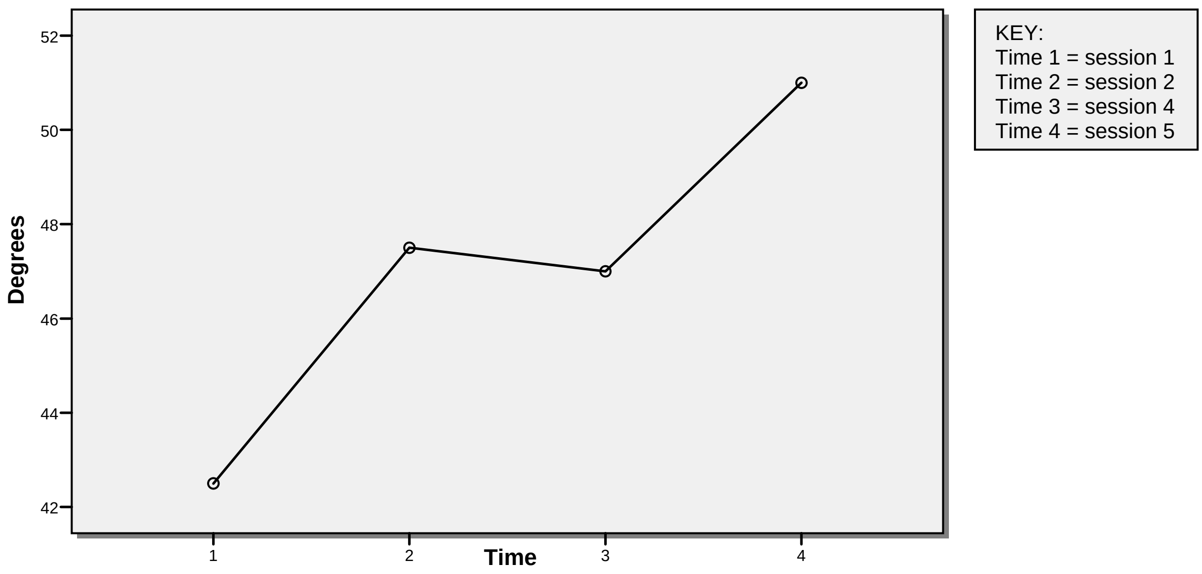


Figure 4.19 Profile plot: CROM - left lateral flexion for the four time periods, Group C

4.5.3. Mouth opening readings

Group C showed no significant improvement on multivariate testing over the four time periods with regards to maximum mouth opening without pain (p = 0.123). However, there was a significant improvement over time with regards to measurements for maximum mouth opening regardless of pain (p = 0.039). The mean increased until time three (visit four) where after there was a slight decrease as seen in Table 4.20 and Figure 4.20. Multivariate testing showed no significant change over time with regards to deviation of the jaw (p = 0.410), nor was there a significant change over time for active lateral deviation of the jaw to the right (p = 0.545) or the left (p = 0.164).

Table 4.20 Multivariate tests: maximum mouth opening (with pain) for the four time periods, Group C

Effect		Value	F(a)	Hypothesis df	Error df	Sig.
Time	Pillai's Trace	0.677	4.880	3	7	0.039
	Wilks' Lambda	0.323	4.880	3	7	0.039
	Hotelling's Trace	2.092	4.880	3	7	0.039
	Roy's Largest Root	2.092	4.880	3	7	0.039

a Exact statistic

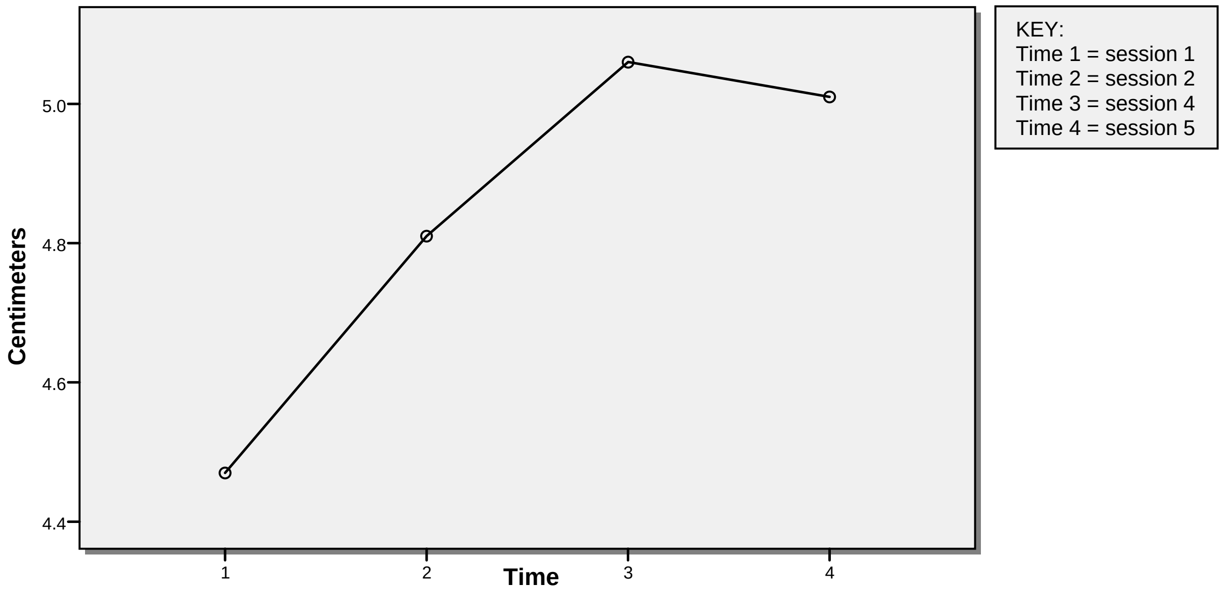


Figure 4.20 Profile plot: maximum mouth opening (with pain) for the four time periods, Group C

4.5.4. Numerical rating scale

Multivariate testing showed that there was a significant improvement over time with respect to the NRS readings for Group C (p = 0.035). Table 4.21 and Figure 4.21 show a decrease in the NRS values over time with time four (follow up session) showing the lowest pain score.

Table 4.21 Multivariate tests: NRS for the four time periods, Group C

Effect		Value	F(a)	Hypothesis df	Error df	Sig.
Time	Pillai's Trace	0.687	5.110	3	7	0.035
	Wilks' Lambda	0.313	5.110	3	7	0.035
	Hotelling's Trace	2.190	5.110	3	7	0.035
	Roy's Largest Root	2.190	5.110	3	7	0.032

a Exact statistic

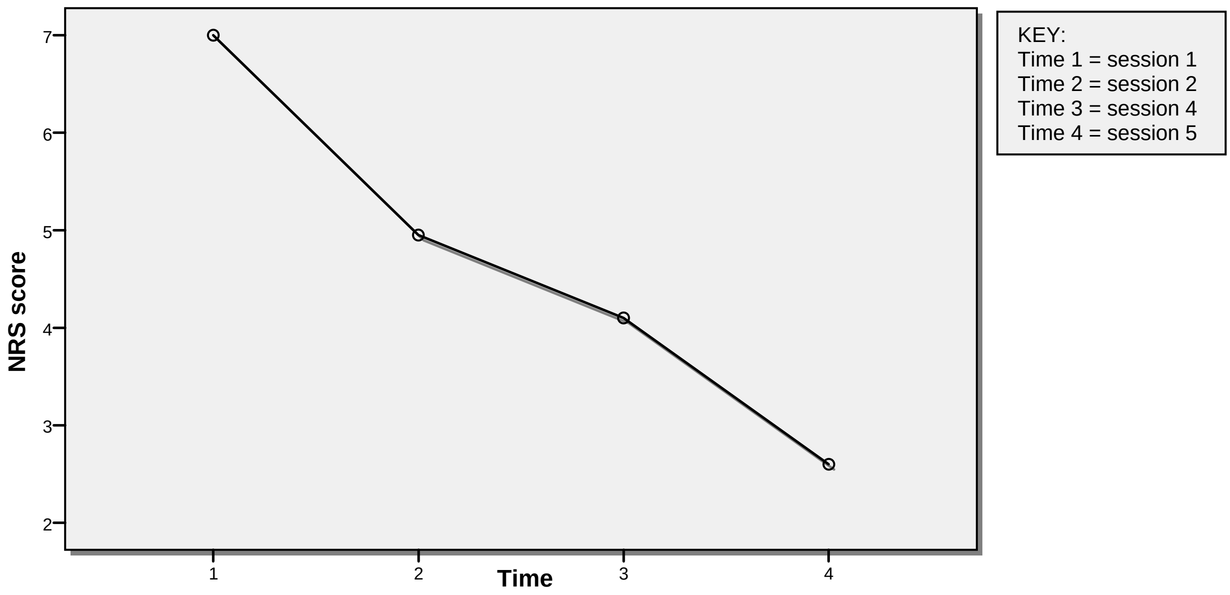


Figure 4.21 Profile plot: NRS for the four time periods, Group C

4.5.5. TMD disability index questionnaire (TMDDIQ)

Multivariate testing showed a significant improvement over time with regards to the TMDDIQ (p = 0.027). Table 4.22 and Figure 4.22 show that there was a decrease in the total score over the four time periods with time four (follow up session) showing the lowest score and hence the greatest improvement.

Table 4.22 Multivariate tests: TMDDIQ for the four time periods, Group C

Effect		Value	F(a)	Hypothesis df	Error df	Sig.
Time	Pillai's Trace	0.710	5.715	3	7	0.027
	Wilks' Lambda	0.290	5.715	3	7	0.027
	Hotelling's Trace	2.449	5.715	3	7	0.027
	Roy's Largest Root	2.449	5.715	3	7	0.027

a Exact statistic

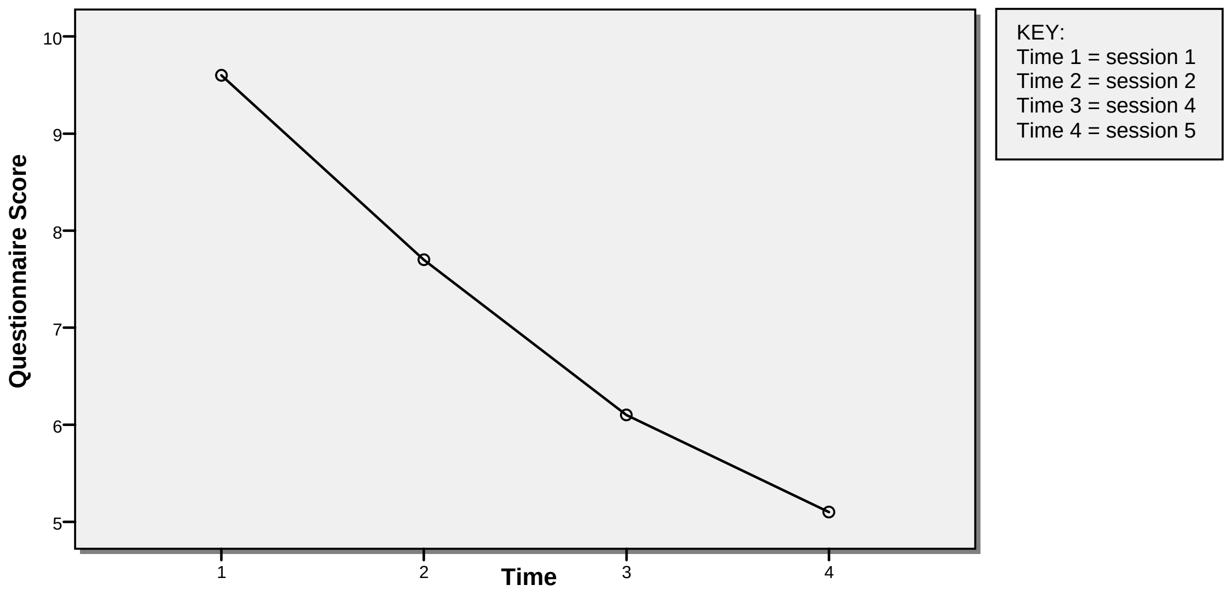


Figure 4.22 Profile plot: TMDDIQ for the four time periods, Group C

4.6. Objective Four: Inter-group analysis

4.6.1. Algometer readings

On multivariate testing, the inter-group analysis of algometer readings showed no significant difference in the rate of change over time with regards to the algometer readings between the three treatment groups for any of the muscles concerned except for the left trapezius muscle, although this was not statistically significant. Right and left temporalis ($p = 0.534$; $p = 0.783$); right and left masseter ($p = 0.327$; $p = 0.655$); right and left posterior cervical ($p = 0.322$; $p = 0.871$); right and left SCM ($p = 0.827$; $p = 0.858$) and the right and left trapezius ($p = 0.625$; $p = 0.053$).

4.6.2. CROM readings

On inter-group analysis, multivariate testing showed no significant difference in the rate of improvement over time for cervical range of motion between Group A, B or C. Rotation to the right and left ($p = 0.595$; $p = 0.404$); lateral flexion to the right and left ($p = 0.615$; $p = 0.892$); flexion ($p = 0.871$); and extension ($p = 0.319$).

4.6.3. Mouth opening readings

On maximum comfortable mouth opening and on maximum mouth opening regardless of pain, multivariate testing showed that there was no difference in rate of change over time between the three groups (p = 0.232 and p = 0.094 respectively). There was also no difference between the groups with regards to rate of change over time for deviation of the jaw (p = 0.297). Nor was there a difference in rate of change over time for active lateral deviation of the jaw to the right (p = 0.415) or the left (p = 0.374).

4.6.4. Numerical rating scale

There was no difference in the rate of improvement over time between the three treatment groups (p = 0.657).

4.6.5. TMD disability index questionnaire (TMDDIQ)

For the TMDDIQ there was no difference in the rate of improvement over the four time periods between the three treatment groups (p = 0.241) on multivariate testing.

4.7. Comparison of improvement by symptomatic side

Table 4.23 shows the mean improvement in each outcome over the four time points by group and by side affected. After controlling for treatment group, there were significant differences between the improvements in the Algometer readings over the posterior cervical muscle on the left (p = 0.006) and there was also a difference between the improvement in the NRS scores by side affected (p = 0.011). Post hoc analysis revealed that the difference lay between the left and bilateral sides in the case of the Algometer reading over left posterior cervical muscle, and between the left and right sides for the NRS scores. No other significant changes were noted.

Table 4.23 Comparison of improvement by symptomatic side.

	group									P value for comparison of symptomatic sides while adjusting for group
	A			B			C			
	Right	Left	Bilateral	Right	Left	Bilateral	Right	Left	Bilateral	
Change in Algometer Temp R	1.70	-1.70	-.10	.43	.73	.80	.17	-.75	.84	0.359
Change in Algometer Temp L	.90	-.80	.53	.10	.10	.80	.10	-.10	1.34	0.075
Change in Algometer Mass R	.93	-.50	.38	-.13	.43	-.30	.53	-.50	.70	0.510
Change in Algometer Mass L	.40	-.30	.30	.17	.17	-.33	.33	-.10	.90	0.689
Change in Algometer PC R	.80	.20	-.72	.47	.53	.65	-.13	-.20	1.04	0.921
Change in Algometer PC L	.77	-1.80	.57	-.03	.37	.78	-.23	-.30	1.72	**0.006**
Change in Algometer SCM R	.27	-.20	.70	-.17	.73	.40	.20	-.10	.90	0.203
Change in Algometer SCM L	.43	-.80	.43	-.27	.30	.53	-.07	.75	1.00	0.072
Change in Algometer Trap R	1.13	-.40	1.50	1.57	1.13	-.15	1.60	-.55	1.34	0.371
Change in Algometer Trap L	1.27	.20	.57	1.63	.90	.63	-.27	-.75	1.92	0.358
Change in CROM Rot R	1.67	30.00	7.50	3.33	10.00	16.25	16.67	10.00	12.00	0.471
Change in CROM Rot L	-5.67	15.00	6.67	7.67	-6.67	5.00	13.33	10.00	14.00	0.691
Change in CROM LF R	14.00	.00	18.33	6.67	8.33	16.25	10.00	.00	11.00	0.150
Change in CROM LF L	.67	10.00	6.67	5.00	13.33	13.75	10.00	5.00	9.00	0.540
Change in CROM Flexion	8.00	.00	14.17	2.67	8.33	17.50	13.33	-5.00	6.00	0.240
Change in CROM Extension	15.00	10.00	3.33	6.67	3.33	.00	-3.33	10.00	9.00	0.723
Change in mouth max no pain	.20	.30	-.25	.60	.53	.28	.30	.15	.80	0.970
Change in mouth max pain	.60	.40	.37	-.10	.60	.13	.13	1.05	.58	0.382

Table 4.23 Comparison of improvement by symptomatic side continued.

Change in Deviation	-.17	.00	-.02	.27	.00	.00	.00	.00	-.12	0.540
Change in lateral deviation R	.27	.00	.12	.10	.20	-.10	.20	-.10	.14	0.508
Change in lateral deviation L	.47	.00	.13	.17	.03	.03	.27	.25	.22	0.352
Change in NRS	-4.67	.00	-2.42	-4.50	-2.83	-1.63	-5.83	-.50	-5.10	**0.011**
Change in TMDDIQ	-3.33	-2.00	-5.17	-4.67	-1.67	-2.25	-5.67	-1.00	-5.20	0.323

KEY:	**Temp**	**= temporalis muscle**	**Mass**	**= masseter muscle**
	PC	**= posterior cervical muscle**	**SCM**	**= sternocleidomastoid muscle**
	Trap	**= trapezius muscle**	**Rot**	**= rotation**
	LF	**= lateral flexion**	**R**	**= right**
	L	**= left**		

4.8. Summary and conclusion

While significant improvement was found in some groups over time e.g. Group A and C's TMDDIQ scores (Table 4.24), the results in all the groups showed trends towards improvements, but statistical power was not sufficient to demonstrate this conclusively, nor to allow conclusive comparisons of the treatment effects between the groups. Inter-group comparisons did not reveal any significantly differential effects of the treatment groups and all appeared to perform approximately equally well when examining the profile plots. When comparing the results of the data by side and group, no significant changes were noted except for the algometer readings over the left posterior cervical muscle which showed the most improvement in those participants that were symptomatic bilaterally regardless of treatment group. The NRS score with the greatest improvement was seen in those participants who were symptomatic on the right. However, these were the only significant changes noted when comparing improvement by side affected.

Table 4.24 Summary of results.

Algometer		Group A	Group B	Group C
	Tempoalis right			
	Temporalis left		√	
	Masseter right			√
	Masseter left	√		
	Posterior cervical right			
	Posterior cervical left			
	SCM right			
	SCM left			
	Trapezius right			
	Trapezius left		√	√
CROM	Right rotation		√	√
	Left rotation			√
	Right lateral flexion	√		√
	Left lateral flexion		√	√
	Flexion			
	Extension	√		
Jaw ROM	Maximum mouth opening (no pain)	√		
	Maximum mouth opening regardless of pain	√		√
	Deviation			
	Active right lateral deviation			
	Active left lateral deviation	√		
NRS		√*	√*	√*
TMDDIQ		√		√

Key: = mild improvement, not statistically significant *** = clinically significant change**

= statistically significant improvement

CHAPTER FIVE

DISCUSSION AND CONCLUSIONS

5. INTRODUCTION

This chapter discusses the results of the demographic data as well as the results obtained from the statistical analysis of this study. The discussion of the data will follow Objective One to Four and will also include conclusions of this study as they arose out of the methodology and statistical analysis of the results.

5.1. Demographics

5.1.1. Gender

There was a greater number of female (*n* = 21; 70%) versus male (*n* = 9; 30%) participants in this study. This is in keeping with the literature which suggest that that the incidence of TMD is higher in the female population (Jagger, Bates and Kopp, 1994), with a ratio of 3:1 (McNeil, 1993) and that females seek care for their condition more often than men, also at a ratio of 3:1 (DeVocht, Long, Zeitler and Schaeffer, 2003).

5.1.2. Ethniticity

There appears to be no difference culturally or ethnically in the occurrence of TMD (LeResche, 1997; Esposito, Panucci and Farman 2000 and Parnes, Sinert and Heffer, 2006). More than half of the participants in this study were of White ethnic origin (53.3%, *n* = 16) while 36.7% (*n* = 11) was represented by Indians and only 10% (*n* = 3) of participants were Black. This demographic profile does not reflect the ethnic distribution of Kwa-Zulu Natal where the Black population is in the majority (http://www.statssa.gov.za/census2001/digi_Atlas/index.html, 2011). This greater percentage of Whites could possibly be because the researcher is White and therefore more likely to recruit from the same ethnic group. Another reason as suggested by (Rattan, 2007) could be that chiropractic as a profession is less well known in the Black population of Kwa-Zulu Natal when compared to the White or Indian population groups. However, there was no significant difference between the groups with regards to ethnic distribution.

5.1.3. Age

The study targeted an age range of 18 to 50 years and the actual age range for the study was 18 to 48 years. Studies by de Wijer, de Leeuw, Steenks and Bosman (1996) and Ciangaglini, Testa and Radaelli (1999) found TMD to predominate in females in their mid thirties and Hertling and Kessler (2006) found it most prevalent in the 20 – 40 age group. Eighteen of the participants in this study were within the 20-40 age range and three were below 20 years of age. The mean age of the sample was 28.9 years and the younger population group represented in this study is supported, in part, by the fact that the study was conducted at a university. There was no statistically significant difference when comparing the age of participants across the three groups (p = 0.826), indicating the homogeneity of the sample.

5.1.4. Side affected.

Fifty percent (n = 15) of the participants were symptomatic on the right, thirty percent (n = 9) were symptomatic on the left and only 20% (n = 6) were symptomatic bilaterally. When controlling for group, comparisons of subjective and objective measures by side revealed that there was no statistically significant difference (Table 4.23). Post hoc analysis revealed that on algometer readings over the left posterior cervical muscle those participants who were affected bilaterally improved to a greater extent, regardless of treatment group, when compared to those participants who were symptomatic on the left (p = 0.006). There was also a difference in NRS score between those affected on the left and right sides (p = 0.011) with those participants who presented with right sided TMD exhibiting the greatest decrease in pain, regardless of the treatment group. However, the above two results were the only significant changes noted when comparing improvement by side affected. Nykoliation and Cassidy (1984) believe that TMD pain is most often unilateral but no literature comparisons were available that documented the most common side affected in TMD or how the side affected influenced the treatment outcomes.

5.2. Discussion

5.2.1. Objective One

The first objective was to investigate the effectiveness of TMJ manipulation and myofascial trigger point therapy of the TMJ musculature in the treatment of TMD. Group A received only treatment to the TMJ and muscles of mastication.

Algometer and NRS readings both measure a participant's pain; one is an objective measure, the other subjective. There was no significant ($p < 0.05$) improvement in any of the algometer readings for this group. This result is unexpected as a study (Maixner, Fillingim, Sigurdsson, Kincaid and Silva, 1998) showed that patients with TMD have lower pain thresholds in the masticatory muscles and it is assumed that by treating the muscles of mastication, as was done in Group A, the participants' pain threshold over the masticatory muscles would increase. NRS scores decreased over the four time periods and there was a clinically significant improvement with an overall difference between the NRS score at the first visit and the NRS score at the final follow up visit being greater than 2.5, but this was not a statistically significant decrease (Table and Figure 4.7). In a study by Alcantara, Plaugher, Klemp and Salem (2002), it was found that in treating the myalgia and tension component of TMD, articular damage to the TMJ became more evident. This may hold true for the current study, as the limitation highlighted in Chapter One, may explain the lack of statistical significance.

Cervical spine range of motion only improved significantly on right lateral flexion (p = 0.006) and extension (p = 0.005). None of the other directions improved significantly. The former two improvements could be due to the proposed biomechanical link between the TMJ and the cervical spine (Higbie, Seidel-Cobb, Taylor and Cummings 1999; and Visscher, Huddleston Slater, Lobbezoo and Naetje, 2000). Hagberg (1987) reported that changes in the position of the mandible affected the isometric strength of the head and neck flexors. It is interesting to note that Eriksson, Haggman-Henrikson, Nordh and Zafar (2000) proposed that any restriction in the upper cervical spine, especially extension at the craniocervical junction, may cause a decreased mouth opening capacity. Maximum mouth opening regardless of pain increased significantly (p = 0.001) and although both comfortable mouth opening (p = 0.098) and active deviation of the jaw to the left (p = 0.062) improved, it was below the level of significance. Many other studies have shown significant success when treating the muscular component of TMD (Gray, Quayle, Hall and Schofeild, 1994; Saighafi and Curl, 1995; Crider and Glaros, 1999 and Michelotti, Parisini and Farella, 2002) and the small sample size of the current study may have resulted in a type two error, in terms of the improvement noted in the madibular range of motion.

TMDDIQ scores revealed a significant (p = 0.003) decrease in the participants' perceived level of disability over time. However, both this improvement and the mildly significant improvement in the NRS scores could be due, in part, to the natural history of TMD which has been shown clinically to resolve over time without treatment (Alcantara *et al*., 2002).

5.2.2. Objective Two

The second objective was to investigate the effectiveness of cervical spine manipulation and myofascial trigger point therapy of the cervical musculature in the treatment of TMD. The participants in this group did not receive any treatment to the TMJ or the muscles of mastication.

The plausibility that with manipulative treatment of cervical spine subluxations there will be an amelioration of TMD is based on the fact that sensory innervations to the face and oral structures as well as motor innervations to the muscles of mastication are supplied by the trigeminal nerve (McNeil, 1993). Furthermore, the Trigeminal nerve sensory fibres extend to synapses in the trigeminal spinal nucleus of the brain stem which itself extends caudally into the region where cervical nerves one through three enter the central nervous system (McNeil, 1993). This convergence of cervical and trigeminal nerves provides an anatomic and physiological explanation for the source of referred pain from the cervical region to the trigeminal region (Giunta and Kronman, 1985) and, as Alcantara *et al*., (2002) points out, the presence of cervical spine subluxations may possibly produce aberrant sensory impulses to the peripheral and central neuromuscular mechanisms, resulting in a pathological tonic neck reflex which in turn alters the posture of the head and neck. Head and neck positioning affecting the kinematics of the TMJ is well documented (Higbie *et al*., 1999; Visscher *et al*., 2000).

Statistical analysis of the pain measurements revealed that there was no significant improvement in any of the algometer readings, however there was a statistically and clinically significant improvement in the NRS (p = 0.005) scores for this group. This is noteworthy as the TMJ area was not treated in this group and the NRS scores in Group A where treatment was aimed at the TMJ and its musculature only showed a clinically and not a statistically significant decrease. Despite Group B receiving cervical spine manipulation, there was only a statistically significant improvement to the cervical range of motion in left lateral flexion ($p = 0.034$). There was no increase in either of the mouth opening measurements and if Eriksson *et al's*., (2000) theory holds true, the lack of improvement in mouth opening in this group could be linked to the fact that there was no significant improvement in extension of the cervical spine. Although in this study, extension subluxations were uncommon and thus very few participants were treated with an extension cervical manipulation, George, Fennema, Maddox, Nessler and Skaggs (2007) had similar findings in their study of 101 asymptomatic participants and concluded that manual therapy to the cervical spine did not significantly improve the mouth opening capacity in this population. Moreover, Group B (as well as Group A and C) showed no improvement when evaluating deviation of the jaw which could be explained by the fact that on clinical evaluation at the commencement of the study few participants presented with an abnormal deviation of the mandible. Maximal active lateral deviation of the jaw to the right or the left also showed no significant improvement.

No improvement was noted in the participants perceived level of disability in this group, unlike the participants in Group A and C who showed an improvement in the TMDDIQ scores.

5.2.3. Objective Three

The third objective was to evaluate the effectiveness of cervical spine manipulative therapy and TMJ manipulation combined with myofascial trigger point therapy of both the cervical and TMJ musculature in the treatment of TMD. In this group participants received manipulation to the TMJ and subluxations in the cervical spine as well as ischaemic compression and PNF stretching to both the masticatory and cervical spine musculature.

This group was the only group to have at least one of the algometer readings show a statistically significant improvement ($p = 0.046$). This improvement was over the masseter muscle. There was no improvement in the other masticatory muscles and one possible reason for this could be attributed to the fact that the masseter muscle and subsequently the MFTP's in the masseter are easier to palpate and hence easier to treat. Therefore it stands to reason that MFTP's in the masseter are clinically more responsive to treatment when compared to the other masticatory muscles (Gray, 2002). This theory is possibly supported by the fact that the left masseter muscle in Group A, showed an improvement, where PNF and myofascial trigger point therapy were also administered to the masticatory muscles; although it did not improve to the level of significance set by the researcher ($p < 0.05$). Conversely, the lack of improvement in the contra-lateral masseter and/ or either of the temporalis muscle MFTP's, which also received myoascial trigger point therapy, may be due to the fact that masseter and temporalis MFTP's do not resolve until secondary or satellite MFTP's in the SCM have been successfully treated (Travell, Simons and Simons, 1999). This could be the case in Group C as no significant improvement in the algometer readings over either of the SCM muscles was noted.

Participants in Group C were the only group to have both a statistically and clinically significant improvement in their NRS scores ($p = 0.035$) as well as a significant decrease in their perceived level of disability ($p = 0.027$). However, these findings could be due to the same reasons elucidated for the improvement in Group A, i.e. the natural history of TMD.

The only statistically significant increase in cervical range of motion was cervical rotation to the left ($p = 0.001$) and the only statistically significant improvement in mandibular range of motion was maximum mouth opening regardless of pain ($p = 0.039$). The normal inter-incisor opening is between 41 to 50.7mm (George *et al*., 2007) and according to Feteih (George *et al*., 2007), a mouth opening measurement of less than 40mm is considered restricted. In light of this, the latter improvement in maximum mouth opening is interesting considering that 24 of the 30 participants had baseline maximum mouth opening measurements which were within the normal range.

5.2.4. Objective Four

There was no means of directly comparing the results of the present study with other studies investigating the same variables due to the paucity of literature regarding the treatment protocols which were used in this study. The results of the current study however, indicated that no one treatment protocol used was vastly superior to another. The possibility that a type two error may have occurred due to a low sample size cannot be excluded and may have resulted in the lack of statistical power.

Furthermore, TMD is a multifactoral condition (DeVocht *et al*., 2003 and Andrade, Gomes, Teixeira-Salmela, 2007) and the treatment protocols which were being evaluated in the current study only addressed an isolated musculoskeletal aspect of TMD thus, vast improvements were not expected. The aim was to determine if these approaches would be a beneficial adjunct in the management of TMD and if possible to determine which would be superior, if any.

Although the sample size of this study was small the overall results indicated that any treatment to the neck or the TMJ seems to have a favorable effect on the amelioration of signs and symptoms in the TMD patient. This is in keeping with literature by Gray *et al*., (1994); Okeson, (1996) and Tucker, Farrell and Farrell (2008) who concluded that conservative treatment options have proven to be effective and should be promoted over surgical or other invasive interventions and that comparable results have been found with whatever treatment was administered. Therefore, strengthening the notion that conservative, non-invasive, revisable treatments such as those used in this study appear to be of benefit to most TMD sufferers (De Laat, 2001).

No one treatment has been studied in enough detail to assess the efficacy or effectiveness adequately and conservative treatment options need to be further investigated in order to determine if manual interventions directed at the cervical spine in the treatment of TMD are beneficial. Chiropractic care of a patient with TMD with or with out the associated craniovertebral complaints needs to be further investigated as the close relationship of the craniocervical-mandibular system, which has been clinically demonstrated by the development of TMD following cervical spine acceleration deceleration injuries (Friedman and Weisberg, 2000) and the increased incidence of cervical spine dysfunction in TMD patients (Ciancaglini *et al*., 1999), cannot be ignored. From the literature review, it is plausible that not only could subluxations in the cervical spine aggravate the TMJ, it could also lead to TMD (Alcantara *et al*., 2002).

5.3. Hypotheses revisited

The first null hypothesis:

There will be no improvement in terms of subjective and objective findings in participants with TMD who are treated with:

A. TMJ manipulation and myofascial trigger point therapy of the TMJ musculature.
B. Cervical spine manipulation and myofascial trigger point therapy of the cervical spine musculature.
C. Combined TMJ and cervical spine manipulation and myofascial trigger point therapy of the TMJ and cervical spine musculature.

The null hypothesis for point A was rejected for the following measured outcomes: CROM right lateral flexion and extension, maximum mouth opening regardless of pain and TMDDIQ. For all the other outcomes the hypothesis was accepted (all algometer readings, CROM in left lateral flexion, rotation to the right and left and flexion, deviation of the jaw, active deviation of the jaw to the right and left, comfortable mouth opening and NRS).

The null hypothesis for point B was rejected for the following measured outcomes: CROM in left lateral flexion and NRS. For all other outcomes the hypothesis is accepted (all algometer readings, CROM in all other directions, all madibular range of motion measurements and the TMDDIQ score).

The null hypothesis for point C was also rejected for the following measured outcomes: Right masseter algometer readings, CROM in left rotation, maximum mouth opening regardless of pain, NRS and TMDDIQ score. For all other outcomes the hypothesis was accepted (all other algometer readings, CROM all other directions and all other madibular ranges of motion measurements).

The second null hypothesis:
There will be no statistically significant difference noted when comparing the three treatment groups.

The second hypothesis was accepted because inter-group comparisons did not reveal any significantly different effects between the three treatment groups. There was, however, insufficient statistical power to allow conclusive comparisons of the treatment effects between the groups owing to the limited sample size.

5.4. Conclusion

All groups responded favorably to the treatment received or showed trends towards improvement, including the cervical spine treatment group. No one treatment protocol was superior to the next in terms of the overall treatment outcomes (p = 0.05). The results of this study are in keeping with the views of Gray, Quayle, Hall and Schofield (1994); Okeson (1996); Kalamir, Pollard, Vitiello and Bonello (2006) and Tucker, Farrell and Farrell (2008) who believe that patients with all forms of TMD improve satisfactorily without any type of long-term or invasive treatment. Further to this, it is believed that manual therapy aimed at either the TMJ or cervical spine are considered to be of value in decreasing inflammation, pain and discomfort and improving range of motion in the short term (Michelotti, Parisini and Farella 2002; DeVocht, Long, Zeitler and Schaefer 2003 and Kraus, 2007). Statistically significant improvements on intra-group analysis in Group A were noted in two of the CROM readings, maximum mouth opening regardless of pain and a statistically significant improvement in the participants' perceived level of disability. In Group B there were statistical improvements in one CROM reading and in the NRS score. Finally, the combined group had the greatest number of statistically significant improvements on intra-group analysis as noted in the statistically significant improvement in one algometer and one CROM measurement, maximum mouth opening regardless of pain, NRS and the TMDDIQ score. However, no one treatment was found to be superior to the other on inter-group analysis and this may have been because statistical power was not sufficient to prove any significantly different effects of the treatment groups conclusively, or to allow conclusive comparisons of the treatment effects between the groups.

According to Alcantara *et al*., (2002) the incidence of TMD is on the rise, therefore, it is of increasing importance to the health care practitioner to familiarize themselves with the myriad of TMD management options available. This study gives an indication that, in addition to treating the TMJ and muscles of mastication, the inclusion of treatment aimed at the cervical spine and associated musculature can be of benefit and should possibly be included in the multidisciplinary approach to the management of TMD.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

The study set out to compare manipulative therapy plus myofascial trigger point therapy of the TMJ, manipulative therapy plus myofascial trigger point therapy of the cervical spine, and a combination of these above two treatment approaches for TMD, showing that there were no statistically significant differences between the three groups based on outcome measure scores. Although no definitive inferences may be drawn regarding the effectiveness of each treatment approach, within-group trends showed that the combination of the two treatment approaches may be preferred.

6.2. Recommendations

1. This study did not address the psycho-physiological causes of TMD and the role that stress, anxiety and depression play in the TMD patient (Okeson, 1996) and it is recommended that patients should be educated with regards to the psychosocial factors which contribute to the development of TMD (Tucker, Farrell and Farrell, 2008). Future studies need to educate the patient so that they can have an awareness associated with their pain and dysfunction and can actively participate in their own improvement.
2. Since psychological factors may play a role in TMD and enhance the central nervous systems response to stimulation, it is suggested that future studies exclude patients who are in a state of depression or experiencing high levels of stress.
3. The sample size in this study was 30 participants (10 participants per group); the use of larger sample size in each group may produce a greater statistically significant result.
4. Following the technique of Peterson and Bergmann (2002), it is suggested that a head belt or an assistant should be used to stabilize the patients head while the TMJ is being manipulated; this may produce better results and was omitted in the current study.

5. The current study did not include a control group and the possibility that participants improved due to the natural progression of the disorder cannot be ruled out. Hence, the inclusion of a control group is suggested. It is also suggested that the study should have made use of allocation concealment and the researcher should have been blinded to rule out the chance of researcher and selection bias.
6. This study did not address the dental component of TMD and although the exact role that malocclusion plays in the development of TMD is subject to debate, it is recommended that future studies should evaluate this component in the multidisciplinary approach to TMD.
7. Ischaemic compression of the medial and lateral pterygoids should be included in future studies to better represent the clinical setting.
8. changes in TMJ muscle tenderness, the researcher felt that this was a weak tool owing to the fact that many of the participants strongly opposed the use of henna marking and thus other less specific methods of marking were utilized which made identifying the exact same spot of muscular tenderness at each session difficult and less accurate. Also, few positive statistically significant results were generated from the use of this tool. It is suggested that future studies use other methods to identify muscle tenderness as methods such as surface EMG may provide more accurate results.
9. In a study where the objective is to evaluate the effectiveness of treatment groups, as opposed to a treatment-dose response evaluation, measurements should only be taken and analyzed at baseline and at completion of the final treatment. This is to ensure that the key message of the results is not clouded by too much data.